

A study of the perceptions of air safety and mid-air collision prevention during regulatory change

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This thesis is submitted in partial fulfilment of the requirements for the award of the degree of Doctor of Business Administration of the University of Portsmouth

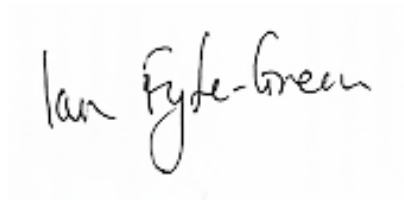
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June 2018

Declaration

Whilst registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

Signature:

A handwritten signature in black ink that reads "Ian Fyfe-Green". The signature is written in a cursive style with a large initial 'I' and 'F'.

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Abstract

The aviation industry has been subject to a steady change in its regulations; any change, however minor, has the potential to lead to a decrease in safety. In analysing the data associated with near-miss reporting, together with opinions garnered from those within the aviation industry, this research highlights the impact that regulatory change can have on the barriers to mid-air collision.

The research is needed now because, over and above the normal level of changes, ‘Brexit’ will undoubtedly lead to a new regulatory framework, and there has also been an exponential increase in the number of near-misses between drones and aircraft since January 2015. There is a need for more, or better, regulation surrounding drones. The chance of a drone colliding with an aircraft has increased substantially, acknowledged by both UK and EU authorities, and the findings from this research have contributed to their public consultations. This thesis is strategic with respect to regulatory change in general, the conclusions being equally applicable in any aviation scenario. Brexit and drone proliferation are current examples of the need to manage safety through times of regulatory change, the latter being an example of when a lag in regulation change can cause safety to decrease. Notwithstanding the immediacy of this research, the principles laid out in this thesis will apply to the introduction and management of any future changes to aviation regulations.

A survey into the perceptions of aviation personnel received 413 responses across 56 countries. The results are analysed quantitatively first, then triangulated with qualitative analysis of free text comments and reports from interviews with key industry representatives. The analysis is further supported by secondary data in the form of near-miss reports and a case study. A limitation of the study is that, although the survey attracted a global audience, the individual numbers of responses from many countries is not enough to make a representative argument for anything but a global perspective, when a comparison between regions would have been useful.

Contribution to Knowledge and Practice

This study has already had impact upon UK Government policy in relation to the regulation of drones. One of the findings of this research is that there is a perception within the aviation industry, that regulations on the use of drones need enhancing in order to decrease the likelihood of a mid-air collision with a manned aircraft. The interim results of this study were submitted to the Government consultation in March 2017; the researcher was one of only 36 members of the public (who were not a pilot or drone user) to make a contribution. The Government announced on 30th May 2018 that new regulations will come into force on 30th July 2018, and drones will no longer be allowed to fly above 400ft or within 1km of an aerodrome. Furthermore, from November 2019 the regulations will include the requirement for drone operators to be registered and to undertake a course on how to safely operate a drone. The survey results that were part of this contribution showed that the overwhelming majority of respondents felt that the regulations needed to be enhanced and suggestions were made on how to do so.

This research will also contribute to ongoing air safety, and the mitigation strategies for the prevention of mid-air collision, with the findings of the study available to safety managers in both military and civilian aviation, as well as to the regulators. The specific contribution that will be made, is to highlight the impact that regulatory change can have on the barriers to mid-air collision, so that those responsible for maintaining these barriers can take the necessary precautions to prevent them being eroded. A summary of the outcomes will be published on the researcher's website and advertised to those who contributed to the study. Articles will also be written for academic journals and practitioner magazines to disseminate the research as widely as possible, so that others may benefit from the findings.

In the short term, the first country that will benefit from the research is Brunei Darussalam, where the findings will be put into practice over the next year. Brunei's aviation regulations date from 2006 and are in the process of being refreshed, with the changes expected to be introduced soon. The researcher will be working with several Government organisations in Brunei, and the findings of the study will be available to assist in the implementation of changes to regulation. Currently, regulation prohibits all drone flying in Brunei airspace, unless a permit is obtained from the authorities. However, drones are flown illegally, and the global proliferation would suggest that a total ban cannot be maintained for long, so a risk of a mid-air collision exists. This research can help with the establishment of appropriate regulation.

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List of Abbreviations

Abbreviations without specific citation are attributed to the researcher's own knowledge

AAL – Above Aerodrome Level

ACAS – Airborne Collision Avoidance System (for example TCAS)

Aerodrome - Collective term to signify any airfield, airport or military air station.

The ICAO definition of aerodrome is: A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft. (CAA, 2014)

AGL – Above Ground Level

AIRAC – Aeronautical Information Regulation And Control

AIRAC defines a series of common dates and an associated standard aeronautical information publication procedure for States. In short it defines that in all instances, information provided under the AIRAC system shall be distributed by the AIS unit at least 42 days in advance of the effective date with the objective of reaching recipients at least 28 days in advance of the effective date. Whenever major changes are planned and where additional notice is desirable and practicable, a publication date of at least 56 days in advance of the effective date should be used. (ICAO, 2015)

Airprox – Aircraft Proximity, usually used to describe a near-miss event or report

Defined by ICAO as: a situation in which, in the opinion of a pilot or air traffic services personnel, the distance between aircraft as well as their relative positions and speed have been such that the safety of the aircraft involved may have been compromised. (ICAO, 2012)

AIP – Aeronautical Information Publication

AIS – Aeronautical Information Services

AMC – Acceptable Means of Compliance

AMSL – Above Mean Sea Level

ANO – Air Navigation Order

ANSP – Air Navigation Service Provider

AOA – Airport Operators Association

AS – a) Air Safety,

b) Aviation Safety, or

c) Air System (meaning aircraft and pilot, remote or onboard)

ASMS – Air Safety Management System

ATC – Air Traffic Control

ATCO – Air Traffic Control Officer, although often termed Air Traffic Controller

ATM – Air Traffic Management (includes ATC)

ATS – Air Traffic Services

ATSOCAS – Air Traffic Services Outside Controlled Airspace

BALPA – British Airline Pilots Association

BowTie – Risk assessment tool used by the UK CAA and other companies (CAA, 2015f)

BVLOS – Beyond VLOS

CAA – Civil Aviation Authority

CANSO – Civil Air Navigation Services Organisation

CAS – Controlled Airspace

CAT – Commercial Air Transport

Air transport services available to the general public for the transportation of passengers, mail and/or freight for remuneration. Includes air taxis and commercial business flights (ICAO, n.d.).

CFIT - Controlled Flight Into Terrain

CMI – Chartered Management Institute

DASOR - Defence Air Safety Occurrence Report

EASA – European Aviation Safety Agency

FIR – Flight Information Region

FIS – Flight Information Service

FL – Flight Level

FS – Flight Safety

GA – General Aviation

All civil aviation operations other than scheduled air services and non-scheduled air transport operations for remuneration or hire (ICAO, 2017).

GATCO – Guild of Air Traffic Control Officers

GUTMA – Global UTM Association

HRO – High-Reliability Organisation

IATA – International Air Transport Association

ICAO – International Civil Aviation Organization

IFR – Instrument Flight Rules

IMC – Instrument Meteorological Conditions

JHC – Joint Helicopter Command

MAA – Military Aviation Authority

MAC – Mid-Air Collision

MOD – Ministry of Defence

MOR – Mandatory Occurrence Report

NATS – Formerly known as National Air Traffic Services, now just NATS

PBN – Performance Based Navigation

PBR – Performance Based Regulation

QFE – Atmospheric pressure at aerodrome elevation (or runway threshold). An aircraft's altimeter readout will show height above this datum

The Q Codes are a series of standardised three-letter codes all starting with Q and were developed in the early 20th Century for radiotelegraphic communication. Some of them are still in common usage within aviation.

QNH – Atmospheric pressure adjusted to sea level. An aircraft's altimeter readout will show its altitude AMSL

RAF – Royal Air Force

RN – Royal Navy

RPAS – Remotely Piloted Air System

SARPs – Standards and Recommended Practices

SERA – Standardised European Rules of the Air

SES – Single European Sky

SESAR – SES ATM Research

SMS – Safety Management System

SUA – Small Unmanned Aircraft

SUAS – Small Unmanned Air System

TAS – Traffic Advisory System (an example of ACAS)

TCAS – Traffic alert and Collision Avoidance System (an example of ACAS)

TCAS RA – TCAS Resolution Advisory

UAS – Unmanned Air System

UAV – Unmanned Air Vehicle

UKAB – United Kingdom Airprox Board

UKFSC – UK Flight Safety Committee

UTM – UAS Traffic Management

VFR – Visual Flight Rules

VLOS – Visual Line Of Sight

VMC – Visual Meteorological Conditions

VPN – Virtual Private Network



Chapter 1 – Introduction

1.1 Overview

The aviation industry has for many years been subject to a steady change in its regulations; 1975 was declared “*a watershed for aviation regulation*” with much criticism of the poor state of industry regulation (Snow, 1975, p. 637). Nowadays there are comments such as “*the only real constant I have seen over nearly 27 years in air traffic control is the constant change*” (Pigden, 2018, p. 9). Even when the intent is to increase safety, any regulatory change, however minor, has the potential to lead to a decrease in safety whilst the changes are implemented and understood. In October 2001 the European Commission adopted the proposal of a Single European Sky (SES), accepted by European Parliament in March 2004 (SES-I) and then revised again in June 2008, under the title SES-II. These principles have given rise to a number of wide-reaching changes to airspace structures. A tangible change embodied within SES-II is the introduction of SERA¹ to UK airspace in February 2015. As an example, a change to the airspace near Southend (UK) is recognised as a contributory factor in a 2015 near-miss (Airprox) between two airliners (UKAB, 2015, p. 5), when both aircraft were cleared to the same level by Air Traffic Controllers “*close to the start of their first shift*” since the change had been introduced.

Regulations can change for many reasons, often through necessity and sometimes in an attempt to make aviation safer. Aviation disasters can share remarkable similarities though, even after many years have elapsed. For instance, two airliners collided on the runway at Los Rodeos airport in Tenerife in March 1977 killing 583 people as a result of a series of events, each of which potentially insignificant but when combined in sequence formed a catastrophic chain of errors (Shorrock & Kirwan, 2002; P. Smith, 2017). In October 2001, a Scandinavian Airlines MD87 collided with a Cessna 525 on the runway at Milan Linate airport killing 118 passengers, crew and ground staff (Catino, 2010; Flottau, 2001; Johnson, 2005; Kirwan & Licu, 2008). In both of these cases one aircraft was taking off and collided with another that was on the runway, but this was not the only similarity. Regulations will have undoubtedly changed many times over the intervening years and yet the accident still happened again. Are these events outliers to an industry record of normally safe operations?

¹ Standardised European Rules of the Air

A Saudi Arabian Airlines Boeing 747 collided with a Kazakhstan Airlines Ilyushin II-76 over Charkhi Dadri near New Delhi in November 1996, killing 349 people (Centre of Disaster Management, n.d.; McGirk, 1996; Shorrocks & Kirwan, 2002) and in 2002 a mid-air collision over Uberlingen between a DHL Boeing 757 and a Bashkirian Airlines Tupolev TU154M killed 71 passengers and crew (de Carvalho, 2011; Leveson, 2015; Reason, Hollnagel, & Paries, 2006). Lessons were clearly not being learnt and operational safety was being compromised, especially as in both of these incidents Air Traffic Controllers were expected to violate established procedures in order to overcome systemic failings (Mearns et al., 2013). Busby and Bennett (2007) opine that failure can seem an inevitability in complex and hazardous systems. These accidents were avoidable and were undoubtedly preceded by a plethora of incidents, any of which could have served as a warning as to what might, and did, happen. Whether through human error or circumstance, at the time of these events something was different to normal; something had changed.

In analysing the data associated with near-miss reporting, together with the opinions garnered from personnel within the aviation industry, this thesis looks at perceptions of air safety and the prevention of mid-air collision during regulatory change. It is not about the specifics of these examples of accidents, nor is there any implication that regulatory change was causatory to them, it is about how air safety can be impacted by changes in regulations and how this impact might affect the possibility of mid-air collision, known in the industry as MAC. ‘Unusual situations’ and ‘procedures not followed’ are phrases that could summarise these examples of accidents, but there are invariably lessons that can be learned from any accident, which perhaps could be learnt earlier from a previous incident. Some disasters can presumably be classified as being outliers with no rational cause, perhaps the disappearance of Malaysian Airlines Flight 370 could be defined as such (Robinson, 2014)? Key terms such as Mid-Air Collision, Air Safety and Airprox are in defined Chapter 2. The study encompasses both military and civil aviation and, whilst initially intended to be restricted to the UK, there is a global element to the study for reasons explained later in the thesis.

1.2 General Context

The genesis for this research was the consultation launched by the CAA² in January 2012, on the European proposal to harmonise the Transition Altitude (TA) across the continent.

² Civil Aviation Authority

In simple terms, an aircraft's altitude below the TA is expressed in thousands of feet above the ground within its vicinity, whereas above the TA it is expressed against a datum common to all aircraft, known as a Flight Level. There was a desire to implement a change of TA in 2018 from 3000ft to 18000ft, which would have meant a significant array of regulatory changes across the industry. However, the consultation process revealed a number of concerns over air safety associated with the proposed change which, coupled with dissent amongst neighbouring Nations as to what level a harmonised TA would be, meant that the proposal is currently on hold. Since the research started, the UK conducted a referendum in June 2016 and subsequently triggered 'Article 50' of the Lisbon Treaty to voluntarily leave the EU. As most are aware, this is dubbed by the media as 'Brexit'.

Additionally, during the initial stages of the research, it was noted that there had been a disproportionate increase in the number of Airprox (see Section 2.2.2 for explanation) reports filed in 2015 (and subsequently another large rise in 2016) against Small Unmanned Aircraft³, commonly known as 'drones'. There seems an obvious need for more, or better, regulation surrounding the operation of drones, especially as many of the Airprox reports suggest that collisions are only being avoided by sheer luck.

1.3 Why this research is needed

After the UK Government announced its decision to withdraw from the EU, a study was conducted into the economic and regulatory consequences of the decision (IATA, 2016). Whilst much of its focus is on the economics, it is highlighted that although there would not be an immediate regulatory impact during the initial 2-year negotiation period, there is potential for significant issues at the point of departure from the Union. The report warns that the regulatory impact might not be felt for 5-10 years whilst trade deals are negotiated, and the uncertainty of the situation will amplify the negative factors. It is also highlighted that as the 'open-skies' agreements with third States are with members of the EU, they will not apply to the UK post-Brexit and will have to be renegotiated on a bilateral basis. It is suggested that if deals are not reached in time, then there may be a reversion to the last agreed position, which "*would have profound implications for airlines and their customers, no matter how unlikely*" (IATA, 2016, p. 5). Further research has been conducted in the industry as to the impact of Brexit on regulation, with organisations such as Baines Simmons commenting that the UK will itself become a third State in its dealings

³ Also termed Unmanned Air Vehicles (UAV), Unmanned Air System (UAS), Small Unmanned Air System (SUAS) or Remotely Piloted Air System (RPAS).

with the EU, and whilst initially it will likely adopt the EASA⁴ regulations, in the longer term the lack of influence that the UK will have in the forming or amending of the regulations may make this position untenable (Scarborough, 2017). There are some that suggest that flights will be grounded without regulatory resolution (for example O’Carroll, 2017) - at least this will be considered to be perfectly safe! The most likely scenario is continued flying, with confusion, disruption and regulatory non-compliance, and the inherent decrease in assured safety that this situation would yield (Decisionpoint, 2017). The Royal Aeronautical Society (RAeS) comments that the construction of regulatory barriers will harm UK aviation and “*above all, there should not be a regression on the levels of safety achieved through European co-operation*” (Whalley, 2017, p. 22). Furthermore, Whalley states that the adoption of a regulatory set that diverges from EASA, deliberately or otherwise, will fundamentally undermine safety. A second RAeS paper encourages the UK Government to ensure that a “*first-class safety culture*” is maintained (Royal Aeronautical Society, 2016), as there is no precedent to an EU Member State leaving the regulatory umbrella of EASA.

In 2016 35% of Airprox reports filed with the UKAB⁵ were between manned aircraft and a drone or other object, whereas the number of aircraft-to-aircraft incidents remained similar to previous years (UKAB, 2017a). Figure 1-1 depicts the increase in near-misses between drones and manned aircraft. Of the 94 drone-related reports assessed by the Board in 2016, 65 were declared as ‘risk-bearing’⁶, of which 34 were awarded Cat A, an assessment usually reserved for the most serious cases “*where chance played a major part in events*” and “*a serious risk of collision existed*” (UKAB, 2017a, 2017c). This Figure is not presented as an analysis of the data, but as a visual representation of the recent rise in the number of Airprox reports which, with the perceived severity, shows why this research is relevant. Analysis of the likelihood is presented in Chapter 6, however, it can be opined from looking at Figure 1-1 that the chance of a drone colliding with an aircraft has increased substantially with their proliferation. This has been acknowledged by both the UK Government and EASA, who independently launched public consultations on drone regulations in 2016.

⁴ European Aviation Safety Agency

⁵ UK Airprox Board

⁶ Assessed as Cat A or B, where there is a definite risk of collision

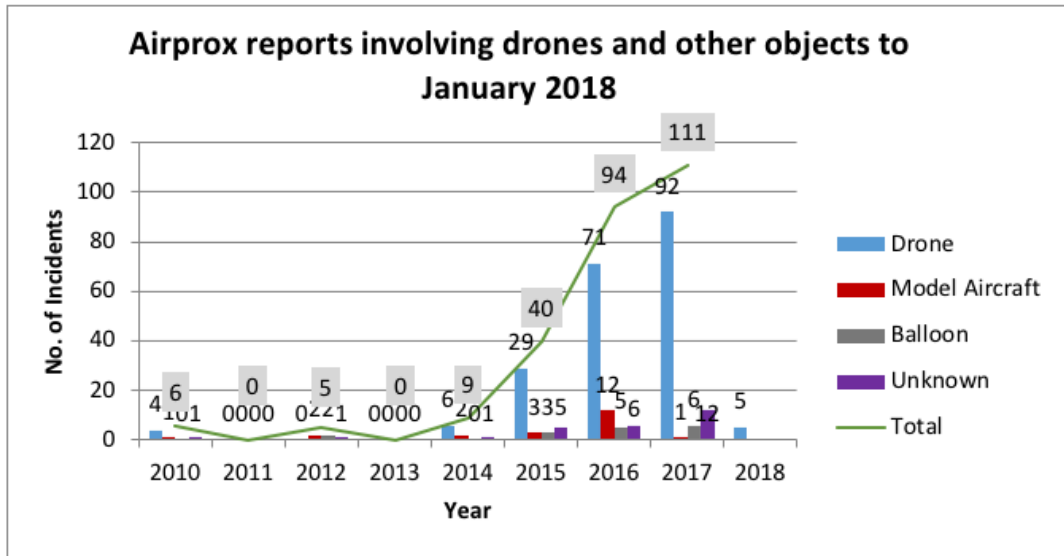


Figure 1-1 showing the number of Airprox involving drones and other objects from January 2010 to January 2018. Copyright 2018 by the UK Airprox Board.

This research is considered to be strategic with respect to regulatory change in general, the conclusions and recommendations being equally applicable in any scenario. Brexit and drone proliferation are used as current examples of the need to manage safety in the air through times of regulatory change, indeed the latter being an example of when regulatory change can lag behind reality and the lack of regulation can be argued to be a causation of the decrease in safety. Notwithstanding the immediacy of this research, the principles laid out in this thesis will apply to the introduction and management of any future changes to aviation regulations.

1.4 Previous research on the subject

A review of the literature is presented in Chapter 2, where the search strategy is outlined. In looking for previous research, the British Library archives (EThOS) were consulted in addition to the literature, in order to identify if any theses had already been submitted on the subject. Whilst some are clearly aviation oriented, none address the fundamental aspect of the safe operation of aircraft when regulations undergo change. The search was widened to include International theses and again none were found. The lack of post-graduate research does not in itself mean that there is a gap in knowledge, however, a thorough review of the literature has been conducted and is presented in Sections 2.2 – 2.7 concerning Mid-Air Collision, Air Safety, Error, Leadership and management, Safety culture, and Regulations relating to drones. No literature has been found that specifically addresses what the impact of regulatory change is on mitigation barriers for mid-air

collision. It is, therefore, suggested that there is a gap in knowledge that can be filled by this research; specific gaps in the literature are highlighted in Section 2.8.

1.5 Intended contribution

It is intended that knowledge of the findings of this research will contribute to the future mitigation strategies for the prevention of mid-air collisions during the implementation of changes to regulations, by military and civilian organisations, in the UK and overseas. This contribution will be achieved by highlighting to those responsible for the management of the barriers to mid-air collision, what the global perceptions of air safety and mid-air collision prevention are, together with recommendations for any improvement based on empirical evidence.

This research has already demonstrated impact by contributing to the development of regulations on the use of drones; the interim results were submitted to the public consultations conducted by the UK Government and EASA in 2017. The UK consultation culminated in the announcement on 30 May 2018 that additional regulations will come in to effect on 30 July 2018 when the Air Navigation Order 2016 is amended, with further changes to be implemented on 30 November 2019 (Department for Transport, 2018). The researcher will continue to be engaged with the UK policy makers in this area though, as the new regulations only go some way to reducing the potential for mid-air collision whilst not completely removing it; for instance, the amended law will restrict the height of a drone to be not above 400 ft, remaining at least 1km from an aerodrome boundary, but if the drone is being flown in the approach path of the runway in use then that height will conflict with the aircraft as it descends to land.

The research was also well received when it was presented at the UK Airport Operators' Association safety conference⁷ and it is envisioned that this will continue to be the case at future flight safety related conferences. An abstract of the research has been submitted to the International Air Safety Summit in the USA for consideration. Thesis submission is not intended to be the culmination of contribution, quite the opposite. Thus far, two attempts at academic publication has been unsuccessful (Safety Science and Journal of Risk Research) but it is intended that further articles will be written to summarise the research and an academic presence achieved. Two invitations for co-authoring journal articles have been received and it is anticipated that articles will continue to be written for

⁷ AOA Operations & Safety Conference 2017, held at Carden Park Cheshire, 19-20 June 2017.

practitioner magazines, building on the success of the invite to write for the Pakistan International Airlines' safety magazine. During the research, personal membership was attained of the Flight Safety Foundation, an independent global organisation dedicated to research, education, advocacy and publishing in the field of aviation safety. Fellowship of the Chartered Management Institute (CMI) and Chartered Manager status were also achieved as part of a strategy of continuous professional development.

1.6 The aim of the research

This study will address the question as to whether changes in aviation regulations can be implemented without decreasing safety and will look at the fundamental aspects of Air Safety Management. The aim of this research is to identify what impact regulatory change has on the barriers to mid-air collision.

1.7 Overarching Research Question

In order to frame the research appropriately, it is first necessary to identify the intended Contribution and then deduce a flow through Focus, Title, Aim, Research Question and Objectives.

Contribution: To highlight the impact that regulatory change can have on the barriers that mitigate against mid-air collision.

Focus: With the impending major regulatory change programs that the aviation industry will face, the focus of the research is to highlight barriers that can be implemented, or reinforced, in order to manage the safe introduction of future regulatory changes in UK aviation.

Thesis Title: A study of the perceptions of air safety and mid-air collision prevention during regulatory change.

Research Aim: The aim of this research is to identify what impact regulatory change has on the barriers to mid-air collision.

Research Question: Can new aviation regulation be introduced without decreasing safety?

1.8 Research objectives

From the overarching Research Question, the following objectives are derived:

1. Determine if there is a correlation between an increase in the likelihood of an Airprox and changes to aviation regulation.
2. Assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation.
3. Analyse whether humans are the weak link in the aviation safety chain.
4. Assess if there is an active culture of learning from incidents within aviation.
5. Determine if changes are required to regulations to integrate drone operations.

Figure 1-2 is a representation of the structure of the research, with the overarching Research Question leading to the setting of objectives and the conduct of a thorough literature review. From these two elements, suppositions are formed and investigated with primary and secondary data as appropriate. Analysis is conducted using mixed methods, with the survey forming the primary data collection, sequentially supported by semi-structured interviews for validation, cross-reference and to capture any extra information that was not picked up in the survey. Quantitative analysis is conducted where possible, supported by qualitative analysis of the free text survey questions and the interviews. Qualitative analysis is conducted on the secondary data, which consists of open-source Airprox reports and a short case study of the introduction of a major regulatory change at a UK aerodrome. All analysis is then related back to the suppositions in order to assess the findings and form conclusions.

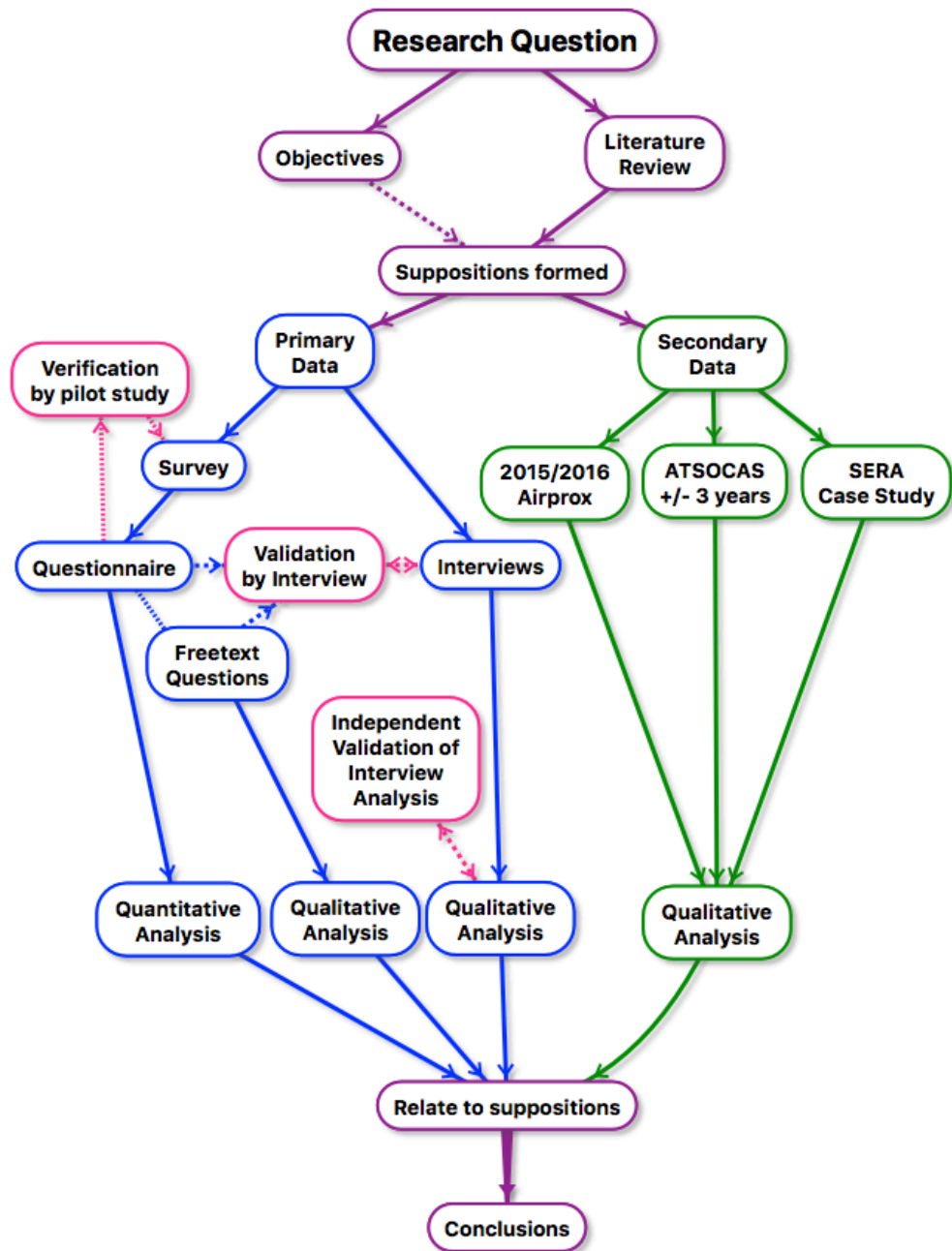


Figure 1-2 showing the structure of the research that will answer the overarching Research Question

1.9 Introduction to methodology

Table 1-1 maps the five research objectives from Section 1.8 against the aspects of data that are expected to yield answers, together with a column depicting the supposition number. The suppositions are not shown at this stage as they are reasoned from the literature review, presented in Section 2.8; for some objectives, two suppositions are set. In this table, the three columns of primary data represent the multiple-choice survey questions, the free text survey questions (which were optional in order not to discourage completion of the rest of the questionnaire) and the interviews. The three columns of

secondary data relate to Figure 1-2, specifically 2015/2016 Airprox reports, Airprox reports from 3-years either side of the ATSOCA⁸ regulation change, and a case study on SERA introduction. This table precedes the analysis in order to signpost which elements of data collection are expected to address each supposition. Obj5 includes the analysis of 2017 Airprox reports that relate to near-miss encounters with drones, in addition to the 2015 and 2016 data. The reason for this is that, despite the normal lag of four to six months to assess a report and publish it, in 2017 the UKAB changed the way that drone reports are processed and subsequently fast-track them in one month. This means that the 2017 data is available for drones at the time of analysis.

Obj		S _n	Primary data			Secondary data		
			Qs	Txt	Int	15/16	+/-3	CS
1	Determine if there is a correlation between an increase in the likelihood of an Airprox and changes to aviation regulation.	1			√	√	√	√
2	Assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation.	2a	√	√	√			
		2b	√	√	√			
3	Analyse whether humans are the weak link in the aviation safety chain.	3a	√	√	√			
		3b	√	√	√			
4	Assess if there is an active culture of learning from incidents within aviation.	4a	√	√	√			
		4b	√	√	√			
5	Determine if changes are required to regulations to integrate drone operations.	5	√		√	√ +17		

Table 1-1 showing the five research objectives, together with supposition numbers. mapped against the data

The research was originally intended to be restricted to the UK aviation industry, but as will be covered later in the thesis (Chapter 4) the survey unintentionally achieved global distribution. Whilst Brexit has been commented on as an example of the need for the research, the principles apply in the wider context of any aviation regulation change programme, irrespective of country. The disadvantage to this is that the population size increased dramatically; however, the number of responses achieved overall was an acceptable sample size to be deemed representative. The major advantage to this global look could be a comparison of responses by continent to assess if there are any regional

⁸ Air Traffic Services Outside Controlled Airspace

variations. This is achievable as the software chosen to host the survey automatically records the country in which the survey is completed⁹. However, as reflected upon in Section 8.2, a small number of respondents spread across many countries does not give the quality of data that would support this kind of comparison. Section 5.2 covers further detail on this aspect.

The intention is to strike a balance between post-positivism and constructionism, and use abductive reasoning. Triangulation is achieved by the formation of suppositions from the literature, which are investigated with the use of a questionnaire survey, and then validated by interview. This is depicted in Figure 1-3. The philosophy associated with the design of the research, and the methodology, are addressed in Chapter 3.

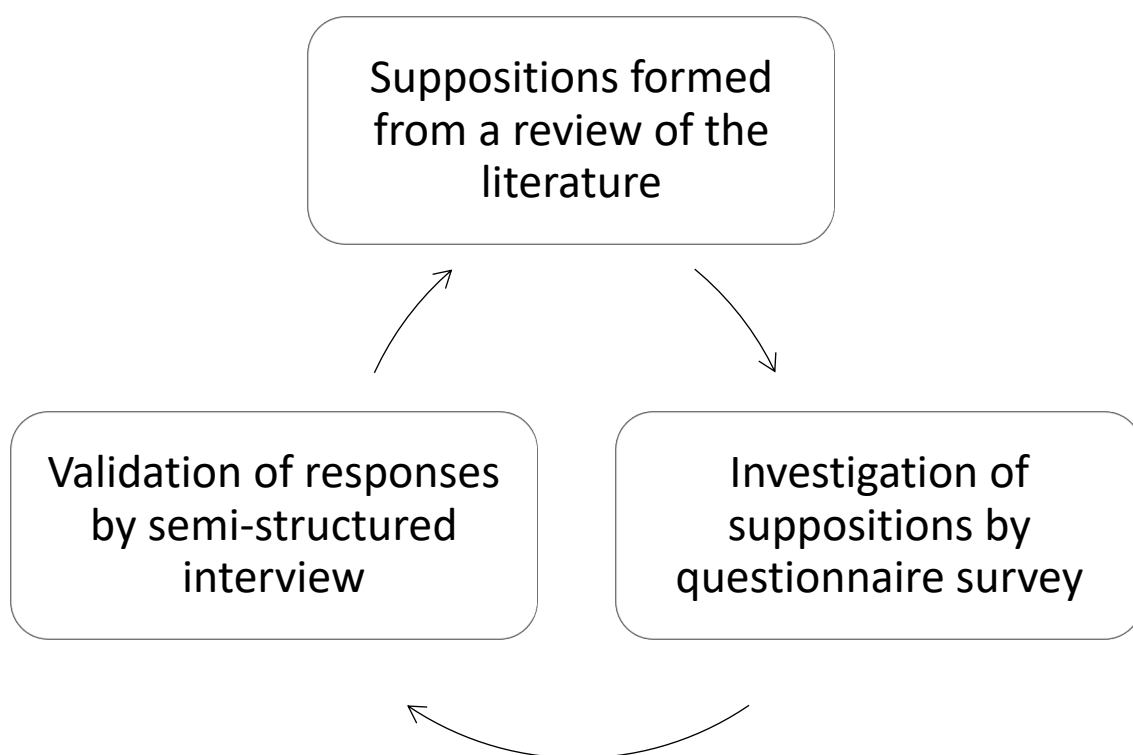


Figure 1-3 showing a depiction of triangulation within the research

Verification of the survey questions is achieved through a multi-stage approach, with the initial phase being the utilisation of colleagues from the military regulator and then the second phase engaging the safety department at Flybe as an independent third-party group. Flybe safety staff were subsequently not approached for participation in the main survey in order to maintain their independence, and so could then be used in the interview stage to assist with the validation of the data and confirming it to be representative of the industry

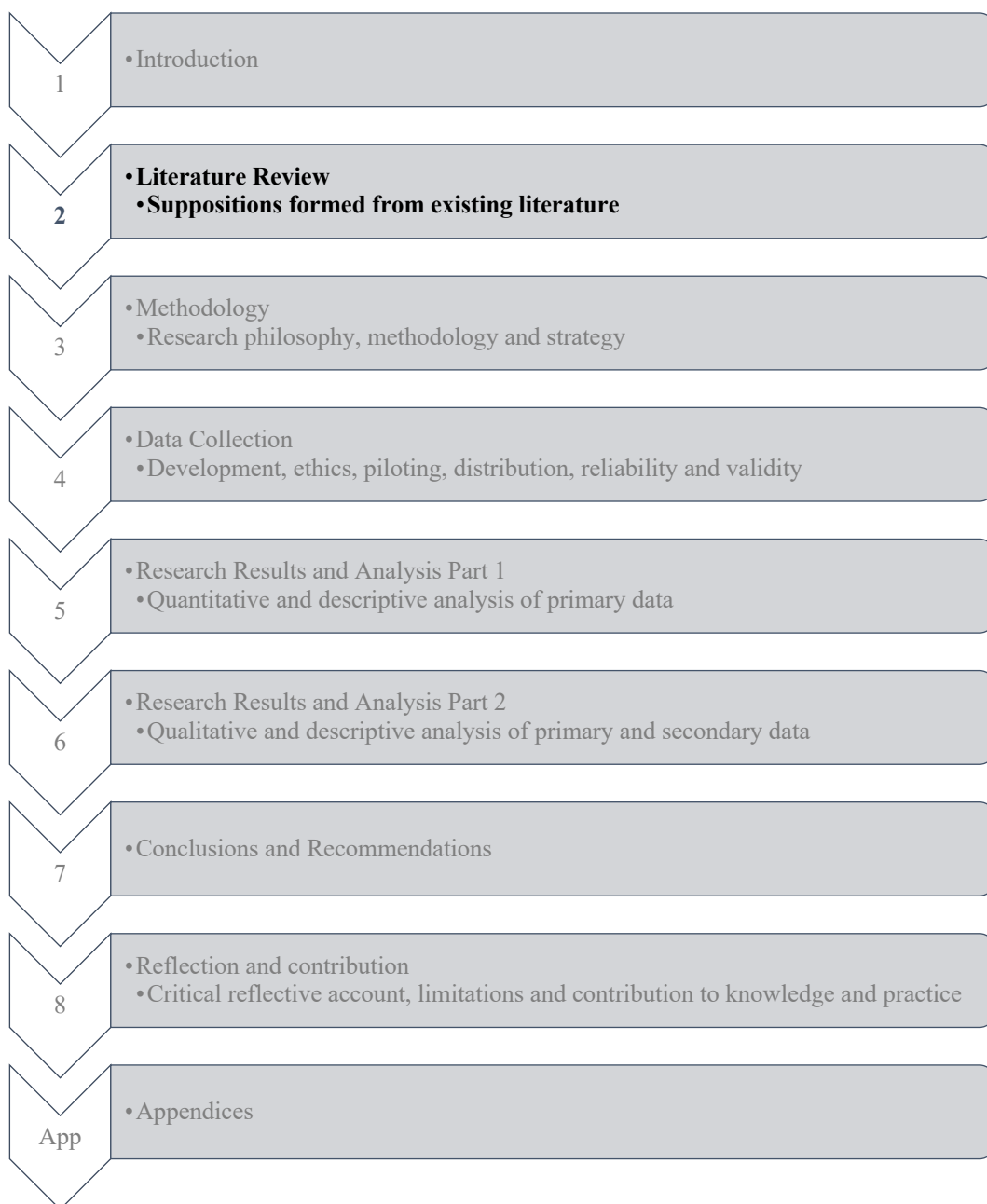
⁹ It is acknowledged that if a Virtual Private Network (VPN) is used this information may not be correct

as a whole. The development of the survey, and the collection of primary data, are presented in Chapter 4.

1.10 Structure of the thesis

This thesis is structured so as to guide the reader through the issue via context, problem and response. The introduction sets the scene, describing the issue and why the research is necessary. This is followed by a review of the literature, from which the suppositions are formed that support the research objectives to answer the Research Question. Chapters 3 and 4 address the principles by which the research is conducted and how the data is collected, including the verification and validation processes, as well as the process of ethical approval. The results and analysis of the research are presented in Chapters 5 and 6, with primary data being offered first followed by secondary data. The analysis of primary data is separated by survey and interview, with the quantitative and qualitative presented sequentially and then related back to the individual suppositions. The secondary data is structured in a way that describes the information harvested, explains its relevance and then relates it to the appropriate suppositions to either answer objectives that were not resolved by the primary data, or in support of some of those that were. Each chapter is summarised independently, with these conclusions then drawn together and discussed with recommendations in Chapter 7. Chapter 8 then finalises the thesis with a reflective summary of the challenges that were faced, some of which were overcome, some not. This chapter also encompasses the contribution of this research to academic and professional knowledge and practice, which includes direct input to the UK Government and EASA consultations on drone regulation.

Fourteen supporting Appendices follow, including the questions used in the online survey, a graphical representation of the responses, extracts from the interview reports, dissemination activities, and the case study from the introduction of SERA at a UK aerodrome. The final Appendix is the mandatory UPR 18 Ethics Review Checklist.



Chapter 2 - Literature Review

2.1 Introduction to the literature review

This literature review covers key areas in order to develop a series of suppositions associated with the research objectives that support the overarching Research Question, ‘can new aviation regulation be introduced without decreasing safety’. UK airspace, and its management, is continuously evolving in order to meet the needs of a growing industry and the extensive changes required to support the Single European Sky (SES) programme, Future Airspace Strategy (FAS) and the developments associated with UK policy on airport capacity (CAA, 2015g). The prevention of Mid-Air Collision (MAC) is obviously paramount, with near-miss reports acting as indicators of areas that can be improved. The management of safety in any aviation organisation must ensure that an appropriate safety culture exists to establish barriers to prevent an accident occurring. Lessons can only be learned from open and honest reporting, which is fundamental to a safety culture. It is the responsibility of an organisation’s leadership to establish this culture, but incumbent upon everyone to be part of it and make operations safe.

The research is grounded in the perspective of Shorrock and Kirwan (2002) where they argue that no amount of technological safeguards can replace the capability a human has of being the effective final barrier to an accident. The review leads to the formation of suppositions to be investigated in the research, the results of which will assist in filling the gaps in knowledge identified in this Chapter.

An initial search of the literature was conducted in year one of the research in order to form the foundations of the study, which has then been built upon in the subsequent years. This comprised searches of multiple academic databases for key terms, as well as the purchase of a number of books to familiarise the researcher with the subject and position the research within it. Newsletters such as Curt Lewis and Aviation Week were subscribed to, which give a daily synopsis of aviation-related news, and this maintained an up-to-date engagement with industry literature. Periodic reviews of the academic databases ensured that new material was appraised as it became available. Much of the academic literature was found from the reference lists of reviewed articles, with a tendency to disappear down fourth or fifth order levels before resetting to the original topic. The websites of the key industry organisations have been monitored for their latest news and notifications of regulatory changes or articles, including the regulators (UK, Europe and Worldwide) and

aviation safety bodies. It is believed that these search strategies have led to a thorough review, which is balanced between academic and practitioner literature, representing a broad picture of the industry as whole.

This review covers the topic of Mid-Air Collision in Section 2.2, which is then expanded upon by explanations of prevention measures and the Airprox system. Section 2.3 introduces the overarching subject of Air Safety before explaining in more detail about the aviation safety chain and the concept of the ‘Four Worlds’ of aviation. In Section 2.4 the subject of Error is presented, as well as how human error factors into the aviation environment and how regulatory change can be thought to induce overload. The importance of Leadership and Management is discussed in Section 2.5, along with the management of safety in particular and how a Safety Management System is used, in many cases mandated, as well as the potential for hindsight bias with investigations. Culture forms the basis for Section 2.6, reviewing the literature on safety cultures, the importance of a Just Culture and how lessons can be learnt in an open and honest reporting culture. Finally, literature surrounding the regulation of drones is reviewed and its adequacy commented upon (Section 2.7), and then the suppositions formed from the literature are presented in Section 2.8.

2.2 Mid-Air Collision (MAC)

According to the UKAB¹⁰, “on average, statistics show one mid-air collision occurs for every 60 Airprox incidents in UK airspace” (Aerossurance, 2017a). An Airprox is defined in Section 2.2.2, but is often a near-miss, whereas a MAC is defined as “*an accident where two aircraft come into contact with each other while both are in flight*” (DNVGL, 2018); the runway collisions at Tenerife in 1977 and Milan Linate in 2001 are not, therefore, considered as MAC, but the lessons from them are still considered relevant. The UK CAA¹¹ (2015e) describes MAC as a “*key risk in UK airspace because of our busy, complex airspace...*” and “*...aims to reduce, by regulatory action, the risk of mid-air collision by pursuing and encouraging targeted and continuous improvements...*”. Sinclair (2014) reports that the construct of the UK’s legacy airspace inhibits “*further safety and efficiency improvements*”. Kirwan (2008, p. 28) postulates that in order to prevent a Mid-Air Collision in Europe, a systemic look at “*the whole problem in all its*

¹⁰ UK Airprox Board

¹¹ Civil Aviation Authority

richness and complexity” should be considered. Collisions between aircraft, either on the ground or in the air, can cause the loss of many lives.

In July 2002, two airliners collided over Uberlingen in Germany, due to a number of failed barriers which included flawed procedures; for instance, both aircraft were fitted with TCAS¹², an electronic system that provides advice to the pilots on how to avoid the collision, but the training and regulations surrounding its use were found to be inadequate (Busby & Bennett, 2007). Analysis of the incident shows that problems were found with regulation, organisation and management, workplace issues, unsafe acts and finally “*flawed safety nets*” (Reason, Hollnagel, & Paries, 2006, p. 25), with these elements being displayed as an example of how Reason’s ‘Swiss Cheese Model’ can be used practically (1990). Normal assumption is that a MAC causes both aircraft to crash with the loss of all lives onboard, but there are occasional examples where at least one of the aircraft survive. One such is from 2015, where a BAe 125 private jet collided with a Boeing 737 over Senegal and whilst the BAe 125 was never found, the Boeing 737 managed to land safely with damage to its wing-tip; the recommendations from the investigation included the introduction of ATC supervisors and that controllers should “rigorously apply the procedures...” as non-compliance with procedures by one of the aircraft operators was cited as a contributory factor (SKYbrary, 2018a). There are many reasons why MAC happens, but supervision and compliance are key tenets of this thesis and are covered in Sections 2.5 and 2.6.

Whilst aviation is considered to be one of the safest forms of transport (Flight Safety Foundation, 2010; Larbi, 2017; Oster, Strong, & Zorn, 2013), there is always the potential for a MAC with either manned or unmanned aircraft (drones). At the time of writing, there have been no cases of MAC with a drone in the UK, although several have been reported worldwide (Aviation Safety Network, 2018). For example, in late-2017 there were three confirmed collisions in North/South America, one with a US Army helicopter and the other two with commercial passenger-carrying aircraft, but none suffered anything more than minor damage (Goldstein, 2017; Levin, 2017, 2018; Lowry, 2017; The Economist, 2018). A recent study by the UK CAA into the risk of MAC with drones states that the likelihood of collision is 2 per million flights, but acknowledges that the severity and likely outcome of such a collision is not well known and would be dependent on many factors (CAA, 2018a). What the CAA’s document does not do at all, is address the debate about

¹² Traffic alert and Collision Avoidance System

whether additional regulation is required for drone operators; this topic is reviewed in Section 2.7.

2.2.1 Prevention and regulation

The campaign ‘five seconds to impact’ is an initiative by the UKAB to focus pilots on the six themes that they should concentrate on, as they may only have five seconds to visually acquire a conflicting object and take evasive action prior to impact (Aerossurance, 2017a). The six themes are ‘eyes’ (lookout), ‘ears’ (communicate), ‘advertise’ (electronic conspicuity), ‘insight’, ‘prioritise’ and ‘foresight’ (defensive flying). Five seconds is unlikely to be enough time to see a drone and avoid it, which is why many Airprox with drones are categorised as being avoided by luck alone (Gilbert, 2017). Netjasov & Janic (2008) rightly point out that in order to limit risks associated with flying an extensive structure of regulations has been established. Rules are generally aimed at making things safer, but there are occasions when the benefits from the changes may only materialise as productivity and not always make things safer (Woods, Dekker, Cook, Johannesen, & Sarter, 2010). Furthermore, there are some regulations that pertain to the UK, some to members of the EU and others to overseas airspace or organisations and they do not always have the same standards applied (Chaplin, 2011). The catalyst behind many airspace changes is to increase efficiency and capacity, not necessarily to deliver safety benefits, although safety cannot be ignored. Regulations exist to prevent MAC, but it can come down to a pilot having only moments to see a confliction in order to avoid it.

Rasmussen (1997) states that when safety is controlled by regulation, it is considered as only one of many elements of normal decision-making. In this way safety may not be given the emphasis it should, if the desire is just to meet the criteria specified in a regulation. Rasmussen (1997) also points out that the inevitable time lag between an event that justifies a regulation change, and the implementation of the change itself, can create a management challenge, especially in a dynamic industry when the changes can be quite dramatic. If the safety managers are aware of the catalyst event they have to manage the risk of recurrence during this intervening period whilst regulation is formed, proposed and introduced. Potentially this might mean making a conscious decision to deviate from the extant regulation, which is seen as a violation or deviance and can become normalised if the regulation change is not introduced quickly. In discussing Rasmussen’s legacy, Dekker (2017) presents this normalisation as being entirely rational when viewed from inside the organisation, and it is only when looked at in hindsight that adverse judgement is

made. Regulations do not necessarily make situations safe, even when the desire is to make things safer.

Airspace modernisation to meet future needs is a regulatory challenge. UK airspace forms only 11% of the overall European airspace, yet has 25% of European commercial aviation flow and around 80% of all transatlantic traffic flying through it to get to Europe (Curtis, 2016). Curtis also reports that with the pace of growth in the industry “...delays are likely to soar to 50 times what they are today and nearly a quarter of all flights will be delayed by more than 30 minutes”, further exacerbating the challenges. UK airspace is in desperate need of modernisation, which can take years to come to fruition; the UK is deemed to be woefully behind and whilst the CAA’s changes to its processes form part of the framework for modernisation, they are not considered “*enough to secure sustainable airspace modernisation*” (GATCO, 2017, p. 4). Airspace design is a form of regulation, that should include safety considerations within its change processes.

There is a demand for regulatory change, yet the pace of change in Europe is acknowledged as being too fast, with a “*rulemaking cool-down*” declared where the number of changes delivered will be deliberately slowed (EASA, 2017, p. 5). This should allow for greater focus on the actual implementation of previous amendments but will invariably mean that a backlog of changes will build up and then be introduced in a block, thereby aggravating the issue of the amount of change.

In order to prevent accidents occurring, it is necessary to consider how actual practice might deviate from how regulation intended, and examine the operating environment to ensure that safety is achievable in the real world, as opposed to only in a theoretical model (Flight Safety Foundation, 2010); no literature was found that assesses safety after a regulation is changed or introduced. Literature addressing aviation safety during regulatory change in the UK can be found in a small sub-section of a Norwegian publication looking for best practice around the world, but comments such as “*long process of change is the most favourable*” and “*provides the involved parties with time to adapt*” are not germane to current operational practices; there is mention though that the UK’s airspace is overburdened, even in 2005 (Accident Investigation Board Norway, 2005). No contemporary literature has been found that specifically addresses a variation in the likelihood of MAC during periods of regulatory change, or the assessment of safety after a change is introduced.

2.2.2 Airprox

The word Airprox is defined by ICAO¹³ (2007, p. 1.2) as “*A situation in which, in the opinion of a pilot or a controller, the distance between aircraft, as well as their relative positions and speed, was such that the safety of the aircraft involved was, or may have been, compromised.*” The UKAB is described as the “*UK’s focal point for investigating and reporting the circumstances, causes and risk of collision for all Airprox occurrences in UK airspace*” (UKAB, 2014, p. 1). The UKAB’s website¹⁴ “*is intended to contribute to the UK’s continuing drive to enhance air safety*” and their “*primary objective is to enhance air safety in the UK, in particular in respect of lessons to be learned...*”, but importantly without apportioning any blame (UKAB, 2015b). Literature in relation to learning lessons is reviewed in sub-Section 2.6.2.

When assessing Airprox, the UKAB determine a causal factor and a risk rating, representing how close to MAC the incident was; these risk ratings are shown in Figure 2-1 (UKAB, 2016b). In their report, they use a list of established safety barriers and determine the effectiveness of each element in relation to preventing MAC. These barriers are shown in Figure 2-2 in relation to a generic Airprox template, where it can be seen that an assessment is made against the effectiveness of regulatory issues for both ANSP¹⁵ and Aircrew, in addition to technological safeguards and human factors (UKAB, 2018a).

Risk ratings	
Risk level assessments are made on the basis of what actually took place and not on what may or may not have happened. There are four categories, A - D agreed at international level, and one UK category, E, as follows:	
A	Risk of Collision: aircraft proximity in which serious risk of collision has existed
B	Safety not assured: aircraft proximity in which the safety of the aircraft may have been compromised
C	No risk of collision: aircraft proximity in which no risk of collision has existed or risk was averted.
D	Risk not determined: aircraft proximity in which insufficient information was available to determine the risk involved, or inconclusive or conflicting evidence precluded such determination
E	Met the criteria for reporting but, by analysis, it was determined that normal procedures, safety standards and parameters pertained

Figure 2-1 describing the risk ratings used for Airprox. Copyright 2016 by the UK Airprox Board¹⁶

¹³ International Civil Aviation Organisation

¹⁴ www.airproxboard.org.uk

¹⁵ Air Navigation Service Provider - synonymous with ATC in the context of this thesis

¹⁶ <http://www.airproxboard.org.uk/Learn-more/Copyright/> grants permission for any material found on the UKAB website or database to be reproduced for research purposes, on the understanding that it must not be sold or used commercially

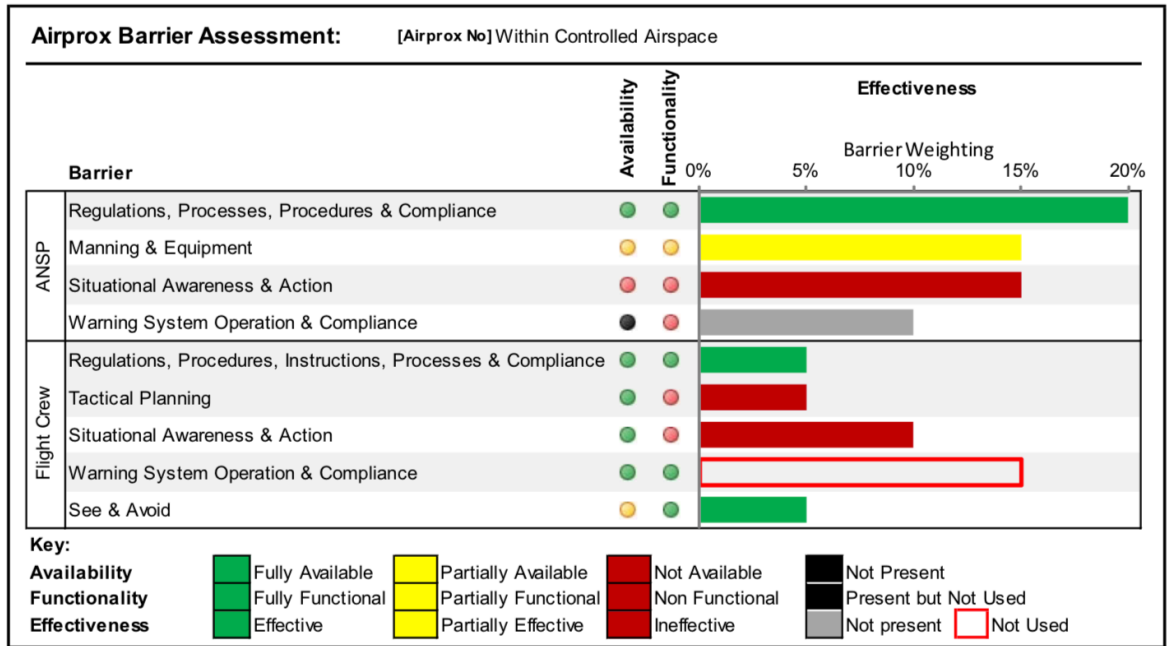


Figure 2-2 showing a list of the safety barriers used to assess an Airprox
Copyright 2018 by the UK Airprox Board

The ‘statistics’ section of the UKAB website shows several graphs covering the number of Airprox each year dating back to 2013, as well as the monthly distributions and historical trends (UKAB, 2018b). Only once the trends are presented by individual category of flight (military, CAT¹⁷ or GA¹⁸) is the number of flying hours introduced to show relativity.

Within the annual summary reports, accessed from the same webpage, the data is predominantly presented as a number of Airprox events, without reference to flying hours, and an overall increase in the headline number shown over the last ten years. With drones removed from the data, the overall picture is shown as being a reducing trend, with an occasional spike such as in 2014. The analyst (UKAB, 2017a) urges caution when attempting to analyse the rate of Airprox for CAT, as the majority of drone-related events are with CAT, and including the drone data can skew the perception of risk.

Flying hours are introduced into the UKAB analysis, but under the caveat that the “collation of reliable flying hour statistics is notoriously difficult due to the fact that much of the sports activity is not logged” and that military hours may not be accurate as they are estimated (UKAB, 2017, p. 6). However, without more accurate data, these hours are used for the analysis in Chapter 6 of this thesis. The UKAB report states that per million flying hours, military aircraft Airprox “are increasing at the highest rate”, twice that of GA (UKAB, 2017, p. 7). Furthermore, in assessing the risk of MAC from trend analysis, they

¹⁷ Commercial Air Transport – see page xvi for further detail, but in general this term is used to signify passenger carrying airliners

¹⁸ General Aviation – see page xvi for further detail, but in general this term refers to flights undertaken for pleasure rather than commercial gain

state that the greatest “*risk for GA is other GA; for military it is [also] GA; [whilst] for CAT it is drones/SUAS¹⁹*” and that the latter predominantly occurs in airspace within which the drone should not be (UKAB, 2017, p. 9). Review of the regulations surrounding drones is in Section 2.7. Analysis on the UKAB website is mostly presented as numbers of incidents which is of little value without reference to the number of flights that these relate to.

Analysis of 1920s industrial accidents resulted in the development of ‘Heinrich’s Triangle’ (Heinrich, 1931); widely known as the ‘Iceberg Model’, it illustrates that unsafe acts lead to minor injuries and, over time, to major injury. Heinrich proposed that for every 300 unsafe acts there are 29 incidents and one accident. In the context of the statement in Section 2.2 that there are currently 60 Airprox to every MAC, Heinrich’s ‘unsafe act’ equates to an event for which a safety report is filed within the company or organisation, or an MOR/DASOR²⁰ with the regulator. An Airprox is akin to an incident, with the conclusion drawn from this that the reporting culture nowadays is significantly more mature and the propensity for highlighting an incident is much better. It is, therefore, not surprising that the number of incidents per accident has risen in comparison to a model from over 80 years ago and shows that reporting cultures have improved. This can be seen as a positive sign of a functioning safety culture, literature for which is reviewed in Section 2.6, and a modern interpretation of Heinrich’s model.

The analysis of Airprox data is key to understanding the risk picture and is used in this thesis to support objective 1, which is to ‘determine if there is a correlation between an increase in the likelihood of an Airprox and changes to aviation regulation’. Whilst the headline figures of the number of Airprox tend to be shown as increasing, it is important to determine the likelihood of an Airprox by normalising the data against flying hours in order to investigate any trends. None of the literature on Airprox assesses the impact that regulatory change has on the likelihood of occurrence, which shows a gap in knowledge.

2.3 Air Safety

‘Air Safety’ is defined by the MAA²¹ as “*the state of freedom from unacceptable risk of injury to persons, or damage, throughout the life cycle of military air systems*” and is used to encompass the terms ‘Aviation Safety’ and ‘Flight Safety’ (MAA, 2015). The three

¹⁹ Small Unmanned Air System – one of the industry official terms for what the public call drones

²⁰ Mandatory Occurrence Report (civilian) Defence Air Safety Occurrence Report (military)

²¹ Military Aviation Authority

terms ‘Air Safety’, ‘Aviation Safety’ and ‘Flight Safety’ are treated as synonymous throughout this thesis as they are often used interchangeably in the literature (for example in EASA, 2018b); ‘Air Safety’ is the predominant term used in this thesis. In the early years of aviation, safety initiatives were focussed on technical factors and working out why components failed, then in the 1970s-90s technical safety became more assured and the focus switched to the human as an interface to the system (ICAO, 2013b). The ICAO manual explains that the third phase of development, applicable nowadays, places much more emphasis on an organisation as the overarching system covering humans and engineering, along with established cultures and risk management principles. The CAA’s webpage on Aviation Safety looks “*at the regulation and procedures that make aviation one of the safest forms of travel*” and lists the elements of safety and regulatory oversight that they conduct in relation to international standards, introducing both ICAO and EASA²² as higher regulatory bodies, as well as describing the Airprox process and the UKAB (CAA, 2015a). Irrespective of the term used to describe or label it, Air Safety is about ensuring that aviation operations are conducted safely and should be considered to be the responsibility of everyone involved, not just any single element.

‘Four Worlds’ is a term which is used in military aviation but without formal progeny or reference, except for a magazine article from the RAF Safety Centre (Spry, 2011), with Spry being a pseudonym as the authors of the magazine vary. Without a better alternative from the literature, the term is used within this thesis to categorise respondents as Aircrew, Engineer, ATM²³ or Other Support Staff. The ‘Four Worlds’ of aviation work together to ensure that Air Safety is maintained, each playing a part in how they “*directly affect the safe operation of aircraft*” (Spry, 2011, p. 39). Differing perspectives and experiences are required to ensure that all aspects of a situation are covered in relation to aviation risk and safety (Mearns, Flin, & O’Connor, 2001). The perceptions of members of each of the ‘Four Worlds’ are required in order to form an holistic understanding of Air Safety. The absence of a definition of what roles constitute this ‘Fourth World’ is considered to be a gap in the knowledge.

Within the industry, safety surveys are carried out as part of routine safety assurance practices, to garner the perceptions and opinions of aviation personnel within an organisation (for example European Commission, 2011). It is considered important, when evaluating the efficacy of a safety culture or an organisation’s management of safety, to know the attitudes, beliefs and behaviours of the staff (Von Thaden & Gibbons, 2008) and

²² European Aviation Safety Agency

²³ Air Traffic Management – includes Air Traffic Controllers

aviation employees are used to being asked to provide this information. How people perceive Air Safety, and the prevention of MAC, relates to their understanding of human error (sub-Section 2.4.1) together with the culture (Section 2.6) and safety management (Section 2.5) within their organisation (Perezgonzalez, 2012). Air Safety is seen as being pertinent to all elements of the industry that are involved with the safety of flight, any one of which can act as a barrier to preventing an accident, be they Aircrew, ATM, Engineer or other support staff.

2.3.1 Aviation safety chain

The example of the accident at Milan Linate airport in October 2001, when a Scandinavian Airlines MD87 collided with a Cessna 525 on the runway killing a total of 118 passengers, crew and ground staff (Catino, 2010, p. 187), illustrates how an aviation safety chain can include the 'Four Worlds' as the report into the accident implicated the Aircrew, Air Traffic Controllers, Engineers and other support staff. Court proceedings were brought against seven individuals, with five receiving custodial sentences for their part in culpable negligence in relation to the events that led to the accident (Landucci, 2008); this demonstrates that aviation safety, and avoiding collision, are not just the bailiwick of pilots. Engineers and other support staff were implicated in the accident sequence because of the unserviceable ground equipment that had a replacement awaiting installation for many years, whilst several other elements of essential aerodrome infrastructure were found to be in poor condition and non-compliant with extant regulations (Ball, 2001; Busby & Bennett, 2007; Johnson, 2005). Furthermore, Busby and Bennett (2007) highlight that the report released in 2004 found that there was no ongoing training provided to controllers, no system for reporting errors, no SMS²⁴, and a culture of blame. These elements are reviewed in Sections 2.5 and 2.6. This example highlights how all 'Four Worlds' of aviation act as a single homogenous unit in relation to Air Safety, and whilst it is always easy to imagine pilots, or ATC staff, being the reason why accidents happen, it can also be down to the actions of others that form part of a chain of events that breach safety barriers.

The Milan Linate accident was not the last time that aircraft have collided, with collisions reported in two consecutive years in Indonesia (AFP, 2017; Reuters, 2016) and even more recently, on 23rd May 2018 an Airbus A330 hit a building whilst taxiing due to an error by the marshaller (CBS, 2018) whilst on 25th May two passenger jets collided at Stansted (Kelly, 2018).

²⁴ Safety Management System

Feggetter (cited by Murray, 1997, p. 83) suggests that people “*are the weak link in the aviation safety chain*”, Murray’s stance being that humans can make poor decisions, especially when under pressure or when training; this topic is addressed in sub-Section 2.4.1. Supervision is considered a key mitigation to this, but there are other human factors that may be germane which are often overlooked in the quest to apportion blame to a human as the weak link (Wiegmann & Shappell, 2016). Literature in the context of error is reviewed in Section 2.4, whilst learning from lessons, an important aspect of Air Safety, is reviewed in sub-Section 2.6.2. The phrase ‘aviation safety chain’ should be seen to represent the linking of the ‘Four Worlds’ into a single entity for the purpose of safety in aviation.

2.4 Error

ICAO considers error to be an “*action or inaction...that leads to deviations from...intentions or expectations*” (2008, p. 3). Reason uses “*the failure of planned actions to achieve their desired ends – without intervention of some foreseeable event*” as his definition of error, explaining that the second part of the definition is required in order to separate the “*controllable action from the either good or bad luck*” (1997, p. 71). Errors are thought to be an inevitable part of any industry that relies heavily on human participation and no matter how good someone’s training is, all errors will never be completely eliminated (Shorrock, 2007). This view is also supported by Perrow (1999) in relation to high-risk technologies and the acceptance that when two or more elements of a system fail an unforeseen event may occur, because the interaction of the two elements was not expected. These system elements can equally be considered as engineering components or people, and during the life of any system there will inevitably be changes in the way that it is used which were not envisaged by the original designers.

Yang, He, Wu and Wang (2014) claim that the chance of an aviation accident is 1 in 5 million flights and that this is proof of inevitability, the prevention of human error being the most important factor in reducing this. According to IATA²⁵ (2018), the 2017 worldwide aviation accident rate was 1.08 (per 1 million flights) which was declared as a significant improvement from 1.68 in 2016 and an average of 2.01 for 2012-2016. However, the more important statistic is that there are 8.7 million flights to every major jet

²⁵ International Air Transport Association

accident, which includes MAC as well as other forms of crash, such as CFIT²⁶ (IATA, 2018). It is suggested that irrespective of who resolves a conflict, the chance of two aircraft actually hitting each other are minimal due to the size of the sky (Di Gravio, Mancini, Patriarca, & Costantino, 2015). They also add that because of this theory the number of ‘near’ mid-air collisions will be significantly greater than the number of ‘actual’ mid-air collisions, which supports Heinrich’s theory (1931) and potentially the current Airprox to MAC ratio, which is analysed in Chapter 6.

Errors that are left unmanaged, or mismanaged can lead to an undesired event, thus errors reduce safety margins and increase the risk. Dismukes (n.d.) asks whether it is reasonable to expect that pilots will never make mistakes, suggesting that it is not, and that changes must be made in the way that error is thought of. This implies that errors are perceived to be an inevitability and that the proactive management of safety, which is covered in sub-Section 2.5.1, is essential. There is evidence in past accidents as to the outcome of ignoring it, such as Columbia and Deepwater Horizon (Le Coze, 2013). It must be accepted that errors occur, but not all errors become accidents. This can only be attributed to one of two things, luck or management; only if left unmanaged do errors increase risk. Furthermore, in this management of error, humans can “*actually make safety through their efforts and expertise*” (Woods et al., 2010, p. 11), which implies that new regulations can be safely introduced through human endeavour and training.

2.4.1 The human element

The term ‘human error’ is used frequently but has no particular definition or acknowledgement that it is unlikely to have been a single error that caused an unsafe act to occur (Marx, 2017). Errors are made by humans every day in normal life, predominantly without consequence, but the same error can have a different outcome dependent on the system within which it is made (Eurocontrol, 2010). ‘Human error’ is a label normally associated with inadvertency and an unintended act, and “*involves a sense of expectation about what a human being should have been able to do under the circumstance*” (Marx, 2017). It is also postulated that human error is “*a by-product of normal variability in human performance*”, which relates to the earlier point about inevitability, but it is this attribute of a human that allows the flexibility of response to different conditions, that perhaps a machine could not (Eurocontrol, 2010, p. 11). An example of human error causing a MAC is from September 2006 where an aircraft collided with another at 37,000

²⁶ Controlled Flight Into Terrain – e.g. flying into a mountain, but not due to mechanical failure

feet, and the investigation found that the pilots had become so distracted in the cockpit that they had not noticed that they had switched their transponder off, thereby disabling the final safety barrier of TCAS (SKYbrary, 2018b). As error is inevitable and a “*by-product of normal human performance under changing contexts*” (Shorrock, 2007, p. 903), systems must be established that take account of this and mitigate the risk.

Kontogiannis and Malakis (2009, p. 693) argue that the “*total elimination of human error*” from the workplace is impossible and Woods, Dekker, Cook, Johannesen and Sarter (2010, p. xviii) suggest there is “*an almost irresistible notion that we are custodians of already safe systems that need protection from unreliable, erratic human beings*”. Shorrock (2017) describes this scenario as “*the system is basically safe, so long as the human works as imagined*” which invariably leads to the human being blamed when the system doesn’t work as planned. Bainbridge (1983) discusses the irony behind the drive towards automation, in that humans are still required to program and supervise the automated machinery, and in doing so the system retains its susceptibility to error. Indeed, she further explains that in taking away from the human the requirement to do something routinely and then expecting them to supervise a machine performing the task, means that should the need arise to intervene they no longer have the currency and experience to do so (Bainbridge, 1983). Amalberti (2001) states that whilst beginners make frequent errors, learning from experience means that the frequency declines; yet automation is often suggested as the mitigation strategy to counter human error but reduces the experience levels of the human in the process. When compared to machines, humans can be described as “*imprecise, variable and slow*”, a precursor to failure and a hazard to the system (Hollnagel, 2014, p. 44), which Shorrock (2017) reasons has developed from thinking that safety is solely the prevention of error. This concept of inherent safety until the human becomes involved, suggests that humans are the weak link in the aviation safety chain and that eradicating human error will achieve safety of operations.

However, when people are viewed as being a flexible resource, they can be considered as a resilient factor in the system (Shorrock, 2017), “*an integral and indispensable part of a successful safety system*” (HeliOffshore, 2017) and “*the last barrier to risk*” (Fernández-Muñiz, Manuel Montes-Peón, & José Vázquez-Ordás, 2014, p. 305). The study of human error “*provides a universal basis to tie all the ingredients of risk management together into a meaningful whole*” (Flight Safety Foundation, 2010). Marx (2017) posits that “*human error is never the root cause*”, which implies that investigations must delve beneath the surface to discover the systemic issues surrounding the conditions that permitted the error to occur.

2.4.2 Information overload

Communication is claimed to be a key factor in creating an unsafe incident in ATC (Yang et al., 2014), with decisions about regulatory process, intuition and supervision superimposed on their potential workload. Reason (1990) explains how the cognitive workspace can suffer informational overload and subsequent data-loss because of a finite processing capacity that cannot always be controlled. Kontogiannis and Malakis (2009) opine that communication amongst a team is the best way of preventing an occurrence as each controller will be monitoring another. It is also stated that “*ATCOs very frequently deal with information overload*” and that performance decays over a given time interval (Di Gravio et al. 2015, p. 355), a view supported by Shorrock (2007) when he says that the probability of error increases with the length of time a controller is in position.

With the suggestion that Air Traffic Controllers can face excessive workload which can cause a degradation of performance, it is thought that this could be true of all personnel in the industry, but no literature was discovered that expanded this concept across the other areas of aviation and it is considered that humans can be subject to information overload during regulatory change.

2.5 Leadership and management

The report into the loss of an RAF Nimrod aircraft over Afghanistan in 2006 says much about the content in its own subtitle: ‘A failure of leadership, culture and priorities’ (Haddon-Cave, 2009). In the report, Haddon-Cave states that there were numerous relevant indicators and warnings that made the loss of the aircraft entirely avoidable. The safety case for the Nimrod aircraft was criticised heavily with phrases such as “*riddled with errors*”, “*lamentable job*”, “*fundamentally lax*” and “*serious design flaws*” used when describing it (2009, pp. 10-11). He also talks about the criticality of leadership within any safety culture and how important it is that the lead role in any process should be started and sustained from the very top level of the organisation concerned. This is supported by Mannan, Mentzer and Zhang where they say that “*frontline supervisors are primarily responsible for the ground level implementation*” (2013, p. 146) and then suggest that it is senior management’s responsibility to maintain a supportive momentum through commitment and leadership. Similarly, Paton and McCalman (2008) suggest that senior management must maintain an active role in order for any change to be implemented successfully. In his paper on cultural differences in aviation, Liao (2015, p. 194) comments that “*managers are essential for delivering the safety concept of the*

organisation to subordinates”, but the delivery of this training, education and persuasion of the workforce requires a demonstration of leadership. Leadership and management are essential to achieving consistent organisational safety.

In a white paper on Safety Intelligence, formed from the opinions of senior aviation executives in Europe and North America, the requirement is stated for all CEOs and Board members to be at the vanguard of leading safety (Eurocontrol, 2013). Visionary leadership forms a theme within Kotter’s *“Eight-Stage Process of Creating Major Change”* (1996, p. 21) where leaders are required to create a strategic vision for others to follow, which must be communicated throughout the organisation as a whole to have any chance of success. This is then followed by the need for the visionary leadership to empower those people subordinate to them and remove obstacles. Kotter answers the question *“Why Culture is Powerful”* (1996, p. 148) by saying that culture and vision are entwined and are within the jurisdiction of leadership. Transformational changes of regulations can involve completely new strategies and organisations doing things differently rather than just better. This is why an organisation confronted with transformational change must consider a *“reworking of the organization’s mission and strategy, its leadership and its organizational culture”*, whilst also ensuring *“holistic change management integration”* in order to introduce change without increasing risk (Flouris & Kucuk Yilmaz, 2009, pp. 12-14). Any introduction of regulatory change must be managed carefully so as not to impact adversely upon safety.

Differing perspectives as to what constitutes a safety concern between groups within a workforce can be difficult to mitigate against, especially when these concerns are associated with regulatory compliance (Pilbeam, Doherty, Davidson, & Denyer, 2016). Hutter (2011) opines that when management learn of risk through reports and the workers through experience, the two will invariably have differing viewpoints which will need aligning. In order to achieve the right balance of attitude and belief, the perception of risk must be shared between employees and management. It is these different perspectives on risk and safety between managers and workers that underpins the analysis of risk assessments in the Royal Netherlands Air Force (Bakx & Richardson, 2012). They believe that significant factors in risk assessments can perceptually vary dependent on hierarchical level, citing the difference between an employee who physically bears the operating risk versus the level of risk that management deems acceptable. The acceptance of this risk, therefore, depends on the level to which the risk-bearers trust their management. It can also be the case that perception of risk is lowered due to near-miss reporting, because of the mistaken belief in systemic resilience instead of luck (Dillon, Tinsley, & Cronin,

2011). When considering risk severity versus risk frequency (the usual method by which a risk assessment is conducted), Bakx and Richardson (2012, p. 601) found that the perception of severity remained consistent between worker and manager but the frequency with which a risk event could occur was deemed “*consistently slightly higher at the operator level than at the headquarter level*”. This could be due to low-severity high-frequency events not being conveyed upwards to management, or not being captured and recorded appropriately. Safety leadership is about creating a shared perception of risk.

Hepler (n.d., p. 6) posits that “*Safety leadership is not a one-person, one-department job*”. Key supervisory roles can often be under-utilised and studies show that there is generally less compliance with safety rules amongst the workforce when their supervisors are not seen to be enforcing them (Griffin & Hu, 2013; Petitta, Probst, Barbaranelli, & Ghezzi, 2017). In order for an organisation to be safe, its leadership must be able to convey the importance of safety to employees and share the perceptions of risk (Kuenzi and Schminke, 2009). Any changes to regulation must be implemented in such a way as to ensure that safety is not impacted by the change itself; to be successful these changes require leadership from the top of an organisation, with every level of management ensuring that safety is paramount.

2.5.1 The management of safety

Woods et al. (2010, p. 8) discuss the rarity of a single cause of a failure event, there more commonly being a “*dynamic interplay of multiple contributors*” with the desire to find a root cause interfering with an understanding of the relationships between the barriers. This is a modern equivalent to Reason’s ‘Swiss Cheese’ theory (1990), where it takes the holes in the barriers to line up for an accident to occur. Because of the multiple barriers through which an event sequence must flow, there are many opportunities for the failure event to be prevented.

Von Thaden and Gibbons (2008, p. 6) state that “*even when the importance of organisational safety factors is understood and acknowledged, many airlines struggle to balance safety and profitability*”, with an example given as staff specifically employed to oversee safety routinely reported that they did not have the time or resources to process the immense amount of data that is gathered, instead expending the majority of their capacity on emergent issues. This resource deployment is commented on by Dekker (2014), in the context of nugatory work for already overstretched staff. The need to deploy scarce resources wisely is perhaps one of the reasons why regulators are moving towards a regime

of risk-based assurance and PBR²⁷ (described in CAA, 2015a, 2015b, 2014; CAAi, 2016; Kneepkens, 2012; May, 2003). These regulatory developments can concentrate resources on the areas of the industry that most need oversight, but safety staff must be adequately resourced.

Ogilvie (2017, p. 1) suggests that the CAA is “*under-funded and under-staffed...for it to provide the right regulation in the right timescales*” to meet future challenges, and that “*a struggling regulator is good for no-one*”. The CAA’s response to these comments is that “*it is true that major change is underway in our industry, but I fundamentally disagree with [the] comments about the CAA’s regulation and our ability to tackle these new challenges*” (Haines, 2017). Furthermore, he adds that the CAA will “*continue to adapt to new challenges and capture future risks*” and that “*safety assurance is an ongoing process*”. This is countered with the argument that widespread short-term thinking has culminated in a position where staff numbers have been reduced whilst traffic volumes have increased, notably amongst those in regulatory roles within the CAA (GATCO, 2017b). Ogilvie (2017, pp. 1-7) draws a comparison with a recent report from the Netherlands which highlighted that the Dutch CAA “*lacks the knowledge and resources required to maintain in-depth oversight of the parties operating at Schiphol*” and suggests that Brexit might be the opportunity to re-assess how best the CAA can support future regulatory challenges and their involvement with EASA. It is suggested that at every level from the regulator to the ANSP and airline, resources are stretched when managing safety, especially during regulatory change processes.

Dekker (2014a) posits that safety bureaucratization has delivered many benefits to the industry, including standardising regulations, but these bureaucratic tendencies cause a certain amount of pettiness, unpredictability and a loss of focus on what should actually matter when ensuring safety. Muller, Wittmer and Drax (2014) identify that there is a gap in knowledge in relation to risk-based safety management in aviation. Safety can get lost in accountability, new unnecessary problems can be imagined and a cultural perception that safety hampers innovation can develop (Dekker, 2014a). Provan, Dekker and Rae (2017, p. 109) present a review of the factors that shape the role of a safety professional, and in doing so conclude that “*there is a dearth of reliable empirical research on safety professional practice with organizations*” which can reduce their overall effectiveness in trying to make safety improvements. They also indicate that the task of a safety professional is dominated nowadays by too much focus on compliance and “*increasing*

²⁷ Performance Based Regulation

goal-based regulation”, but the role can have many positive implications on an organisation’s safety culture through individual influence and conduct as well as how safety concerns are related to senior managers (Provan et al., 2017, p. 110). It can be seen that there is an important relationship between an organisation’s safety culture, its leadership, and the importance placed on providing adequate resources to maintain it. Any systemic process for the management of safety must look at all of these elements and ultimately provide the environment whereby all in the organisation seek to learn from near-misses in order to prevent future accidents.

2.5.2 Safety Management System (SMS)

The systematic management of safety is intended to contribute to a safe aviation environment and is a constantly evolving and developing technique. Flouris and Kucuk Yilmaz (2009) describe what an aviation SMS is, how it can be effectively used and what essential practices are associated with it, proposing that an airline must use an effective SMS to process a new regulatory standard in order to remain efficient. Stolzer and Goglia (2015) consider an effective SMS pivotal to maintaining aviation safety, and yet despite investing finance and resources into managing safety, accidents still happen (Stanton, Margaryan, & Littlejohn, 2017). In the UK, an aviation SMS is defined as “*a systemic approach to managing safety including the necessary organisational structure, accountabilities, policies and procedures*” (CAA, 2018b). Safety Management is of vital importance to many industries, including aviation where it is seen as a “*strategic priority*” (EASA, 2017b) and, according to Saleh, Marais and Favaro (2014, p. 283), system safety “*refers to the state or objective of striving to sustainably ensure accident prevention through actions on multiple safety levers, be they technical, organizational, or regulatory*”. It is imperative that at the heart of any safety culture is a learning culture and by necessity a reporting culture to capture potential lessons (Appelbaum, Habashy, Malo, & Hisham, 2012). An SMS must link these cultural facets together, underpinned by leadership and “*internal systemic alignment*” whereby all “*policies, procedures and rules should be consistent with each other*” (Littlejohn, Lukic, & Margaryan, 2014). Ensuring that an SMS appropriately dovetails into the organisational culture “*will help to ensure that the capacity, efficiency and safety benefits expected are realised*” (Eurocontrol, 2010). An important link is, therefore, established between safety culture, systemic management and leadership.

International SARPs²⁸, in the form of ICAO Annex 19, requires that any “*aviation service provider*”, which includes aircraft operators, ATC and engineering organisations, shall have a State Safety Programme (SSP), which includes an SMS that continually monitors and regularly assesses the organisation’s safety performance (ICAO, 2013a; Panagopoulos, Atkin, & Sikora, 2016). European legislation requires that an aviation organisation “*shall manage safety risks related to change*” and that this process is documented, identifying any “*adverse effect on safety*” (EASA, 2012b). In the UK, the CAA provide guidance on the AMC²⁹ in support of ICAO and EASA, together with regulation in the ANO³⁰ that captures any aerodrome that is not covered by higher regulation (CAA, 2015e, 2018b). The CAA is also cited by Gill and Shergill (2004, p. 234) as ensuring safety through culture and SMS, by recognising them as contributory to “*the systemic management of the risks associated with flight operations, related ground operations, and aircraft engineering or maintenance activities to achieve high levels of safety performance*”. UK regulation requires that “*all organizations directly or indirectly involved in Defence Aviation shall establish and maintain an effective Air Safety Management System (ASMS)*” (MAA, 2014, p. 1). This Regulatory Article applies to ‘Fourth World’ elements within military aviation. A civilian equivalent has not been found in the literature, other than for those “*working airside*” who are covered by the guidelines in CAP 642, which are not binding in any way (CAA, 2006, p. 2). The exclusion of other support staff (‘Fourth World’) within the civilian aviation environment from regulation requiring the support of an SMS exposes a gap in industry practice.

2.5.3 Investigations

Aviation accidents can often be branded with the cause being human error, but this label is counter-productive and the causes of these incidents can only be learnt by looking beyond the label into the detail (Woods et al., 2010). Human nature, coupled with the expectations of stakeholders, will usually demand an explanation for an accident as soon as possible after the event, which can lead to a rushed answer which will often be linked to human error (Woods et al., 2010). If human error is found to be the cause then removing the human removes the error, which implies that an automated system would be preferable. By investigating beyond the label of human error, it may be found that the error was actually systemic and replacing the human would not be the best answer. This postulation is supported by analysis where it was found that when human error training has been

²⁸ Standards and Recommended Practices

²⁹ Acceptable Means of Compliance

³⁰ Air Navigation Order

conducted, there is a significant increase in the number of reports attributed to systemic causes rather than to human error (Aslanides, Valot, Nyssen, & Amalberti, 2007). Investigations are an opportunity which is often missed by the temptation to immediately blame human error or rationalize the causes through ‘hindsight bias’.

This ‘hindsight bias’ relates to the desire to always rationalize an event rather than accept the randomness concept of it being a ‘Black Swan’ and not at all foreseeable (Taleb, 2007). A Black Swan event is an outlier when considered against the field of normal expectation, usually because there was no indication beforehand of its possibility, which also has enormous impact and then human nature will often try to rationalize the incident in hindsight, therefore making it predictable (Taleb, 2007). Labib and Harris (2015) describe the accident at Fukushima as a Black Swan, as it was an extreme, infrequent event, that has an enormous consequence on history. Woods et al. (2010) support Taleb’s theory of a Black Swan event when talking about the principle of hindsight bias, by saying that incidents are surprising and shocking, and investigations are tasked by stakeholders to establish what happened, effectively labelling an event with a cause. Furthermore, they acknowledge that hindsight bias cannot easily be avoided and that the “*knowledge of outcome biases our judgement about the processes that led up to that outcome*” (Woods et al., 2010, p. 15). In this process, the investigator will often apply judgement to identify a single causal factor, despite the potential for there to be any number of other factors that led to the event.

Von Thaden and Gibbons (2008) advocate that the focus of investigations should be beyond simple error and be developed around organisational dynamics and the effects of regulatory oversight. They also explore the latency of errors and suggest that often the incident shows only the symptom and not the root cause, stating that there can be a significant time delay between what should be considered as the cause (perhaps software programming) and the final event that caused the incident, which links with Rasmussen’s point in sub-Section 2.2.1. The term ‘root cause’ can incorrectly imply that there is a single cause of an event when there could be many (Marx, 2017). Whilst errors undoubtedly contribute to accidents, they can only be labelled as an error through hindsight (Eurocontrol, 2010). At the time, when the outcome was not yet known, the actions may have seemed entirely reasonable, and it may not be the action in isolation that is the error, but the system that facilitated it (Dismukes, Berman, & Loukopoulos, 2006). Often the application of hindsight bias to an investigation will “*fundamentally undermine*” the process of fully understanding “*the factors that influenced practitioner behaviour*” (Woods & Cook, 1999, p. 29). These statements lead back to the belief that the events

leading up to an accident are systemic and, only through the application of hindsight bias are the events rationalized to determine a single cause, without any acknowledgement that they may have been an outlier.

2.6 Safety culture

Almost every Section and sub-Section of this review of the literature has mentioned culture in one form or another, be it organisational, compliance, learning, reporting, blame, just or safety. A management's "*commitment to safety*" is considered to be the foundation of any good safety culture, and this commitment can be tested by exploring the opinions and perceptions of the workforce to achieve an indication of success (Reiman and Rollenhagen, 2014, p. 9). A culture of safety must be an intrinsic part of any organisational culture, which is often espoused in company manuals (Flannery, 2001), but what does safe look like (Cox & Flin, 1998)? Dictionary definitions of what safe is, stop short of anything useful in this context and it is often assumed that everybody knows what safe means already (Hollnagel, 2014). Public perception of safety plays a significant part and there is supposition that the absence of any incident means that an organisation is de-facto safe (Flannery, 2001). Hepler (n.d.) uses the ironic example from the BP Deepwater Horizon disaster that on the day of the explosion senior management were at a plant celebrating seven years' free from incident. She states that this focus on the past lack of incidents led to a presupposition that things were safe, which in turn led to complacency and assumption that there would not be any incidents in the future because of it.

This review discusses safety culture but deliberately avoids using the term safety climate. The terms safety culture and safety climate are prevalent in everyday parlance in the aviation industry, yet there is no common understanding or definition of the delineation between the two terms, and they are often used symbiotically. Vu and Cieri (2014) found 108 different definitions of safety culture or climate, despite safety culture often being cited as contributory in accident reports. Commonalities in the literature are that a safety culture is determinant on the shared values and beliefs of its stakeholders, which shapes the behaviours and attitudes of the employees, and that leadership is key to successful safety management and also the force behind how an organisation manages safety. All of these elements need to operate in unison to develop and maintain a successful safety culture, whilst acknowledging that the human is both the problem and solution. However, Edwards, Davey and Armstrong (2013, p. 79) conclude that there is no coherence or lucidity as to what each actually comprises, which leads to a multiplicity of understanding and "*a risk that safety culture may become little more than a catchy title for safety*

management". A more in-depth presentation of the issue is included in Appendix L³¹ but for this review the topic will be restricted to the term 'safety culture'.

Reason (1997) describes the fundamental components of any safety culture as including just, reporting, learning, informed and flexible cultures. Although Haddon-Cave cites much of Reason's theories on safety culture, agreeing these elements as "*cornerstones under-pinning the over-arching edifice of a strong safety culture*", he also adds an extra sub-component that he feels should be in place to "*foster a strong and effective safety culture vital to reducing accidents*", namely a questioning culture in which he explains that it is vital to ask 'what if?' and 'why?' questions, because "*questions are the antidote to assumptions, which so often incubate mistakes*" (2009, pp. 569-576). In other words, challenging established norms can yield safety benefits if they are found wanting. All of these points link together as part of an organisation's overall culture, which must have a safety culture at its heart.

Olive, O'Connor, and Mannan (2006, p. 133) define safety culture as "*the overarching policies and goals set by an organisation...*" which is often summarised as 'the way things are done around here'. They also say that the workforce must be encouraged to report not only the shortcomings of the system but also their own weak areas and mistakes. "*The culture of safety has really progressed collectively over the years...when it comes to safety, we do truly collaborate as an industry...this is not an area to compete*" said Boeing's vice president for safety, security and compliance (Richter, 2017). On many occasions in aviation history, an organisation's safety culture has been brought in to question during the accident investigation. Events such as the runway collision at Milan-Linate in 2001 (Catino, 2010; Flottau, 2001; Johnson, 2005), the loss of an RAF Nimrod in 2006 (Haddon-Cave, 2009) and a recent National Transportation Safety Board (NTSB) ruling that a company's safety culture was "*directly responsible*" for a crash that killed nine people in a floatplane in Alaska in 2015 (Klint, 2017), show that in the subsequent investigation, safety culture is considered important. The coroner's inquiry into the 2013 helicopter crash in Vauxhall, London, commented on the commercial pressures that the pilot was under to fly on that day and found his decision "unsafe" (Aerossurance, 2017b; BBC, 2017b). Labib (2014) suggests that whereas a high-impact low-frequency event can obviously be disastrous, it is repeated low-impact events that can indicate a failing safety culture. An organisation's safety culture is often brought into question during an accident

³¹ Appendix L is an article that was submitted to Safety Science for consideration in 2017, which has been peer-reviewed and feedback given for improvement. It is included to offer a deeper (and broader) argument to the discussion on safety culture versus climate than the boundaries of this thesis support.

investigation, which should mean that management would want to be aware of how their culture looks beforehand.

Williamsen (2013) presents a cyclic model for inculcating the required culture, in that accountability should cycle between a definition of expectation, the provision of training, performance measurement and recognition of outcome. This last point is important for any self-reporting system to work fully, there must be a clear objective as to the outcome; this need not always be reward, but can be as simple as a feedback mechanism to show that management has taken the report seriously and has been diligent in responding (Mannan et al., 2013). Hollnagel (2014) uses the absence of unwanted outcomes as his working definition and describes how humans have an underlying need to both be safe and feel safe, and it can be argued that a safety culture is more aimed at the latter. Hepler (n.d., p. 3) believes that *“the term ‘safety culture’ has been overused to the point that it has become virtually meaningless”* which has led to a *“false sense of security”*. Yet CANSO³² declares that *“all organisations operating in safety-critical industries, including Air Navigation Service Providers (ANSPs), have a safety culture”* (2013, p.1). ICAO Annex 19 (2013a, p. 37) does not mention safety culture at all, the term organisational culture is used in relation to safety promotion by States and in the context of both internal and external training that *“fosters an effective and efficient”* State Safety Plan or SMS. Subordinate to this is Doc 9859, the Safety Management Manual (ICAO, 2013b). This book is the ‘how to’ and covers safety culture in some detail, stating that the character of a culture is measured by the behaviours, biases and beliefs of any group. Reiman and Rollenhagen (2014, p. 14), posit that the term safety culture is viewed with the same distrust as human error and that *“in general, safety culture research and practice has so far missed the opportunity to integrate with systemic perspectives”*. So, for a phrase used often, there is much confusion in the literature as to what a safety culture is, and it is commented that the phrase itself has been overused to the point of being meaningless.

It can be said that an organisation’s safety culture determines how safe it is (Von Thaden & Gibbons, 2008) and, therefore, assessing it will provide a measurement of safety. Methods of assessment vary, but the one element that seems key in each is the use of a questionnaire survey to ascertain the perceptions and opinions of the workforce (for example Noort, Reader, Shorrock, & Kirwan, 2016; Reader, Noort, Shorrock, & Kirwan, 2015). Assessing how Just an organisation’s safety culture is, and its willingness to learn from lessons identified, will often provide insight into its overall efficacy.

³² Civil Air Navigation Services Organisation

2.6.1 Just Culture

A Just Culture is described as one where there is an atmosphere of trust within the organisation and where employees are positively encouraged to report essential safety-related information, but importantly with a clear moral component about where the line is drawn between acceptable and unacceptable behaviour, which is now enshrined in European law (European Parliament, 2014). Furthermore, a Just Culture is related to a way of thinking with a questioning attitude towards safety matters, cognizant of both personal and corporate accountability, but where everyone is “*prepared to report their own errors and near-misses*” (Reason, 1997, p. 195). Therefore, in order for a safety culture to be considered Just, it must be attitudinal as well as structural and relate to both individuals and organisations (CAAi, 2018; Reason, 1997). A Just Culture is not one that is free from blame, but one where there is personal accountability, and justice, which remains “*conducive to reporting, engagement and safety improvement*” (Dekker & Breakey, 2016, p. 187). Without a Just culture, management will never really know all of what is happening in their area of responsibility, and without honest and open reporting, learning from minor incidents cannot take place.

2.6.2 A culture of learning lessons

Statistics presented by EASA (2017a) show that in 2016 there was an overall trend of fewer accidents. This makes learning lessons more challenging as there are fewer examples from which to identify lessons that can be learnt, and it is commented that the accident rate is not high enough to ascertain a meaningful measure of safety (O’Connor, O’Dea, Kennedy, & Buttrey, 2011). However, according to data from the UKAB (2016), there are ample opportunities in UK aviation for learning from incidents, which supports the editorial comments made by Stanton, Margaryan and Littlejohn (2017) in relation to the special series on this learning process, and that there are plenty of lessons that can be learned. Taleb (2007) suggests that humans seem to find it difficult to learn that they find it difficult to learn, whilst Amalberti (2001, p. 116) sees mistakes as being inevitable and “*cognitively useful*”, acting as “*flags on the learning curve*”. Busby and Bennett (2007) identify a number of determinants that were causative to the Uberlingen mid-air collision, described in Section 2.2, listing interactions between systemic fault and structural vulnerabilities, as well as a lack of professional rigour and redundancy, with evidence directed towards management failures. With the runway collision at Linate (see Section 2.2), the evidence correlates with Uberlingen, including structural, managerial and

individual behavioural traits or faults (Busby & Bennett, 2007). Clearly, lessons are not being learnt, but aviation is not the only industry where this is the case.

October 1999 saw one of the UK's worst rail crashes when, just outside Paddington Station in London, two trains crashed into each other killing 30 people and injuring 245 others (Hutter, 2001). The irony is that only two weeks earlier the public inquiry into a similar event killing seven passengers, and injuring 147, on the same stretch of track two years prior, had been re-opened. Lessons were clearly not learnt, similar to NASA and BP, and this accident is seen as a failure of self-regulation for the railways, whereby individual companies were given the flexibility to establish their own regulatory system to suit their own unique circumstances and associated risks. This system was heralded as giving companies a greater commitment to the process as they had derived the rules by which they governed themselves, whilst also saving the Government money as the costs were borne by the companies themselves (Hutter, 2001). A lack of standardisation and assurance, together with a steady reduction in the number of safety personnel, invariably led to the conditions that allowed the accidents to happen. Labib (2014) describes, in the analysis from the two space shuttle accident reports, the flawed decision-making processes that were found in both, including a lack of foresight and hindsight, with no assimilation of the lessons identified in the earlier accident. Analysis concluded that both reports were caused by human error and extremely similar, showing that learning had not occurred (Vaughan, 2005). The same similarities can also be found when looking at other organisational accidents such as BP with Texas City and Deepwater Horizon. Labib (2014, p. 77) lists lessons in the latter which include a lack of effective communication, poor safety management and "*insufficient organisational cultural change*". Haddon-Cave (2009) describes previous incidents as missed opportunities and lists seven incidents from the years before the accident, which could have been taken as warning signs of some of the problems and issues, five of which involved identical aircraft. This is an example of Heinrich's Iceberg Model (sub-Section 2.2.2) with the undoubted plethora of below the waterline occurrences that were not reported, followed by the documented minor and major incidents leading to the one catastrophic accident at the top.

Research has found that the greatest benefit from the learning process can be gained by challenging the operating norms and digging deeply into identified systemic issues (Lukic, Littlejohn, & Margaryan, 2012). The prevention of incidents relies on the continuous monitoring of safety as a dynamic phenomenon (Mearns et al., 2001), and "*connecting incident information with professional practice can lead to improved learning*" (Margaryan, Littlejohn, & Stanton, 2017, p. 5). Kirwan (2008, pp. 29-30) states that "*from*

a systems perspective, if you want to put something right, it is not enough to look always at what is going wrong – ‘normal’ behaviour must also be analysed". This implies that an incident is not always necessary in order to make changes or learn lessons, but in order to prevent future accidents, every opportunity must be taken to learn from previous events.

2.7 Regulations relating to drones

It is reported that *"more than 1,200 safety occurrences"* between drones and aircraft happened in Europe during 2016, underlining *"the pressing need for a modern and flexible EU regulatory framework"*, and *"if we don't move fast enough, the near misses between drones and airplanes could one day have disastrous consequences"* (GATCO, 2017a). The only law that currently applies to the use of drones in the UK is the ANO³³, with Article 94 covering elements of where and how the drone may be flown and Article 241 stating that *"a person must not recklessly or negligently cause or permit an aircraft to endanger any person or property"* (CAA, 2018b, p. 107). A synopsis of the regulations is presented in Figure 2-3, reproduced from a UKAB late-2016 Airprox report; 2017 reports are much briefer and no longer contain this detail, albeit unchanged. According to The Economist (2018), *"more than 3.1 million drones were shipped last year in America alone"* and there is an urgent *"need to devise smarter technology and better rules to keep drones away from aeroplanes, and from each other"*. Vogel (2017) suggests that in order for drones to be integrated safely, regulation needs to be introduced with tough sanctions against those that do not comply or behave irresponsibly, drones must be trackable at all times and the police should have the capability to override the controls. It is a generally held belief that the level of regulation surrounding drones use is insufficient.

³³ Air Navigation Order (latest edition 2016)

UKAB Secretariat

There are no specific ANO regulations limiting the maximum height for the operation of drones that weigh 7kg or less other than if flown using FPV (with a maximum weight of 3.5kg) when 1000ft is the maximum height. Drones weighing between 7kg and 20kg are limited to 400ft unless in accordance with airspace requirements. Notwithstanding, there remains a requirement to maintain direct, unaided visual contact with the aircraft sufficient to monitor its flight path in relation to other aircraft, persons, vehicles, vessels and structures for the purpose of avoiding collisions. CAP 722 gives guidance that, within the UK, visual line of sight (VLOS) operations are normally accepted to mean a maximum distance of 500m [1640ft] horizontally and 400ft [122m] vertically from the Remote Pilot.

Neither are there any specific ANO regulations limiting the operation of drones in controlled airspace if they weigh 7kg or less other than if flown using FPV (with a maximum weight of 3.5kg) when they must not be flown in Class A, C, D or E, or in an ATZ during notified hours, without ATC permission. Drones weighing between 7kg and 20kg must not be flown in Class A, C, D or E, or in an ATZ during notified hours, without ATC permission. CAP722 gives guidance that operators of drones of any weight must avoid and give way to manned aircraft at all times in controlled Airspace or ATZ. CAP722 gives further guidance that, in practical terms, drones of any mass could present a particular hazard when operating near an aerodrome or other landing site due to the presence of manned aircraft taking off and landing. Therefore, it strongly recommends that contact with the relevant ATS unit is made prior to conducting such a flight.

Notwithstanding the above, all drone operators are also required to observe ANO 2016 Article 94(2) which requires that the person in charge of a small unmanned aircraft may only fly the aircraft if reasonably satisfied that the flight can safely be made, and the ANO 2016 Article 241 requirement not to recklessly or negligently cause or permit an aircraft to endanger any person or property. Allowing that the term 'endanger' might be open to interpretation, drones of any size that are operated in close proximity to airfield approach, pattern of traffic or departure lanes, or above 1000ft agl (i.e. beyond VLOS (visual line of sight) and FPV (first-person-view) heights), can be considered to have endangered any aircraft that come into proximity. In such circumstances, or if other specific regulations have not been complied with as appropriate above, the drone operator will be judged to have caused the Airprox by having flown their drone into conflict with the aircraft.

A CAA web site¹ provides information and guidance associated with the operation of Unmanned Aircraft Systems (UASs) and Unmanned Aerial Vehicles (UAVs).

Additionally, the CAA has published a UAV Safety Notice² which states the responsibilities for flying unmanned aircraft. This includes:

'You are responsible for avoiding collisions with other people or objects - including aircraft.
Do not fly your unmanned aircraft in any way that could endanger people or property.
It is illegal to fly your unmanned aircraft over a congested area (streets, towns and cities).
..., stay well clear of airports and airfields'.

Figure 2-3 showing a synopsis of the current drone regulations in relation to Airprox

The CAA's 'drone code', is a pamphlet designed to provide a one-stop document for drone users, who are not necessarily aviation-minded, to understand the rules for flying them in the UK within two pages (CAA, 2017b). Keeping a drone below 400ft is mentioned in the drone code as best practice but is not a specific regulation. An EASA analysis report states that "the number of near-miss occurrences between drones and aircraft has increased significantly in the past 2 years" (EASA, 2016c), and that the UK has the highest number of airborne conflict occurrences with drones of all EU Member States. A separate EASA study recommended that further analysis and research be conducted (EASA, 2016a). It is important though that the problem is addressed rather than just analysed, and the rules need

to be understood by drone operators in the first place, although they may not be aware that the rules apply to them.

In 2017 there were numerous developments in proposals for future drone regulation. The UK Government (DfT³⁴) ran a public consultation entitled “*Benefits of drones to the UK economy*”, in which there was an opportunity to make comment on future policy and regulatory framework in relation to the operation of drones in the UK; interim results from this research were submitted to the consultation. The Government’s response to the consultation was to commit to reviewing the registration and licencing of all drone pilots and restricting the flight of drones to a maximum of 400ft above the ground (Department for Transport, 2017). As this thesis was being finalised, an announcement was made that the restriction on a drone’s height to 400ft, and to be operated no closer to an aerodrome than 1km, would become law on 30 July 2018 when the ANO is amended; compulsory testing and registration of drone users will also become law but is delayed until 30 November 2019 (Department for Transport, 2018). These are signs of progress, but the problem remains, as a drone that is 1km from an aerodrome, on the approach to a runway at less than 400ft (i.e. operated legally), can still conflict with an aircraft that is trying to land as the manned aircraft is also likely to be below 400ft at that point.

EASA also published a proposal which covered the possible introduction of European Regulation for drone use (EASA, 2017c). The most notable suggestion in the context of this research is the introduction of regulation for drones weighing less than 25kg to be only flown VLOS³⁵ and not to be flown above 120m (400ft) AGL³⁶. The proposed rule also proposes registration for all but those weighing less than 250g (toys) and then a rising scale based on mass, where either just the operator, or the operator and every individual drone must be registered, and the appropriate information displayed on the drone. It also suggests that drones that are flown close to people should have electronic identification and geofencing³⁷.

In 2016 EASA produced a report of a survey of regulatory initiatives across Europe, which found an absence of globally accepted terminology which is a barrier to progress, and suggests that internationally agreed definitions be produced to resolve confusion (EASA, 2016b). It recommended that further research is conducted in order to better understand the risks associated with the proliferation of drones and what could be done to ensure

³⁴ Department for Transport

³⁵ Visual Line Of Sight

³⁶ Above Ground Level

³⁷ the use of GPS or RFID technology to create a virtual geographic boundary

safety of manned aircraft operations. EASA has now issued their ‘opinion on safe operations for small drones in Europe’, which is described as being “innovative and globally recognized as the best way forward to keep drone operations safe”, but have not set a date by which it should become formal regulation (EASA, 2018a). With the evidence building rapidly this needs to be addressed soonest.

The last few years have seen many instances of commercial aviation around the world being disrupted by the proximity of drones to airports (BBC, 2017a; Lake & McRae, 2018; Remeithi, 2016) but it was in Autumn 2017 when the first reports of collisions between drones and aircraft received media attention (Hsu, 2017; Transport Canada, 2017). These incidents led in February 2018 to the President and CEO of Flight Safety Foundation writing an open letter to the Secretary-General of ICAO to explain the Foundation’s “concerns regarding the relative lack of regulation of unmanned aircraft systems (UAS) or drones for recreational purposes” stating that “the proliferation and operation of small drones by people without aviation experience is becoming one of the most significant hazards to manned aviation...poses unacceptable risks to aviation safety, and ...perhaps catastrophic injury” (Beatty, 2018, p. 1). ICAO are urged to accelerate their efforts to provide guidance to States and intensify their approaches to delivering suitable regulation. The crux of their argument is that recreational drones pose the same risk to manned aviation as do commercial drones, yet they are not regulated to the same standard.

The latest developments in the integration and regulation of drones are reported as being the formation of strategic partnerships between some key industry members, such as NATS³⁸, Frequentis and Altitude Angel (McLellan, 2018; NATS, 2018a), as well as DFS³⁹ with Deutsche Telekom (Geelvink, 2018). This latter development uses the existing network of mobile telephone masts to track drones and then integrate this UAS⁴⁰ Traffic Management (UTM) into the Air Traffic Management (ATM) system. Airways New Zealand has also announced an area of airspace allocated for the trial of new UTM software, which is seen as “an important step in investigating how Airways could develop a UTM system that safely integrates into New Zealand’s wider air traffic control network” (Airways, 2018). These are just a few examples of the plethora of initiatives being introduced, further exacerbating the lag of associated regulation. There is clearly not enough current regulation on the use of drones in airspace where manned aviation exists.

³⁸ Formerly National Air Traffic Services, now referred to just as NATS - the main Air Navigation Service Provider (i.e. provider of ATC) in the UK

³⁹ Deutsche Flugsicherung

⁴⁰ Unmanned Air System

2.8 Summary and supposition formation

This review of the literature supports the overarching Research Question of ‘can new regulation be introduced without decreasing safety’ and has led to the reasoning of suppositions associated with each research objective which can be used to gather empirical evidence; these are presented in Table 2-1.

Obj		S _n	
1	Determine if there is a correlation between an increase in the likelihood of an Airprox and changes to aviation regulation.	1	The introduction of regulatory change can increase the likelihood of an Airprox.
2	Assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation.	2a	Errors occur, but only if left unmanaged do they increase risk.
		2b	Humans make safety through their efforts and expertise; this implies that new regulation can be safely introduced through human endeavour and training.
3	Analyse whether humans are the weak link in the aviation safety chain.	3a	It is widely considered in the aviation industry that eradicating human error will achieve safety of operations.
		3b	Humans can be subject to information overload during regulatory change.
4	Assess if there is an active culture of learning from incidents within aviation.	4a	There is a temptation to rationalize every incident with hindsight bias and not acknowledge that some events are ‘Black Swans’.
		4b	The capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome.
5	Determine if changes are required to regulations to integrate drone operations.	5	There is not enough regulation on the use of drones and more is needed urgently.

Table 2-1 showing the suppositions established for investigation

The broad topics covered are Mid-Air Collision (MAC), Air Safety, Error, Leadership and Management, Culture and Regulation relating to drones. Specifically, it explains that MAC happens for a number of reasons, including with drones, but worldwide the number of aviation accidents are low in comparison to the number of flights. Regulations are in place to prevent MAC, but not every scenario can be regulated against and there are times when a visual lookout by the pilots is the final barrier to prevent collision, with potentially only five seconds for a confliction to be noticed and acted upon. Regulations by

themselves do not make things safe, and the most basic form of regulation is the design of the airspace structure itself, which is in need of modernisation to cope with the growth of both manned and unmanned aviation. The pace of change has been acknowledged by European regulators as being too fast, with a slowdown of regulatory change forecast, but this will inevitably create a backlog. There is a gap in knowledge about the effects of the introduction of large swathes of regulatory change on human performance. It is postulated that ‘humans can be subject to information overload during regulatory change’ (S_{3b}).

There is a gap in the literature surrounding how practice deviates from what regulation intended. There is also a gap when considering whether the perception of MAC likelihood increases during regulatory change. It is postulated that ‘the introduction of regulatory change can increase the likelihood of an Airprox’ (S₁). Airprox is introduced as the industry term for an incident which may have been a pre-cursor to a MAC, as well as the concept of barriers of safety as part of the investigative process and assessment of how close the Airprox was to MAC. The UK Airprox Board’s (UKAB) analysis is described as being mostly numerical with very little rate, or likelihood, described in it, which would require the figures to be considered in relation to flights per year and a trend ascertained. There is insufficient literature associated with the likelihood of an Airprox occurring. Modern interpretation of Heinrich’s Iceberg Model (1931), where for every accident there were 29 incidents, is represented by the UKABs 60 Airprox to each MAC, which demonstrates a significantly improved reporting culture than 87 years ago.

Air Safety is described as being the way in which unacceptable risk is removed and encompasses both aviation safety and flight safety. The ‘Four Worlds’ are introduced as a concept familiar to UK military aviation professionals, but not civilian or overseas counterparts. The term links together the elements of Aircrew, Air traffic, Engineer and other support staff, within an aviation safety chain where all parts pull together to achieve Air Safety. The perceptions of safety for each of these elements are important as they show differing perspectives on an issue and can highlight areas where resources can be better focussed to ensure safety. The collision at Milan Linate in 2001 is used as an example of how failures in several elements of the aviation safety chain can breach the barriers to safety, ultimately leading to an accident and unnecessary loss of life. The absence of a clear definition of what constitutes the ‘Fourth World’, or a civilian equivalent term, and how the linkages of support staff with safety consequence are managed are gaps in the literature.

Humans are considered as the weak link in this safety chain, because of their propensity for error, with the concept that their removal will enhance safety. This leads to the supposition that ‘it is widely considered in the aviation industry that eradicating human error will achieve safety of operations’ (S_{3a}). A counter-argument to this is that a human is still expected to develop and then monitor the automated system, whilst not having the currency or skills to intervene and take over at the point when they are most needed to do so. Humans are also the final barrier to prevent an accident from occurring, be it wresting control from a machine or visually sighting a conflicting aircraft or drone for instance. Errors are thought to be inevitable, but the way in which errors are managed is the key to accident prevention, which leads to the supposition that ‘errors occur, but only if left unmanaged do they increase risk’ (S_{2a}). Humans can be seen to make things safer with their actions and endeavours, perhaps in their role as a supervisor, within a training environment or as a manager. It is postulated that ‘humans make safety through their efforts and expertise; this implies that new regulation can be safely introduced through human endeavour’ (S_{2b}). To remove humans from the environment to make things safer is counter-intuitive, even though it is felt that humans can be overloaded by regulatory change.

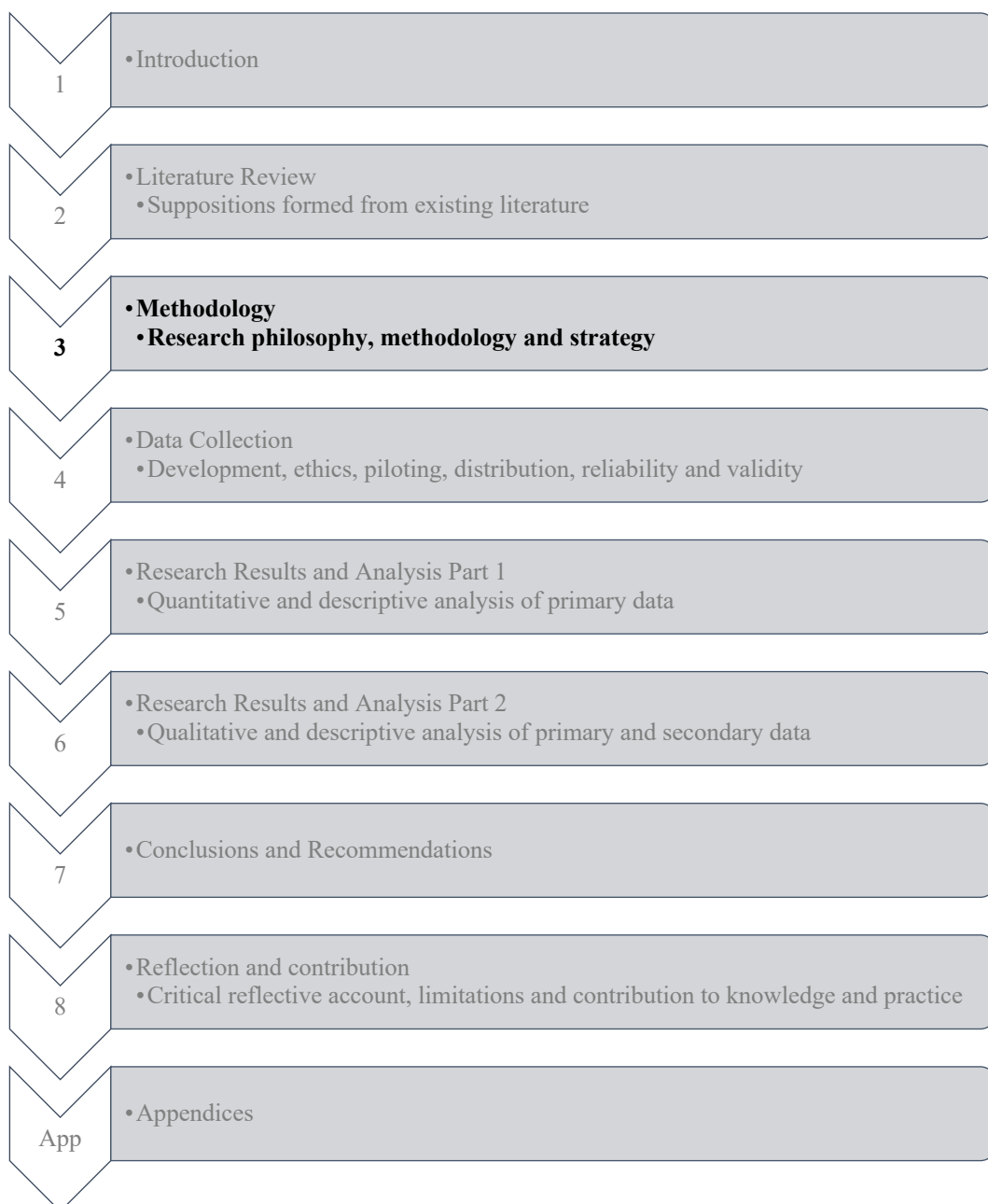
The chance of MAC is remote when compared to the worldwide statistics for aviation accidents, and this supports Heinrich’s theory that there are many minor events before incidents and accidents occur. Capturing and understanding these minor events is key to preventing future accidents and a reporting culture is required to generate the lessons from which learning can take place, leading to the supposition that ‘the capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome’ (S_{4b}). Additionally, an organisation’s quest for safety must be led from the top and the message communicated in such a way that managers and their subordinates understand it in the same way. Safety leadership is about the shared perception of risk. Staff employed in safety roles must be adequately resourced to carry out those roles and must not end up solely focussed on achieving compliance at the detriment of safety management. Even the regulator is considered over-stretched.

An effective SMS is central to the management of safety and an important area of the aviation industry is often excluded from the regulated requirement to have an SMS, namely the ‘Fourth World’ of support staff. The omission of these support staff from any regulation applying the need to manage safety through an SMS is a gap in the professional literature. A culture of safety must be at the heart of an organisation, but an organisation’s safety culture is often questioned in an accident investigation, and so often is found

wanting in the report. The six elements of a safety culture are just, reporting, learning, informed, flexible and questioning. Changing established norms can deliver safety improvements, however, there are accusations that the term safety culture is overused and has become meaningless, much like human error. A safety culture must be just to be of any use to learning, because unless open and honest reports are submitted and investigated properly then lessons will not be identified. Hindsight bias can be found in an investigation, where the desire is to rationalize the accident and conclude a single root cause, rather than accept that there were a number of systemic issues or acknowledge the event as an outlier. It is postulated that ‘there is a temptation to rationalize every incident with hindsight bias and not acknowledge that some events are ‘Black Swans’ (S_{4a})

There are still plenty of lessons to learn, and equally plenty of people to relearn the old ones. However, lessons are not being learned, with many examples to support this, not just from aviation: the rail industry has suffered similar accusations of not learning from accidents, as has NASA and the petrochemical industry. More regulation is needed for drone operations to remain safe, which supports the supposition that ‘there is not enough regulation on the use of drones and more is needed urgently’ (S₅). The problem is acknowledged but not enough is being done about it, urgency is required. The driver for change needs to be at the very top, from ICAO, but industry developments are outpacing the regulators. There is a gap in the literature about how urgent the industry perceives the need for regulatory change.

The results of the research are presented in Chapters 5 and 6, with a discussion and conclusions in Chapter 7 that goes some way to filling the identified gaps in the academic and professional literature.



Chapter 3 – Research Methodology

3.1 Introduction

This chapter covers the foundations of the research, the philosophical underpinnings from which the development of the methodology and the strategy are conceived and builds upon the literature review in Chapter 2. The research uses a mixed methods approach, which is discussed and justified. Creswell (2009) recommends that four principles need to be established to present a mixed methods study, that of balance/relative weightings, the timing associated with the collection of both the quantitative and qualitative elements of the data, the method of integrating the data or analysis, and which paradigm the researcher identifies with. Bisman (2010, p. 5) believes that a “*researchers’ ontological viewpoints shape their epistemological beliefs in terms of how knowing and understanding reality can be developed...*”, which dictates the interaction between them and their research. In this study, a predominant stance of critical realism was adopted, with an epistemological balance struck between the extremes of post-positivism and constructionism, favouring that which is most appropriate between the two when required by the phase of the study.

The strategy for the research is cross-sectional using abductive reasoning, which is explained in Section 3.4, whilst ensuring triangulation throughout. This is achieved by transposing the suppositions, reasoned from the literature reviewed in Chapter 2, in to survey questions (see Chapter 4), with the survey results then validated by semi-structured interviews, presented in Chapter 6. The findings from investigation are then cross-referred back to the literature for direct comparison. Verification of the quantitative analysis is achieved with the semi-structured interviews, and the qualitative analysis is independently verified with the assistance of a third-party researcher in a different country.

Although the research commenced with four research questions, as time went on it became apparent that it was more appropriate to re-brigade these into a single Research Question supported by five SMART⁴¹ objectives. The questions and objectives were restructured after the data was collected as part of a holistic review prior to analysis, and this is covered in Chapter 4. Chapter 3 focuses on the theory behind the design of the research prior to the commencement of data collection. In doing so, it follows the theoretical journey from

⁴¹ SMART is a commonplace acronym for Specific, Measurable, Achievable, Realistic and Time-bound, although it was not necessary to specify the timeline for their achievement as these objectives are not designed to stand alone and will always be an intrinsic part of this study

philosophy, to methodology, to strategy and finally describes how the suppositions were formed, together with the manner in which they are investigated.

3.2 Research philosophy

Before embarking on a program of research, it is necessary to introspectively assess perception of knowledge, in regards to its development and nature (Saunders, Lewis, & Thornhill, 2007). The purpose of this process is to understand with what philosophy the researcher views the world and encapsulates many pivotal assumptions. Crotty asks “*What kind of knowledge do we believe will be attained by our research?*” (2015, p. 2) in assessing the choice of methodology to use.

Crotty (2015) warns of a confusing lack of consistency in the literature, with the same words being utilised differently and often contradicting each other; for the purposes of consistency in this thesis, the framework suggested by Crotty is followed, supported primarily by Easterby-Smith, Thorpe, & Jackson (2015) and Saunders et al (2007), with alternative viewpoints related where appropriate. Even the terms philosophy and paradigm are used synonymously in some of the literature, which can lead to significant confusion. This is especially true when these terms are further distinguished as either quantitative, qualitative or mixed methods (Freshwater & Cahill, 2013; Knox, 2004; Morgan, 2007a, 2007b). Silverman (2013) even goes as far as replacing the terms with “*models*” to describe the overall philosophy, stating that “*models roughly correspond to what are more grandly referred to [by Guba and Lincoln (1994)] as paradigms*” (p. 112). By the end of this Section, a paradigm will have been declared and the underpinnings of the research identified.

Much of the literature mentions ontology as being at the heart of philosophical debate, despite Crotty (2015) stating that it should be considered on a par with epistemology and separating them out produces needless complication. Easterby-Smith et al. (2015) state that ontology consists of “*physical assumptions about the nature of reality*” (p.47) and presents four options for ontology, that of Realism, Internal Realism, Relativism and Nominalism. Robson posits that “*realism is an attractive choice for those doing social research who wish to characterize what they are doing as scientific*” (2002, p. 29). Robson then argues that the standard positivist views towards the sciences must be discounted through its own inadequate explanations and descriptions and rejects the relativist approach because it can give rise to several equally valid answers, before going on to describe realism in terms of an example using gunpowder, asking if the powder

ignited with the introduction of a flame. The answer is, of course, yes, but only if the conditions are right, such as the powder is dry and there is oxygen. He explains that in a position of realism:

...the outcome (the explosion) of an action (applying the flame) follows from mechanism (the chemical composition of the gunpowder) acting in particular contexts (the particular conditions which allow the reaction to take place). (Robson, 2002, p. 30)

Realism is summarised by Easterby-Smith et al. (2015, p. 50) as a “*single truth*” and that “*facts can be revealed*”, whereas Saunders et al. (2007) refer to realism as being epistemologically similar to positivism. Morgan (2007a) also states that realism belongs to epistemology, although he later describes realism as a paradigm. Easterby Smith et al. agree with Saunders et al. that positivism is associated with epistemology, whereas Morgan feels that it is a paradigm. Sayer postulates that realism is positioned between positivism and relativism within “*the philosophy of natural science*” (2000, p. 2) and Crotty (2015) suggests that social constructionism combines realism and relativism at the same time. Maxwell and Mittapalli (2015) initially describe realism as a suitable substitute for positivism and constructivism, but later recommend integrating an ontology of realism with an epistemology of constructivism when conducting a mixed methods study. What is apparent from these authors is that it seems acceptable to combine different aspects and attributes when relating philosophical positions to an individual’s own research and whilst there are some elements of positivism that sit well with this study, much of it does not suit.

Although realism, and post-positivism, are normally considered synonymous with objectivism, there are plausible links between constructionism and realism, with enough disagreement for them “*not to be seen as watertight compartments*” (Crotty, 2015, Pp. 9-10 & 64). Positivism is linked to the formation of hypotheses for testing (confirmation of refuted) and the collection of fact-based data for analysis to advance knowledge (Saunders et al., 2007), but quantifying data in the analysis should not be restricted to only positivism (Crotty, 2015). Robson (2002) claims that “*positivism has been discredited but avoids the divorce from science implied by a thoroughgoing relativist approach*” (p. 42), whereas critical realism “*can encompass a range of post-positivistic approaches to social science*” (p. 17), with it also being described as able to “*recognize the reality of the natural order*” and allow the social world to be understood if the structures within it are identified (Bryman & Bell, 2007, p. 18). Furthermore, constructionism displays a “*meaningful reality*” that is fashioned socially, rather than the tendency towards objectivism that is

intrinsic to pure positivism (Crotty, 2015, p. 55). Crotty then explains that the adopted epistemological stance needs to be declared and explained, using the analogy of a tree by way of example; an objectivist believes that a tree is a tree, whether someone knows its location or not, whereas a constructionist will be cognisant that it is only a tree because humans named it as such, and the value of the tree will vary dependent on what it means to an individual (for instance a paper-mill owner versus someone living in an impoverished city). In relation to this study, and in the context of the previous example, a constructionist approach is predominant in much of the research as the value of Air Safety is very different between Aircrew (personal survival), ATM and Engineer (professionalism but without the personal jeopardy), and Other Support Staff (survey respondents in this category included aviation insurance, transport and logistics – see Section 5.2).

Maxwell and Mittapalli (2015) cite the works of Bhaskar (1978,1989) in presenting their thought that critical realism is the paramount development of realism in social sciences and, in describing the features of realism, they explain that there is a denial of the certainty of knowledge and acceptance of other versions of events. Critical realism is therefore presented as retaining “*an ontological realism while accepting a form of epistemological relativism or constructivism*” (Maxwell & Mittapalli, 2015, p. 8). In this way, critical realism has attained general recognition as a substitute for interpretations of naïve realism and radical constructivism. Furthermore, they state surprise that realism has not had more effect on research approaches due to its philosophical eminence, especially given the thought that someone’s societal environs can directly influence their perceptions and approach to life. De Souza (2014, p. 142) posits that the distinction that critical realism displays is that in the world of social science there are identifiable foundations, which “*...have causal mechanisms that produce events*”, a stance supported by Bazeley (2018) and also credited to Bhaskar (1998, 2008 & 2011) by de Souza.

Bazeley (2018) cites Miles and Huberman (1994) as saying that epistemologically the desire is often to operate at the extremes of the continuum, whereas it is a perfectly legitimate approach to explore the middle-ground. Furthermore, in a later edition of their book, they recommend “*avoiding polarization*” and that “*realists, idealists, and critical theorists can do better by incorporating other ideas than by remaining pure*”, coining the phrase “*hybrid vigour*” (Easterby-Smith et al., 2015). Reportedly, it is often the case that researchers do not rigidly stick to one approach or the other, and although there has been a general migration from positivism towards constructionism, it is quite normal in social research to combine elements from both positions (Easterby-Smith et al., 2015). This thesis cannot be considered to be set in a strong positivist epistemology, but the research

can be described as having favoured postpositivism when in the context of its quantitative aspects, whilst also being of a constructionist nature in its qualitative side. Alise and Teddlie (2010) suggest that mixed methods research would normally be underpinned by pragmatism, accepting also that it can be swayed towards a different part of the positivist-constructionist continuum in relation to specific elements of quantitative or qualitative bias. The delineation between quantitative and qualitative research occurs in the description of methods, not in the philosophy of the research (Mackenzie & Knipe, 2006). This is true for this study and the methods used are presented in Section 3.3 and within the data collection in Chapter 4.

So, to properly address the issue of perception of knowledge, it is necessary to consider what is understood in regard to the philosophical foundations that the programme of research is built upon, in terms of the type of knowledge expected and how it is perceived. Despite the confusion that prevails in the literature, a path is shown that draws upon the ontological and epistemological debate, arriving at a paradigm of critical realism, but with some vestige of the ends of the continuum associated with post-positivism and constructionism. This distribution of positions dependent on the stage of research is supported by several authors (Bazeley, 2018; Crotty, 2015; Easterby-Smith et al., 2015), this middle-ground described by the latter as a ‘hybrid’ approach. Because of its “*potential of incorporating features highlighted by the emancipatory approach, such as taking note of the perspectives of participants*” and its suitability for use in management and organisational research (Robson, 2002, p. 30), realism is also deemed particularly suited to this programme of research, but only when in the context of critical realism, and even then for those elements that are compatible with a predominantly constructionist epistemological approach.

3.3 Methodology

It is important to acknowledge that the Research Question will more often than not dictate the method or methods, rather than the paradigmatic position (Bazeley, 2018), with Mertens then cited by Bazeley as describing a situation of “implicit pragmatism or subtle realism” (Denzin, 2012). With a critical realist paradigm, it is possible not to have to make a choice between qualitative and quantitative data analysis, combining the best features of both in a mixed methods approach (Bazeley, 2018). A mixed methods approach is therefore adopted, collecting primary data through survey and interview to analyse quantitatively and qualitatively, whilst also conducting a blend of qualitative and quantitative analysis on relevant secondary data to support the research aim.

In looking to provide clarity in the relationship between triangulation and mixed methods research, in which confusion must therefore be presumed, Denzin (2012) suggests that research utilising a mixed methods approach is often associated with naïve postpositivism, citing Howe (2004) as saying that with a supposed hierarchy any qualitative study that is conducted after quantitative is consigned to just being ancillary to the main function. Denzin (2012, p. 82) supports the desire to properly understand the issue and accepts that many authors have a “*post-positivist bias...and tendency to subordinate QUAL to QUAN*” whilst extolling the adoption of pragmatism as a means to unlock this debate. Bazeley (2018) explains that a mixed-methods approach is superior, with each method complementing the other with a unique contribution that gives an enriched answer to the Research Question that neither single method could fulfil. In contrast, Greene and Hall (2015) warn that mixing methods may not always be the perfect solution to any perceived methodological problems. This said, Crotty (2015, p. 15) feels that research can be “*both qualitative and quantitative, without this being in any way problematic*”, with Howe (2012) suggesting that as long as the two methods have a distinct role that is pre-planned, and executed in accordance with that plan, there should not be an issue.

Creswell (2009) suggests that when designing a mixed-methods study it is important to establish the balance that the two (or more) methods will be allocated and the order in which they will be conducted. The collection and analysis of quantitative followed by qualitative data within a single research project is termed a ‘mixed-methods sequential explanatory’ approach (Cameron, 2009; Creswell & Plano Clark, 2018; Ivankova, Creswell, & Stick, 2006). In this way, the second element of research is designed to add to the knowledge gained by the first method, the justification being that neither is satisfactory in isolation to fully answer the question (Ivankova et al., 2006), but if combined are able to mutually support one another producing a better analysis product where the two methods aim to complement each other to answer a multi-faceted Research Question (Bazeley, 2018). Within an engineering context, this type of approach would be termed a ‘hybrid model’ where the output of one model becomes the input of another (Stephen & Labib, 2018). Creswell (2009) describes the sequential explanatory design, which fits the research requirement to inform a secondary qualitative interview with analysis of the data collected in a preliminary quantitative survey. It is felt that this design perfectly encapsulated the reasons why the format is chosen for this research, a theory supported by Cameron, who suggests that the formula is particularly appropriate for “*...usage in business and management fields...*” and “*...applied social science and evaluation...*”

because of the rationale that both methods of collecting data have their advantages and disadvantages (2009, p. 140).

In the design of the research study, it is important to ascertain not just the order in which the methods will be used, but also the point at which the data or analysis is combined (Moran-Ellis et al., 2006). Bazeley (2018) posits that it is in harmonising the analysis where a researcher can see the benefit of using the mixed-methods of data collection, where the integration of the information can strengthen or emphasise the points to enhance the overall picture. This merging of analysis can occur once, or many times, dependent on the Research Question and how best this can occur to aid the overall understanding (Creswell & Plano Clark, 2018).

Conversely, if it is felt that the two elements of data gathering are epistemologically incompatible, then they must be kept separated at this stage; however, at some point there must also be an integration of one form or another, which when done sequentially will mean that the second method will invariably augment the first, whilst also benefiting the later stages of the analysis (Bazeley, 2018). It is not as common, but possible, for analysis of the first stage to influence the way in which the data collected in a subsequent method is analysed (Ivankova et al., 2006), which could be considered akin to abductive reasoning. In sequential mixed methods the purpose of the subsequent method is to either confirm, generalise or validate the original data, and in doing so an example of this could be the generation of nodes from the quantitative research that can be applied to the qualitative data in coding (Creswell, 2009). Integrating the analysis provides the desired level of cross-validity, irrespective of the paradigm in which the data was gathered, and it is the combining of the analysis that is deemed more important epistemologically than the method itself (Bazeley, 2018).

Triangulation is an epistemological claim concerning what more can be known about a phenomenon when the findings from data generated by two or more methods are brought together. (Moran-Ellis et al., 2006, p. 47)

Bazeley (2018) cites Denzin's 1978 work as the root source of much of today's thoughts on triangulation in qualitative research, although he credits "*Campbell and Fiske's landmark article in 1959*" as being the originator of the concept of triangulation by utilising more than one distinct method for the purpose of validating another (p.107). In order to reinforce this, Bazeley (2018) lists four possible approaches, using multiple different methods, varying the sources of data, approaching the research with different perspectives of the theory and using more than one investigator. Denzin is further cited as

suggesting that ‘within method triangulation’ is different to ‘between method triangulation’, where the latter achieves external validity with a comparison of one set of data against another. Flick (2004, p. 178) adds that two or more methodological approaches can be used as a validation strategy for “*the procedures and results of empirical social research*”. Robson (2002, p. 174) also recommends triangulation as a “*valuable and widely used strategy...[that] involves the use of multiple sources to enhance the rigour of the research*”. In a similar way, Bryman & Bell (2007) extol the use of triangulation to study different facets of the same phenomenon.

Whilst using mixed methods in research can be seen to improve the validity of the findings, in respect to triangulation, validity is achieved in this way by comparison of the results of two distinct methods to determine if the Research Question has been appropriately answered (Lub, 2015). Morgan-Ellis et al. (2006) then go on to question whether this way of validation by triangulation is actually achievable due to the differing philosophical approaches associated with positivism and interpretivism, however, this stance is refuted by their suggestion that it is the methods that are being triangulated and further supported by the argument they put forward that the use of more than one method is crucial when conducting research in social sciences. Silverman (2013) recommends triangulation as a way of increasing the reliability of any one method, which is also recommended when validating qualitative research (Mertens & Hesse-Biber, 2012). Creswell states that convergence can be used to validate both methods of data collection against each other (2014), whilst Creswell and Plano Clark (2018) say that the bewildering array of validity options make choosing one difficult, but the aim must be to assess accuracy. They go on to recommend triangulation of the information collected and using key participants to assess whether the findings are an accurate reflection.

As stated previously, the Research Question should always dictate the method (or methods) by which a study is conducted. Conducting the research with a critical realist paradigm means that the benefits of qualitative and quantitative analysis can be combined into a cohesive mixed-methods approach, with the qualitative data used to enrich, and validate, the quantitative data gathered through the online survey, whilst also achieving triangulation with the literature. Of the four different methods of triangulation cited to Denzin by Bazeley (2018) and Flick (2004), the research strategy incorporates data triangulation in using different sources of data (i.e. different people) at different times (the survey was open for several months) and in different places (52 different countries), methodological triangulation, and investigator triangulation with the use of an independent researcher to corroborate the interview analysis. The fourth element is stated as theory

triangulation, which at first would not seem to fit with this research, but the description given by Flick (2004) describes using differing perspectives and hypotheses in the analysis, which does relate to this study. The research was always planned to be mixed methods from the initial establishment of the Research Question and conducted according to that plan.

With this framework in mind, the collection of quantitative data first gives the wide foundation upon which the addition of qualitative data sits and provides further information to answer the over-arching Research Question. A greater weighting is given to the quantitative data to recognise the larger number of objectives that can be answered by it and acknowledge the wider participation in the survey than the number of interviews conducted. The two methods are conducted sequentially to explain the data acquired in the first, with the qualitative analysis not only validating the quantitative results, but also adding to the depth of the answers and filling in some of the missing information required to fulfil the research objectives. Triangulation is used to validate the data garnered quantitatively, and then independent corroboration of the qualitative analysis of primary data is achieved through the use of a third-party researcher (detailed in Section 4.10). Initially the intention was to use the term ‘hypothesis’ in both quantitative and qualitative analysis to represent not only statistical testing, but also to challenge proposed explanations requiring further investigation. However, in order to avoid confusion of the two different uses of the same term, the word ‘hypothesis’ is only used in the thesis when referring to statistical analysis. When referring to qualitative investigation of a proposed explanation, the term ‘supposition’ is used consistently.

3.4 Strategy

Fox and Do (2013, p.744) espouse the use of abductive reasoning as being the norm when conducting research from a paradigm of critical realism, because this strategy allows causal understanding to evolve as the research analysis does. In doing so, they say that *“iterative cycles of reference to theories and observations leads to increasing understanding of causal mechanism and causal context”*. With the traditional reasoning models being Induction or Deduction, Peirce (1903) is cited as concluding that Abduction is needed to bridge the gap between the two and allow room to explain human behaviours and reasons for their actions (Gold, Walton, Cureton, & Anderson, 2011) or conceivably their inactions. This is explained in reference to Peirce’s work as deduction being proof that something exists, induction showing that it works and abduction suggesting that perhaps something might happen, with a suggestion as to the reason as to why.

Modell (2009) describes how abductive reasoning can be used in a critical realist approach to assist with validation through triangulation, with this form of reasoning unearthing causal explanations, which are especially useful when the survey results do not agree with a supposition that has come from theoretical knowledge. Furthermore, he suggests that the use of abductive reasoning supports the paradigm of critical realism in wide-ranging exploration to discover knowledge, that perhaps through human constraint cannot be verified. Gold et al. (2011, p. 238) describe ‘simple abduction’ as the production of hypotheses as generalisations, with ‘existential abduction’ used for cases of best guess in the setting of plausible hypotheses (also see Aven, 2015) and ‘analogical abduction’ which relates to the use of “*existing hypotheses to generate something similar*”. It is this latter case that shows similarity with the methodology used for this research study, with the suppositions being formed from a review of previous literature in the specific subject area.

The strategy that is employed in the research for the collection of data is cross-sectional, which is described by Robson (2002) as being the most popular when utilising a survey. Cross-sectional has breadth but is limited in its nature as a snapshot, and according to Bryman and Bell is “*placed firmly in the context of quantitative research*” (2007, p. 59). This said, they do accept that some cross-sectional research can be predominantly quantitative whilst utilising some elements of qualitative analysis, and when it is considered that the research is weighted towards the quantitative, with qualitative support for enrichment and validation, cross-sectional is believed to be the correct strategy.

To fully research the subject area, the opinions and attitudes of practitioners in the four areas of Aircrew, Air Traffic Controller (ATC), Engineer and ‘Other Support Staff’ need to be understood. This can only be achieved with the collection of primary data. The intended survey population of the UK aviation sector consists of “*150,000 jobs in the UK*” (Hammond, 2011), but this can be reduced when only considering personnel directly involved in the four areas listed, estimated to be 100,000 people. It is also estimated that the military aviation community numbers around 10,000 people. It is recommended that in probability sampling, the sample size is big enough to ensure an appropriate level of confidence that the data is representative of the population; in order to achieve a 95% level of certainty the minimum number of respondents required for a population of 110,000 is calculated to be 383 (Saunders et al., 2007). Cross-checking this figure with an online sample size calculator for comparison, also delivers the answer 383 (SurveyMonkey, 2016). In order not to underestimate the population size, figures of 150,000, 175,000 and 200,000 people are also checked, returning an answer of 384 each time.

Therefore, a target of 500 respondents is set for the survey, with an anticipated completion rate of around 80%. Although relatively high, this is a believable completion rate as Safety Management in the UK aviation industry is, in general, actively embraced. With ‘buy-in’ from airline safety managers, the survey is easily distributed to the intended audience. Within the military, flying is conducted by not only the Royal Air Force (RAF) but also the Royal Navy’s Fleet Air Arm (RN FAA), and the Army Air Corps (AAC). Officers responsible for Air Safety Management at the respective Service headquarters were approached ahead of the study, to act as gatekeepers and facilitate the distribution of the survey. As representatives of civilian aviation, communication was also established with the Safety Managers of several UK airlines. The airlines are able to represent the Aircrew, Engineer and Other Support Staff fields, but not ATC⁴². Therefore NATS, who are “*the UK’s leading provider of air traffic control services*” (NATS, 2018b) was also approached for assistance. This was the initial picture at concept development stage, the actuality of the situation as it unfolded is quite different and is addressed in Section 4.6.

The sampling strategy used for the survey had been initially intended to be snowball sampling, but as time elapsed it morphed into convenience sampling, due to the developments explained in Section 4.6. The Safety Managers in the military and civilian sectors are considered gatekeepers to their organisations (Bryman & Bell, 2007) and as such a snowball sampling method (Easterby-Smith et al., 2015; Robson, 2002; Saunders et al., 2007) was envisioned whereby the Safety Manager would be sent a link to the web-based survey with an explanatory paragraph requesting assistance (and meeting all of the ethical considerations that were approved – see Section 4.3), that they could then forward to their staff who would remain completely anonymous. Snowball sampling can also be known as chain, chain-referral or network sampling (Penrod, Preston, Cain, & Starks, 2003; Singh, 2007), and each of these descriptions fitted the design of the research. Singh (2007) also suggests that this form of sampling is especially useful for hard to reach populations or ones that are not easy to identify. This method ideally suited the situation that was envisaged, as it would have been highly likely that the recipients of the email would match the target population.

When the support of several organisations approached was surprisingly not forthcoming (detailed in Section 4.6), the method had to be changed to convenience sampling (Easterby-Smith et al., 2015; Robson, 2002). The survey was successfully distributed by

⁴² Air Traffic Control

means of an online link from a website established for the research⁴³, through social media (LinkedIn and Facebook) and from a link embedded within an aviation safety newsletter that was sent out every weekday (Lewis, 2017). The (very basic) website was not expected to attract ‘passing’ traffic and people would have to specifically be linked to it to get there, so anyone looking at it would highly likely be from within the industry. The Curt Lewis newsletter⁴⁴ is distributed worldwide, Monday to Friday, to a mailing list that could be assumed to be aviation professionals due to the topic being aviation safety.

With regards to the sampling strategy for the second phase of data collection, the qualitative semi-structured interviews, Ivankova et al. (2006, p. 12) state that “*there are no established guidelines as to how researchers should proceed with selecting the cases for the follow-up qualitative analysis...*”. However, Singh (2007, p. 108) introduces a method called ‘expert sampling’ which involves the selection of interviewees “*who are known to have demonstrable experience and expertise in a particular area of study interest*”. Furthermore, he specifically states that this method of sampling can prove useful in validating another sampling approach elsewhere in the research. The selection of interviewees is covered in sub-Section 4.7.2, where it is explained what the criteria for selection is.

In the design phase of the study, it was identified that the Research Question would not be completely answered without support from analysis of secondary data. Redacted Airprox (introduced in sub-Section 2.2.2) reports, together with the UKAB’s findings and assessments, are available for download from their website⁴⁵. The UKAB staff also made available the Airprox reports from the 3-years prior to, and the 3-years after, the introduction of the ATSOCCAS⁴⁶ regulation change for comparison, as an example of a major aviation regulatory change. Furthermore, the researcher had been employed at a UK aerodrome when the SERA⁴⁷ changes were implemented to UK regulation, and a short case study is included in the thesis (Appendix I) by way of example of some lessons that can be gleaned from this.

In establishing the overall research strategy, this Section has covered the use of abductive reasoning, within the paradigm of critical realism, to assist with validation through

⁴³ www.ifgairsafety.co.uk

⁴⁴ www.fsinfo.org

⁴⁵ UK Airprox Board - www.airproxboard.org.uk

⁴⁶ Air Traffic Services Outside Controlled Airspace

⁴⁷ Standardised European Rules of the Air

triangulation. Data collection is described as being through the medium of a cross-sectional survey, with a target of 500 respondents to satisfy the calculated sample size of 383, with distribution attempted through organisational gatekeepers initially and then through ‘convenience sampling’. In the second phase of the data collection, semi-structured interviews were conducted with people who were selected through ‘expert sampling’ for their expertise in particular areas of aviation, in order to validate the quantitative study, whilst also enriching the information gained by the first phase analysis. The Research Question could not be completely answered by analysis from the primary data alone, therefore, open source secondary data was collected, together with an example of EU-led implementation of a regulatory change and the impact on one UK aerodrome.

3.5 Suppositions to investigate

The review of the current literature, presented in Chapter 2, led to the forming of suppositions to investigate in order to answer the Research Question. How these suppositions are investigated is covered in Chapter 4. Table 3-1 shows what methods are used to analyse the data.

Obj		S _n		Method
1	Determine if there is a correlation between an increase in the likelihood of an Airprox and changes to aviation regulation.	1	The introduction of regulatory change can increase the likelihood of an Airprox.	Qualitative Primary & Secondary Data
2	Assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation.	2a	Errors occur, only if left unmanaged do they increase risk.	Quantitative & Qualitative Primary Data
		2b	Humans make safety through their efforts and expertise; this implies that new regulation can be safely introduced through human endeavour and training.	Quantitative & Qualitative Primary Data
3	Analyse whether humans are the weak link in the aviation safety chain.	3a	It is widely considered in the aviation industry that eradicating human error will achieve safety of operations.	Quantitative & Qualitative Primary Data
		3b	Humans can be subject to information overload during regulatory change.	Quantitative & Qualitative Primary Data
4	Assess if there is an active culture of learning from incidents within aviation.	4a	There is a temptation to rationalize every incident with hindsight bias and not acknowledge that some events are 'Black Swans'.	Quantitative & Qualitative Primary Data
		4b	The capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome.	Quantitative & Qualitative Primary Data
5	Determine if changes are required to regulations to integrate drone operations.	5	There is not enough regulation on the use of drones and more is needed urgently.	Quantitative & Qualitative Primary & Secondary Data

Table 3-1 showing which method is used to investigate the supposition

3.6 Review of the research plan

The original research outline included four research questions and the suppositions were formed in relation to these. The survey questionnaire was written to support these suppositions and the data gathered against them. Several authors recommend taking a step back during the process and conducting a holistic review of the original starting criteria to see if they are still fit-for-purpose, especially for mixed-methods studies (for example Bazeley, 2018; Bryman & Bell, 2007). A full review of the study was conducted after the collection of primary data to see if the data collected properly answered the questions being asked. Whilst broadly speaking the questions were found to be appropriate, in the

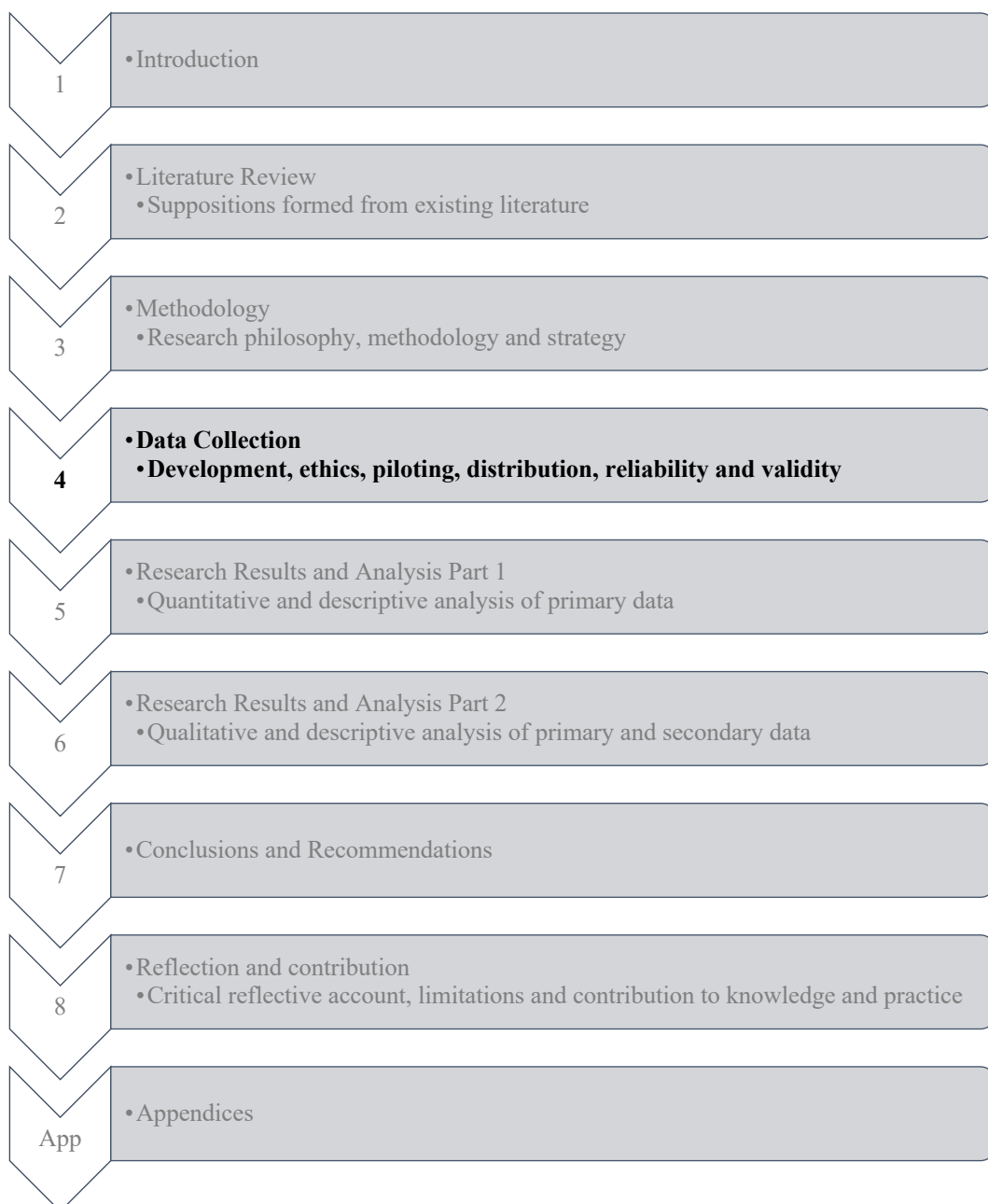
process of conducting this review the knowledge gained during individual development meant that the structure of the research plan itself was found wanting. In essence, it lacked a common thread or theme that could easily be identified and followed through the research. A more coherent plan was needed, and it was felt that the four research questions were in themselves unwieldy. A single over-arching Research Question was interpolated from the previous four, and five supporting objectives declared, against which the suppositions could be mapped. There were some minor changes to the way the suppositions were worded, and when they were mapped against the objectives the order in which they were written changed. These were all minor changes to individual aspects, but the overall impression was one of a coherent message that linked the contribution, focus, thesis title, aim, Research Question, supporting objectives and suppositions. This flow was presented in Section 1.7 and the thesis is written in relation to this revised framework.

3.7 Summary

This chapter has established what the foundations of the research are and how the methodology and research strategy develop and build upon the literature review. The research is conducted using a mixed methods approach, with a predominant stance of critical realism, albeit tinged with a measure of postpositivism or constructionism in some parts, the most appropriate epistemology being adopted for the phase of research being conducted at the time. A cross-sectional strategy is followed, with abductive reasoning, and whilst the originally intended sampling strategy was to be snowball, it morphed through necessity to convenience sampling as the research progressed. This element is expanded upon in Section 4.6 when the challenges associated with the survey distribution are presented. Triangulation is achieved by the transposition of the suppositions that were formed from the literature, into the survey questions, with the results validated by interview and then the answers referred back to the literature. The quantitative analysis is also verified by the interviewees and the qualitative analysis of the interviews independently verified as well, by another researcher. This process has also ensured reliability in the data and confidence that it is truly reflective of the industry as a whole, across the 'Four Worlds'.

After a thorough review of the research around the midpoint of the study, the structure of the research objectives was adjusted to better reflect and support the aim. The questions were restructured, and the suppositions renumbered, but without changing the underpinnings of the study. The new framework confirmed a cohesive flow from philosophy through methodology to strategy, ensuring that the suppositions supported the

research objectives appropriately. The philosophical foundations remain intact, and the Research Question itself dictates the need to use a mixed methods approach as no one method would be able to fully satisfy the aim. A merging of the benefits of qualitative and quantitative analysis is facilitated by a ‘mixed-methods sequential explanatory’ approach. The secondary data analysis furthers the understanding of the primary data, allowing for a rich interpretation to gain as much knowledge as possible from it.



Chapter 4 – Data collection

4.1 Introduction

As introduced in Section 1.9, there are six elements of data associated with this research, with Table 4-1 showing which datum source is expected to address the suppositions introduced in Chapter 3. The primary data is from a questionnaire survey (Qs), which included multiple-choice and free text questions (Txt), which was sequentially supported by semi-structured interviews (Int). The first element of secondary data consists of Airprox⁴⁸ reports from 2015, 2016 (15/16) and drone-based ones from 2017 (+17), downloaded from the UKAB⁴⁹ website. The second element is a summary of the Airprox reports from three years either side of the introduction of ATSOCCAS⁵⁰ (+/- 3). The third element is a short case study (CS) on the introduction of the SERA⁵¹ regulation change at a UK aerodrome⁵². This was compiled by the researcher, as an employee at the aerodrome at that time, based on feedback reports from the staff. Additionally, the CAA⁵³ provided the raw data from their survey of the British public on the perception of drones.

This chapter covers the collection of this information, predominantly focusing on the primary data aspects of generating and distributing the survey, as well as conducting the interviews and preparation for analysis.

4.2 Questionnaire development

The first step in the development of the set of questions is to look at the individual suppositions associated with each objective and conceptualise how an answer might be elicited from the data sources introduced in Table 1-1, represented again in Table 4-1.

⁴⁸ Airprox – Aircraft Proximity, usually used to describe a near-miss event or report (defined on p. xv)

⁴⁹ UK Airprox Board www.airproxboard.org.uk

⁵⁰ Air Traffic Services Outside Controlled Airspace

⁵¹ Standardised European Rules of the Air

⁵² The ICAO definition of aerodrome is used: “*A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft*” (CAA, 2014). In this context, the term is being used to describe a generic aerodrome in the UK, the name of which is irrelevant.

⁵³ Civil Aviation Authority

Obj		S _n		Primary data			Secondary data		
				Qs	Txt	Int	15/16	+/-3	CS
1	Determine if there is a correlation between an increase in the likelihood of an Airprox and changes to aviation regulation.	1	The introduction of regulatory change can increase the likelihood of an Airprox.			√	√	√	√
2	Assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation.	2a	Errors occur, but only if left unmanaged do they increase risk.	√	√	√			
		2b	Humans make safety through their efforts and expertise; this implies that new regulation can be safely introduced through human endeavour and training.	√	√	√			
3	Analyse whether humans are the weak link in the aviation safety chain.	3a	It is widely considered in the aviation industry that eradicating human error will achieve safety of operations.	√	√	√			
		3b	Humans can be subject to information overload during regulatory change.	√	√	√			
4	Assess if there is an active culture of learning from incidents within aviation.	4a	There is a temptation to rationalize every incident with hindsight bias and not acknowledge that some events are 'Black Swans'.	√	√	√			
		4b	The capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome.	√	√	√			
5	Determine if changes are required to regulations to integrate drone operations.	5	There is not enough regulation on the use of drones and more is needed urgently.	√		√	√ +17		

Table 4-1 showing which datum source is expected to address each supposition

Ekinci (2015, p. 132) suggests that the questions should be “*laid out in a logical sequential order with a neat physical appearance*”. The classification questions are added at the end to keep respondents motivated towards completing all of the questions. This decision is vindicated in analysis as there are no dropouts at the classification questions. When deciding upon a scale, it is deemed appropriate to ensure that the choices are not at all contentious and kept as simple as possible. An answer of ‘maybe’ or ‘don’t know’ is avoided as it is felt that this would add nothing to the analysis. The specific exclusion of this option is supported by contemporary advice (Garland, n.d.; Vannette, 2015), as well as academic literature (Krosnick, 1991; Krosnick & Presser, 2009; Oppenheim, 1992), in which the theory of ‘satisficing’ a survey is presented, where a respondent automatically opts for the ‘don’t know’ answer when faced with a complex question, rather than trying to understand it and think of a reasoned response. Furthermore, the value of a ‘don’t know’ option is acknowledged for potential respondents who may genuinely not be familiar with a topic, however, in this survey every respondent should be knowledgeable enough about the subject to have an opinion or perception as to the answer.

Gillham (2007) suggests that whatever approach is taken to options, the overall style is kept consistent. Seven of the questions require a simple Yes/No answer, three questions offer a 3-level Likert answer with a ‘middle ground’ and a 5-level Likert scale is offered in a further three questions when the strength of an opinion either way is desired. In the 3-stage question on information overload (page A-9), a software limitation means that a ‘not applicable’ option has to be offered at all three stages, rather than just the second and third stage which are follow on questions to the first.

It is deemed important to ensure an overall professional look and feel to the survey, which, given the nature of intended distribution, has to be web-based. Cognisant of the researcher’s position at the time, within the military aviation regulator, it is considered important that the survey does not have a military ‘feel’ to it, and that whilst the connection is acknowledged in the introductory text, the overall impression of the survey should be that of post-graduate research. Ekinci (2015, p. 133) comments that an “*attractive and interesting appearance is likely to increase the motivation to complete the questionnaire, along with the overall response rate*”. A purple and blue colour scheme that was a close match to the UoP⁵⁴ logo is specifically used. Figure 4-1 shows this layout and colour scheme in the initial prototype version.

⁵⁴ University of Portsmouth

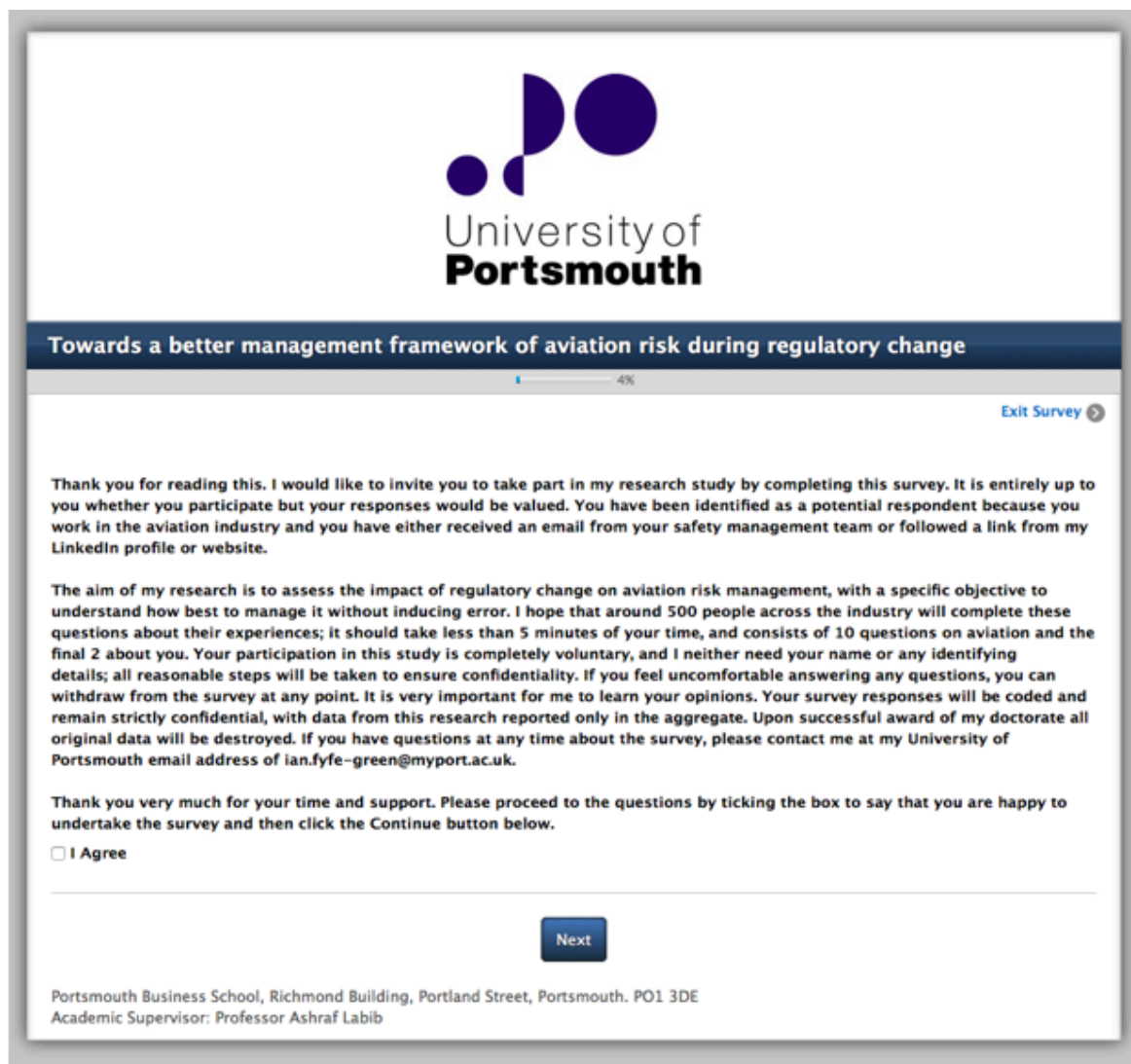


Figure 4-1 showing the layout and colour scheme used in the initial prototype survey

4.3 Ethical issues and approval

The greatest threat to ethics from the research is in relation to the questionnaire survey amongst military participants, due to the researcher's employment in the MAA⁵⁵ at the time of data collection, and the slight potential for some reticence to provide open and honest answers to the questions. The initial application for ethical approval was submitted under the premise that in order to guard against this potential bias, no mention of the researcher's position in the MAA would be made. This stance failed initial ethical scrutiny and the revised application was reworded to acknowledge the employment but stressed that the research was being "conducted for personal academic study with the University of Portsmouth". The introductory paragraph can be seen in Appendix A, along with the survey questions.

⁵⁵ Military Aviation Authority - the military regulator

MOD⁵⁶ policy for research involving human participants is specified in JSP 536⁵⁷, which requires that anyone researching human participants completes the table shown in Appendix E to ascertain if MOD ethical approval is required. As every answer is in column B, specific MOD approval is not required. Feedback from the initial ethics application highlighted a need to expand the explanation that should a participant wish to withdraw before completing the questionnaire, they could do so, and their answers would not be retained. In order to comply with this statement, once the survey was closed, the data in its entirety was looked at to assess dropout points and rates, and country of completion, incomplete responses being deleted from QuestionPro and not downloaded for analysis. Ethics approval (Appendix E) was achieved on 8 December 2016.

The secondary data is predominantly open source and anonymised, although some items are only available on request. By nature of employment the researcher has access to the raw data that is not anonymised; extreme care was taken not to use this privileged information in the research and to only access the data through open source channels so that identifiable aspects are not transposed into the thesis. The case study is authored by the researcher as a professional embedded in the system; no names or identifying details are included in the case study summary.

4.4 Pilot (prototype) study

Research literature commonly recommends that a survey is piloted before distribution to the target sample population and is required to ensure validity and reliability (for example see Bryman & Bell, 2007; Ekinici, 2015; Gillham, 2007; Robson, 2002; Saunders, Lewis, & Thornhill, 2007). Gillham recommends that this pilot is conducted in two stages, firstly by asking a small group that are similar to the sample to complete the questionnaire with the researcher monitoring them and available to answer queries, and then a wider distribution to simulate the real survey. Whilst the literature universally uses the term ‘pilot’, this is inappropriate for this research due to its aviation basis and the possible confusion this term might cause. The survey is aimed at Air Traffic Controllers, Engineers, Pilots, Aircrew and any ground-staff associated with aviation. The term pilot in relation to the survey is unacceptable as it may convey the wrong message to the rest of the industry. The survey was, therefore, piloted using the term ‘prototype’ in all correspondence.

⁵⁶ Ministry of Defence

⁵⁷ Joint Service Publication

4.4.1 First stage – Military Aviation Authority (MAA) colleagues

The questionnaire was tested on both home and work computers, as it is imperative that the survey could be accessed from the MOD intranet so as not to alienate a substantial population of potential respondents. As advocated by (Ekinici, 2015), colleagues were used for this pre-pilot stage, with a request to go through the questionnaire and make comment on the content and layout, as well as testing functionality but without answering the actual questions as ethics approval had not been received at this stage. The colleagues selected included representation from Aircrew, ATC⁵⁸ and Engineer (both military and civilian) and responses were predominantly positive. There was one comment that the language was “obviously not aimed at the military”, which is taken to be valedictory as it means successful navigation away from the use of military jargon and achieves the desire of making it universally understandable. One Engineer assumed that the survey was only for Aircrew and ATC, with the example given that one of the questions began “As an operator do you...”. This is a valid statement and the question was changed accordingly so that it would be seen as inclusive to all of the target audience.

4.4.2 UoP annual review

Whilst UoP ethical approval was awaited no further testing was conducted. At the University annual review with both Supervisors and an independent examiner, the survey was presented. In addition to positive feedback, very useful advice on developing some of the questions further was given. It was at this forum that the independent examiner raised an issue with regards to the proposed method of using LinkedIn as the vehicle for piloting the survey, in that there was potential for the same respondents filling in the prototype study who could also participate in the main survey as well. Flybe head office kindly accepted the request to conduct the prototype survey and not be included in the main release; the staff are deemed representative as they consisted of Aircrew, Engineer and ex-Air Traffic Controllers.

⁵⁸ Air Traffic Control

4.4.3 Second stage - Flybe airline head office staff

A proper pilot study is one where you simulate the main study. It will involve fewer people, but they will be of the same kind as your final target group. Here the questionnaire has to stand on its own two feet. You send it out, and you wait and see what happens. (Gillham, 2007, p. 42)

Gillham suggests that there are two things to look for in the responses to a pilot survey; a poor response rate is indicative of the way in which the questions were asked, and incomplete or unexpected responses show that a question was phrased badly. For this second stage prototype the survey was amended slightly to add an extra question requesting feedback on the questionnaire itself, as well as an amendment to the introduction to explain that the answers would not be counted towards the final statistics, but it is more important to get feedback on the process in the final question than it is to understand the specific answers to the questions themselves. This change needed to be made as the survey was only being distributed in one company and total anonymity of the participants could not therefore be guaranteed. 25 members of Flybe staff started the survey and 17 completed it, a completion rate of 68%. Comments received are generally very positive; the full critique is in Appendix M. Ekinici (2015) proposes a list of questions to reflect upon after a pilot survey, and these are represented in Table 4-2, together with a completed checklist.


4.5 Refinement of the survey questionnaire

The results of the prototype survey were evaluated directly against the research objectives and suppositions. Analysis was conducted on the Flybe responses to specifically try and answer the research questions. It was found that in most cases the responses answered the original questions and affirmed the suppositions. However, in one case it was discovered that whilst the response and question matched, the supposition didn't support the objective in the right way and the supposition adjusted accordingly. There is one comment in the feedback that an individual did not understand the term 'outlier'. This point prompted a full review of the questions to ensure that the language used was applicable for all audiences, which invariably means that the questions got longer but became easier to read.

Reflective question	Answer
Do the questions sound right?	Yes
Is there a better way to ask the questions?	No
Do respondents and interviewers understand the questions?	Yes
Are the questions free from technical words and jargon?	Yes
Are any questions double-barrelled, loaded, leading or ambiguous?	No
Will the questions be understood as intended?	Yes
Are any questions unnecessary?	No
Have all the relevant questions been included?	Yes
Has anything been missed out?	No
Does the order of the questions flow properly?	Yes
Do respondents and interviewers understand the skip patterns?	N/A
Are there any spelling or grammatical errors?	No
Is there sufficient space for the answers?	Yes
How long does it take to complete the whole questionnaire?	10 mins
Do respondents find the questionnaire interesting?	Yes, +ve feedback

Table 4-2 showing answers to the reflective questions that the researcher should ask themselves after the pilot survey, as proposed by Ekinici (2015)

The biggest single change made was the rewording of survey question 1, which had rightly been highlighted as being off-putting and cumbersome. The original version can be seen at Figure 4-2. As this is the very first question it is possibly somewhat over imposing and might make some people leave the survey at this point. After several iterations, the following version was settled on as being a way to ask the same question in a not so imposing manner: “In his 2007 book called *Black Swans*, Nassim Taleb stated an opinion that all major catastrophic occurrences are just random events and as such have no rational answer as to why they occurred. The implication being that although there is a temptation to rationalize every incident with hindsight bias, attempts to identify the cause of a past event are a waste of time and we should just acknowledge their randomness. How much do you agree that this is applicable to the aviation industry?” The same response options are maintained.


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13%

[Back](#) Questions marked with a * are required [Exit Survey](#)

* Major catastrophic events were described by Nassim Taleb (2007) as 'Black Swans' (*deviates beyond what is normally expected of a situation and extremely difficult to predict*) and as such are considered as outliers to the norms, with no rational answer as to why they occurred.

How much do you agree that this is applicable to the aviation industry?

Very
 Somewhat
 Neutral
 Not very
 Not at all

Can you provide an example where an event has been over simplified and the cause is much deeper than widely concluded?

[Next](#)

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Figure 4-2 showing the layout of the prototype questionnaire and the original first question

4.6 Distributing the survey

The version of the questionnaire that was distributed in the survey can be seen in Appendix A. The initial intention for launching the survey was to send a link to the safety managers of the major ATC companies and airlines based within the UK, along with the military safety centres. Despite establishing links beforehand, the initial launch of the survey did not achieve the expected take up, with not all of the organisational gatekeepers agreeing to distribute the link, some citing reticence from senior management for the company to be seen to be supporting the research directly.

These setbacks encouraged the researcher to look at other organisations to assist in the distribution and much success was gained after approaching Thomson Airways, Titan

Airways, Jet2, the UKAB, the UKFSC⁵⁹, the CAA, the AOA⁶⁰, Aquila, Airways New Zealand, ATC Network and a significant number of individuals who were directed towards the link on a website established for this research⁶¹. The greatest single success from this widening of distribution came from the inclusion of the survey link in the Curt Lewis newsletter (Lewis, 2017), which achieved unintended global distribution. It was this newsletter link that generated the interest in the research from Pakistan International Airlines (PIA) and their subsequent invitation to write an article for their safety magazine (Fyfe-Green, 2017), which is included in Appendix J.

4.7 Preparing for interviews.

The reason for conducting semi-structured interviews is three-fold, firstly to discover answers to the research objectives that the survey did not achieve, secondly to garner evidence in support of the answers gained in the survey, and thirdly to validate the survey results as being representative of the UK industry. A detailed discussion of the literature supporting this course of action was presented in Section 3.3; in summary, interviews assist in validation when part of a mixed or multi method strategy, by accessing subjective opinion to support the objective achieved in a survey (Gillham, 2003).

4.7.1 Identifying the questions that the survey did not answer

First stage (descriptive) analysis of the survey data was conducted to identify which suppositions could be satisfactorily addressed at this point, and which needed further information. The survey questions were numbered to correspond with the original four questions that the research started with. A review after the survey morphed the four questions into five enabling objectives supporting a single overarching Research Question, which was described in Chapter 1. Some suppositions were merged and reworded to better support the objectives, thereby reducing the number being investigated. This means that the survey questions map across in a different order than originally envisaged; this is depicted in Table 4-3, where the revised layout is used.

⁵⁹ UK Flight Safety Committee

⁶⁰ Airport Operators Association

⁶¹ www.ifgairsafety.co.uk

Obj	S _n		Survey	Quantitative answer from the survey responses	Question still to be resolved	Interview
1	Determine if there is a correlation between an increase in the likelihood of an Airprox and changes to aviation regulation.	1	n/a	Answer will come from secondary data.	Obj 1 was not achieved from the survey.	An interview with a UKAB representative would provide an answer to this which could be correlated with analysis of the secondary data.
2	Assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation.	2a	Q2a Q2c	93% believe that errors are an inevitable part of day-to-day business in the aviation industry and 70% of all respondents feel that it is how errors are managed and dealt with that determines whether or not an error becomes an incident. 90% have witnessed an occasion when barriers have failed.	Supposition fully addressed by the survey responses.	
		2b	Q1b	95% of respondents believe that safety can be enhanced or made through their own endeavours.	Supposition fully addressed by the survey responses. Objective completed.	
3	Analyse whether humans are the weak-link in the aviation safety chain.	3a	Q2b	Only 16% of respondents believe that aviation operations are intrinsically safe, with 4% thinking it possible to completely remove human error.	Literature review derived the hypothesis, which has not been supported by the survey results.	Interview to confirm this as representative of the UK aviation industry.
		3b	Q2d	80% had at some point in their career felt overloaded by the amount of change being introduced, 64% of these confirmed that it was because of the amount of regulatory change. 5% felt that the change could not have been introduced any better than it was.	Supposition fully addressed by the survey responses.	
4	Assess if there is an active culture of learning from incidents within aviation.	4a	Q1a Q3b	67% believe that events are never random and 23% support this by saying that randomness is not very applicable to aviation. 68% believe that it is not necessary to identify only 1 cause, but 79% have experienced bias in an investigation.	Supposition fully addressed by the survey responses.	
		4b	Q3a Q3c Q3d	54% of respondents thought that it was always important to identify all errors, no matter how trivial, in order to prevent future accidents. This was supported by 34% choosing "most of the time" as their answer. 69% stated that most or all the time a well-run SMS captured every error and analysed them appropriately, whilst a further 22% agreed that this happens sometimes. 3% felt that this never happened. 58% feel that management have the same perception of risk and 84% report working in a Just culture.	Supposition fully addressed by the survey responses.	
5	Determine if changes are required to regulations to integrate drone operations.	5	Qx	1% felt that there was too much regulation, with 34% stating that extant regulations need some development and 52% saying that more regulation was needed urgently.	Supposition fully addressed by the survey responses.	Interview with a representative from each of the two regulators would provide a balance to this answer.

Table 4-3 showing the process of identifying the questions that remained unanswered after the survey

4.7.2 Selection of interviewees

Interviewees were selected for their expertise in aviation in order to provide “illustrative depth” (Kendall, 2008, p. 139) and to satisfy the requirement to provide the remaining answers to the research objectives. Whilst selecting experts is a recognised form of purposive sampling, Singh (2007) comments that ‘expert sampling’ itself can be used as a way of validating another sampling method, such as the snowball and convenience sampling used in the survey. In order to provide expertise across the spectrum of aviation, the interviewees were chosen for their specialist knowledge of the following criteria: Airprox, Pilot, Engineer, Drones, Regulation, Air Traffic Control, Safety Management, Commercial Airline, Support staff, Military and Civilian. Of the five interviewees, two are pilots, two are Air Traffic Controllers, one is an Engineer, three are experts on drones, two work for the regulator (one MAA, one CAA), one works as support staff for a commercial airline, one works for the UKAB, one is serving military, three are ex-military now working in civilian aviation, and all have a deep-seated knowledge of Air Safety Management. It is felt that the five interviewees cover all of the necessary areas that are required to be considered as experts for this research. Remaining cognisant of the ethical consideration raised previously about the researcher’s role in the military regulator, the interviewee that is serving in the military was approached as a peer who is known to the researcher and trusted to give open and honest answers.

4.7.3 Conduct of interviews

The five interviewees were approached several weeks in advance and appointments made to visit them at their workplace, or a convenient alternative location. Associated costs (travel and subsistence) were self-funded by the researcher. Prior to the interview a copy of the ‘Survey Infographic’ (Appendix B) was sent to the interviewee, along with a letter (included in Appendix E) explaining the purpose of the research and the ethical considerations of their involvement. Whilst they were assured that their names would not be identified, all five agreed that it would be acceptable for the company that they worked for to be named. The first interview was conducted by asking questions seeking opinion on current regulations and future developments first, before embarking on the validation of the survey by systematically going through each question and gaining their judgement on the majority response. In reflection post-interview, it was decided to change the order for the other four interviews, which made them flow better by doing the validation first and then delving deeper both as it progressed and at the end. This proved to work much better.

Each interview took 60-90 minutes, and a report of the interview was produced afterwards; each interviewee was approached to approve their content that is included in Appendix C.

4.7.4 Validation of survey results

The answers received in the interviews confirm the validity of the responses from the survey. This process was covered fully, and in greater detail, in Section 3.3. There were some differences of opinion and some unexpected answers; acknowledging the richness of the data, and the nuances that are highlighted, detailed analysis is presented in Chapter 6.

4.8 Limitations, reliability and validity

Ekinci (2015) suggests that the validity and reliability of a questionnaire can be assessed after it has been piloted and that a well-worded introduction can improve the response rate. He also comments that to ensure reliability the questions should be checked firstly to correct any mistakes and then secondly for consistency. After the prototype survey was closed the responses were analysed and related back to the survey questions, suppositions and research questions to determine validity. Responses to the request for a critique were checked to make sure there were no negative comments about relevance. Because the original research questions were reviewed and amended after the survey closed, a check was done on the validity of the survey, with the questions re-assessed against these new suppositions to ensure that they are still relevant to the industry and to the revised study objectives. The changes are deemed presentational to demonstrate flow and a common thread, and not fundamental to the underpinnings of the research.

The main limitations of the data collection are associated with the frustrations of access to key organisations and the relatively low proportion of Engineering staff that responded to the survey. The limitations of access were resolved and mitigated by gaining access to other airlines and organisations. It is reported that there are between 130,000 (Prendergast, 2017) and 500,000 (Gabriel, 2017) pilots worldwide. Extrapolated to include ATC, Engineer and other support staff, the global industry is estimated to be circa 3-5 million people. Aviation safety is considered to be a “*shared responsibility across the whole organisation and needs the involvement of all staff*” (CAA, 2015e). The survey population is, therefore, treated as a single homogenous group, and the sample size required at a 95% level of certainty (with a 5% margin of error) is 384 (Saunders et al., 2007). The survey was started by 560 people, of which 413 completed it (a 74% completion rate), and the results considered representative of the global industry.

4.9 Framework for data analysis

As this research uses a mixed methods approach, both quantitative and qualitative analysis is conducted on the data. Quantitative analysis is conducted on the multiple-choice answers from the survey, supported by qualitative analysis of the free text questions and the interviews. Descriptive statistics are used to provide an overview of firstly the whole survey and latterly of the data supporting the individual suppositions and objectives. The results of the analysis are presented in Chapters 5 and 6.

4.10 Corroboration of the interview analysis

In order to corroborate the analysis of the interviews, an independent researcher was approached for assistance. The candidate chosen has an ATC background, and has recently completed a Masters in Air Safety Management at City, University of London. The interview reports were anonymised, and relevant extracts combined in to a single document, which can be seen in Appendix C. This document, together with a copy of the research objectives and suppositions, was emailed to the corroborator with a request to analyse the interview reports and assess the suppositions from them. The output from this corroboration is included in Appendix G.

4.11 Summary

This chapter has presented an overview of the processes of collecting the data, both primary and secondary, which was mapped against the suppositions in order to best address them. It covered the design, development and distribution of the primary research survey and interview, as well as preparation for analysis. Ethical considerations were discussed, and the achievement of University ethics approval confirmed. The stages of refinement of the survey were detailed, together with the process of piloting and the deliberations in regard to the question structure and possible answers. The first challenge that needed to be overcome was the need to separate those that assisted with the prototype survey from the survey population as a whole. This was achieved through using head office staff from one airline (Flybe) for the prototype and then not offering the main survey to them. Further challenges were encountered in the distribution of the survey, when support was not forthcoming from anticipated organisations, which was overcome by widening the distribution to other organisations, and the accidental globalisation of the study. The chapter has explained the validation and verification of the survey, through

prototype piloting and semi-structured interviews, which were also used to enrich the data and explain some of the results from quantitative analysis. The next two chapters present the research results and analysis, Chapter 5 covers the quantitative primary data, and Chapter 6 the remainder.



Chapter 5 - Research Results and Analysis Part 1

5.1 Introduction

The aim of this chapter, and the next, is to present the research results, detailing the analysis conducted in order to answer the over-arching Research Question. Chapter 3 covered methodology, and Chapter 4 data collection, so the intent here is not to repeat the detail from these chapters, except in basic form where necessary for clarity.

The over-arching Research Question against which the suppositions are formed, and the subsequent analysis conducted against is: **Can new aviation regulation be introduced without decreasing safety?** From Table 1-1 in Chapter 1, it can be seen that the intention is to analyse the primary data against objectives 2 to 5. These supporting objectives are:

2. Assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation.
3. Analyse whether humans are the weak link in the aviation safety chain.
4. Assess if there is an active culture of learning from incidents within aviation.
5. Determine if changes are required to regulations to integrate drone operations.

The primary data was collected by the use of a web-based survey and through conducting interviews. This is then analysed quantitatively using IBM SPSS software in conjunction with some utility options within QuestionPro itself and also using Microsoft Excel; the results are presented in this chapter. The free text answers in the survey are analysed separately using qualitative methods, including QSR Nvivo, and presented in Chapter 6. Semi-structured interviews were conducted in order to validate the quantitative results and to provide further depth to answer the over-arching Research Question. Extracts from the interviews can be seen in Appendix C, which are also analysed qualitatively using Nvivo, and presented in Chapter 6. This chapter begins with a descriptive analysis of the results from the survey and is then laid out to analyse each research objective (2 to 5) in the context of the suppositions investigated.

5.2 Descriptive analysis of online questionnaire survey

An online survey garnered the opinions and perceptions of aviation personnel to investigate the suppositions formed from the literature review. The survey was hosted by QuestionPro and distributed by means of an electronic link either in a targeted email through company safety managers, through an article on LinkedIn or via the website established for this research⁶². The survey was developed in late 2016 and launched to the intended population in January 2017. Those people who assisted with the pilot study and development of the final question set were not invited to complete the public survey itself. This process is covered in detail in Chapter 4.

Originally targeted at the UK aviation industry, the survey achieved unintended global distribution when it appeared in several editions of an industry flight safety newsletter with a worldwide readership (Lewis, 2017). As can be seen from Figure 5-1, the survey was viewed by 1104 people in 56 different countries around the world (55 countries plus ‘unknown’). Of the 560 people who started to answer the questions, 413 completed responses were received, representing a completion rate of 74%. The initial estimate of 10 minutes to complete the questionnaire was a reasonable estimate as the average time taken across all respondents was 12 minutes, although this does rise to an average of 15 minutes when only comparing fully completed responses. In analysis, it is discovered that once the data is scrubbed to remove the partial answers, 45 countries have fully completed responses recorded against them, including the category ‘unknown’.

The results in Figure 5-1 are compiled automatically by the QuestionPro software, including the country in which the questionnaire was completed. It must be noted that the country specified does not necessarily represent the nationality of the respondent, instead it captures the country in which the software recognised the IP address of the device used to complete the survey, but if a VPN⁶³ was used this might not be an accurate reflection of location. In nine cases the software did not record the country and in one case it recorded the response against EU rather than a more specific country. It is not known why this has happened, but it does not significantly bias the results of the data. A record of the country was not designed into the methodology, and is an unintended benefit, which enables an extra dimension to the analysis.

⁶² www.ifgairsafety.co.uk

⁶³ Virtual Private Network

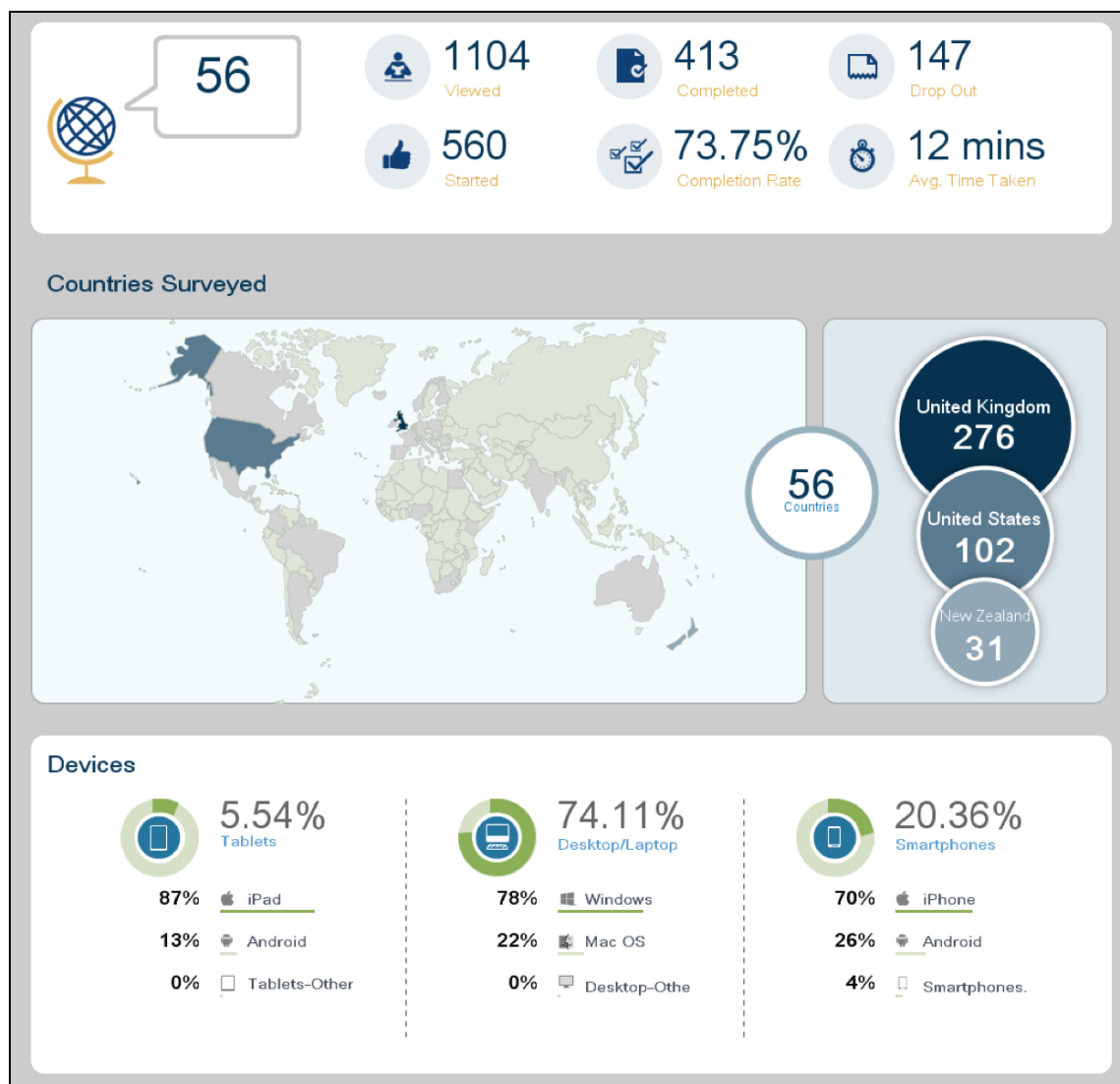


Figure 5-1 showing a summary of the survey data background statistics

Of the 45 countries recorded (44 actual countries plus ‘unknown’), by far the biggest number of responses came from within the UK, the next being the USA and then New Zealand. The countries are listed in Table 5-1. Figure 5-2 shows the statistics for fully complete responses.

	Code	Country	Percentage of completed responses	Number of completed responses
1	GB	GREAT BRITAIN	53%	217
2	US	USA	16%	66
3	NZ	NEW ZEALAND	6%	23
4	AE	UAE	2%	10
5		unknown	2%	9
6	FR	FRANCE	2%	8
7	BE	BELGIUM	2%	8
8	AU	AUSTRALIA	2%	7

9	CA	CANADA	2%	7
10	CY	CYPRUS	2%	7
11	HK	HONG KONG	<1%	4
12	NO	NORWAY	<1%	3
13	PK	PAKISTAN	<1%	3
14	IT	ITALY	<1%	3
15	PH	PHILLIPINES	<1%	2
16	TH	THAILAND	<1%	2
17	ZA	SOUTH AFRICA	<1%	2
18	IN	INDIA	<1%	2
19	ES	SPAIN	<1%	2
20	GR	GREECE	<1%	2
21	DE	GERMANY	<1%	2
22	BB	BARBADOS	<1%	1
23	HT	HAITI	<1%	1
24	JM	JAMAICA	<1%	1
25	HN	HONDURAS	<1%	1
26	PL	POLAND	<1%	1
27	HU	HUNGARY	<1%	1
28	RO	ROMANIA	<1%	1
29	JE	JERSEY	<1%	1
30	FI	FINLAND	<1%	1
31	IM	ISLE OF MAN	<1%	1
32	IS	ICELAND	<1%	1
33	GF	FRENCH GUIANA	<1%	1
34	BR	BRAZIL	<1%	1
35	CO	COLOMBIA	<1%	1
36	IR	IRAN	<1%	1
37	AL	ALBANIA	<1%	1
38	RS	SERBIA	<1%	1
39	PT	PORTUGAL	<1%	1
40	TR	TURKEY	<1%	1
41	IL	ISRAEL	<1%	1
42	OM	OMAN	<1%	1
43	CH	SWITZERLAND	<1%	1
44	NL	NETHERLANDS	<1%	1
45	EU	EUROPEAN UNION	<1%	1

Table 5-1 showing the country where completed responses were received from



Figure 5-2 showing a representation of global survey distribution for fully completed responses

Whilst the global coverage may look impressive, the small number of respondents in many countries make analysis by country alone unrealistic. Respondents are therefore grouped by sub-continent and continent (Adrian World Design, 2017), as shown in Table 5-2 and Figure 5-3, although for the purposes of avoiding confusion between Australia mainland and Australia continent with Australasia and Oceania regions, the term Australasia is used consistently to capture the responses from both Australia and New Zealand.

Sub-continent	Completed responses		Continent	Completed responses	
	Number	Percentage		Number	Percentage
Northern Europe	224	54%	Europe	257	62%
Northern America	73	18%	North America	77	19%
Australia & New Zealand	30	7%	Asia	34	8%
Western Asia	20	5%	Australasia	30	7%
Western Europe	20	5%	unknown	10	2%
unknown	10	2%	South America	3	<1%
Southern Europe	10	2%	Africa	2	<1%
Southern Asia	6	1%	Antarctica	0	0%
Eastern Asia	4	<1%			
South-Eastern Asia	4	<1%			
Caribbean	3	<1%			
Eastern Europe	3	<1%			
South America	3	<1%			
Southern Africa	2	<1%			
Central America	1	<1%			

Table 5-2 showing the number and percentage of completed responses by sub-continent and continent

Figure 5-3 shows that the top four continents by percentage for fully completed responses are Europe, North America, Asia and Australasia. All fully completed responses are used in analysis of the individual questions and suppositions. However, when continents are cross-referenced only the top four are used, representing 96% of the respondents. Once the respondents are grouped by continent it can still be seen that the numbers are insufficient to provide a representative data sample and therefore not of a sufficient quality to make meaningful comparison between the countries, continents or regions. Within the analysis to follow, there are some comments made about regional variations, for instance comparing the responses between the USA and Great Britain, but in general the data can only be considered to represent the global aviation industry as a whole. Any reference in the analysis to a comparison is made with the explicit understanding that it is merely a possible explanation and the small numbers acknowledged. This point is reflected upon in Section 8.2.

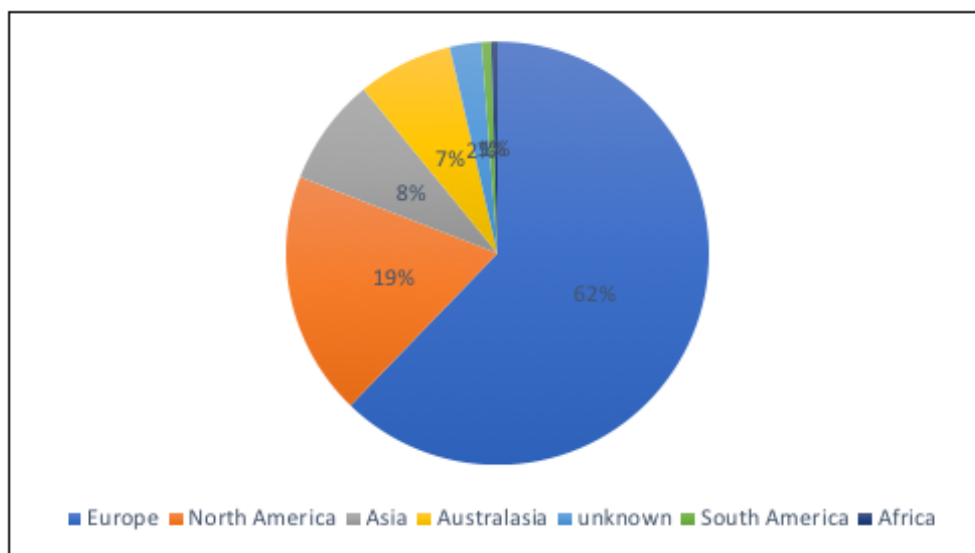


Figure 5-3 showing the breakdown of responses by continent

5.2.1 Incomplete responses

In the introduction to the survey, respondents were assured that they could withdraw from the survey at any point up until final completion and their data would not be retained. Once the survey was closed, the responses that were not fully completed were looked at to see if any country could be seen to have a greater proportion of dropouts in relation to fully completed responses, perhaps as an indicator of a fear to report or the lack of a Just Culture. All of the partially completed responses were then deleted and only the fully completed ones downloaded for analysis.

From the partially completed responses it was noted that there was a 100% dropout from North, West and East Africa; only South Africa as a country registered any completed responses from the African continent and even that was after a 50% dropout. There was a 35% dropout in Western Asia compared with a 9% dropout in Western Europe with a similar number of respondents. All countries which registered 100% dropout had only one or two respondents. Whilst it may be plausible to make inferences as to the reporting culture in Africa, the remaining data on dropouts is deemed inconclusive due to the small numbers of respondents in these countries.

90% of the dropouts happened in the first minute of opening the questionnaire, 80% of the total dropouts happened on the first question. 95% of dropouts had occurred within five minutes, with the remaining 5% dropping out after 30 minutes. It is opined that this would likely represent someone who was called away from their desk at work, and may later have restarted the survey, rather than someone who did not intend finishing. 15% of the dropouts occurred at the first free text question (despite it being optional) and 1% dropped out when asked if they felt that their organisation had a Just Culture. No-one dropped out when asked the categorical questions at the end to determine which of the 'Four Worlds' they came from and the time they had been in the industry and current role. The term 'Four Worlds' is introduced in Chapter 2 of this thesis to categorise respondents as Aircrew, Engineer, Air Traffic Management or Other Support Staff; 'Fourth World' is used to collectively describe personnel who support the delivery of aviation but do not fall into the bracket of the other three. The terms were not used in the survey itself, as they are not well-known industry-wide.

Given the assurance that the data would not be saved it was felt that ethically the incomplete responses should be deleted from QuestionPro and could not be downloaded for analysis.

5.2.2 Classification Questions

The questionnaire culminated with two classification questions, the first asking which of the 'Four Worlds' the respondent belonged to and the second broken down into two parts to ascertain length of time in current post and the number of years in the industry. If a respondent selected "Other Support Staff" they were asked to specify further; this is an attempt to discover boundaries to the 'Fourth World' from those that were part of it. With regards to length of service, the respondent was asked to choose a bracket of <1 year, 1-5 years, 6-10 years, 11-15 years and >16 years. It was anticipated that the longer someone

had served in the industry the more inclined they would be to assist in the survey; it is often the case that the safety management team will primarily consist of the more experienced people in the organisation. However, it was hoped that there would be a suitable spread of experience amongst the respondents and that some of the less experienced would feel inclined to provide their opinions. The questionnaire was designed with this in mind and attempted to appeal to young and old alike.

Figure 5-4 shows the breakdown between the ‘Four Worlds’, as classified by the respondents themselves.

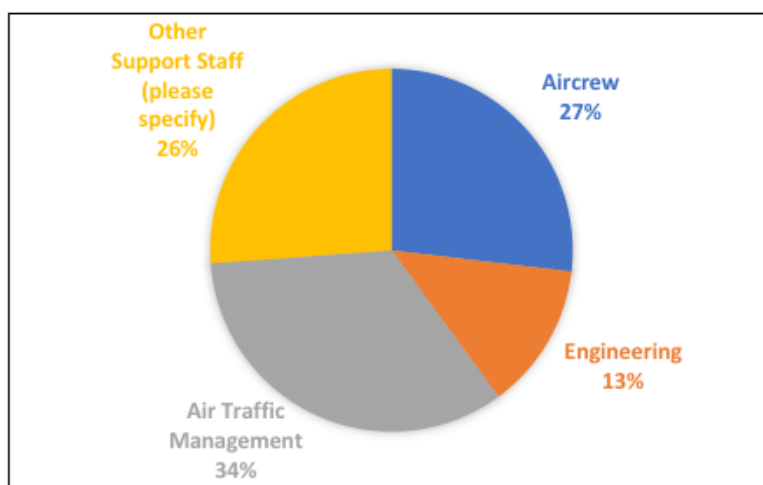


Figure 5-4 showing the breakdown of which of the ‘Four worlds’ respondents classified themselves as

The elements of the ‘Fourth World’ are captured in Table 5-3; duplicates have been removed (one answer does not represent one person), some of the longer answers simplified and a number of specific statements redacted to maintain the anonymity of the respondent. Several respondents from ATC⁶⁴ chose to categorize themselves as ‘Other’ rather than ATM⁶⁵, which is an all-encompassing term that includes ATC. ATM is a term used to cover the three elements of ATC, Air Traffic Flow Management and Aeronautical Information Services (Eurocontrol, 2017a), and it was assumed that ATC would select the ATM option. It is possible that in some countries outside of Europe, ATM might mean something else, perhaps the management aspect (the M of ATM) may be taken to mean those in management positions rather those actually controlling aeroplanes. For the purposes of the analysis the data is used as it stood, i.e. those that ticked ‘other’ but stated ATC are left in the ‘other’ bracket and not manually moved. The numbers are small and deemed not to add any inappropriate bias or skew.

⁶⁴ Air Traffic Control

⁶⁵ Air Traffic Management

Accident Investigation
Administration - Accountable Manager
Agent
Air Safety
Air Safety - previously a pilot
Air Safety cell
Air Traffic Control
Air Traffic Control, UAS research for self-separation and Human Factor Integration
Air Traffic Controller (Retired) Air Traffic Controller SME (Presently)
Air Traffic Management & latterly Safety Management (left the industry now)
Aircraft Mechanic and assistant safety manager
Airfield Operations
Airport
Airport Management
Airport Manager
Airport Operations
Airport Operator
Airport Safety Management
Airside Safety Manager
Airspace regulation specialist
Also work as a safety personnel for 3 years
Assurance Specialist
ATC, ATM (Regulator at DGCA), Project specialist EUROCONTROL, CONOPS expert ADP-i ...and finally retired
Authority
Aviation researcher
Aviation Safety Analyst
Aviation Safety Inspector for the FAA, headquarters in Washington, DC
Aviation Safety Manager
Aviation safety team
CAA
Commercial and Private Yachts
Consultant specializing in regulatory reform and SMS
Crew Planning
Currently a Flt Cdr but spent 2 years at 2 Gp Air Safety as the Assurance lead.
Director General [Retired] of an airline trade association, past member of the Board of Flight Safety Foundation
Engineering and project development at ANSP
Ex aircrew, now work within safety
Ex-ATCO, Aviation Lawyer
FAA Air Traffic Control Safety Risk Management Specialist
Fixed Base Operator
Former aircrew, now regulator
Fractional Aircraft Management
Ground Operations Safety and Compliance

Ground service
Head of strategy ATM Industry
Human Factors
Instrument flight procedure
Insurance
Logistics
Maintenance Planning
Management
My role in my airline (before retirement) involved all 3 of the above disciplines [ie Aircrew, ATM, Engineer]
National supervisory authority, ATM/ANS
Operations Manager and Chief Pilot
Part 119 Director of Safety, Regional Part 121 Air Carrier
Pilot and FOQA Analyst
Previously with a regulator, now independent consultant
Processing navigation data for flight planning
Quality Engineering at a major aircraft manufacturer
R&D
RAF, responsible for admin/engineering/aircrew documentation including operational roles, then many in the NHS
Regulation
Regulator
Regulatory
Rescue and Firefighting, H&S and Fuel Services Manager
Safety system development and auditing
Safety
Safety (Aircrew background)
Safety & Risk Manager
Safety Analysis - former military aircrew, current civilian Flying Instructor
Safety and compliance
Safety and compliance management
Safety department
Safety investigation
Safety Management / Emergency Response / Planning
Safety Management consultancy
Safety manager
Safety Policy Officer and OH&S Auditor
Safety Risk Management and Unmanned Air Systems
Safety/Quality Management
Systems Safety Engineering
Training
Transport

Table 5-3 showing the areas that were specified as being part of “Other Support Staff”

Figure 5-5 represents the data from the question on how long the individual had been in their current post. This question was included to see if there would be a range of respondents' experience within their respective organisations, and there is.

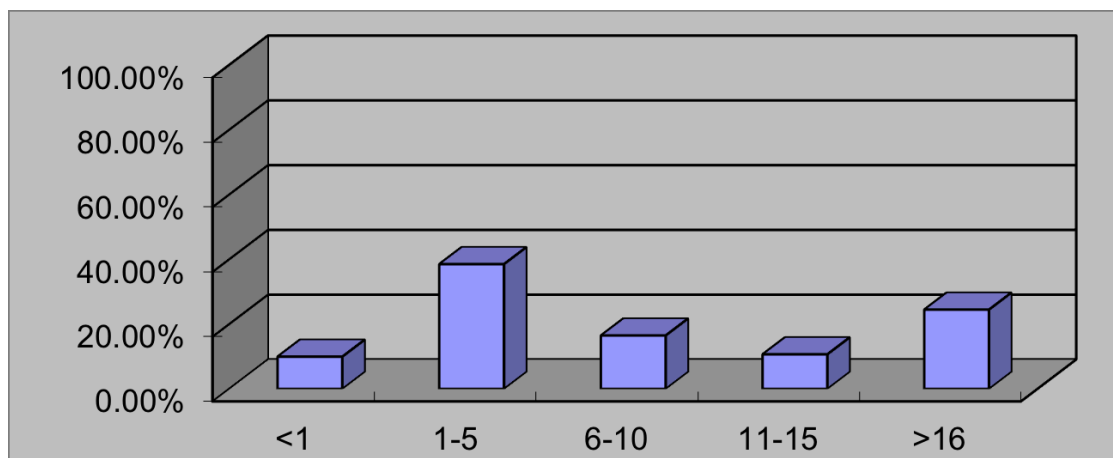


Figure 5-5 showing the percentage of respondents grouped by the number of years they had been in their current post

Of greater interest is Figure 5-6, which depicts the experience level of the respondents. It was assumed that participants were likely to be more experienced because of their general desire to influence the industry coupled with the likelihood that those with safety responsibilities would be those with more time served. It can clearly be seen in this Figure that as expected the majority of respondents had spent over 16 years in the industry (66%). 20% of respondents had been in aviation for 10 years or less, with the survey attracting ten responses from those in their first year in the industry. This shows that the survey did appeal to those new to the industry, as well as the stalwarts, and is seen as a success in capturing the ideas, opinions and concerns of all.

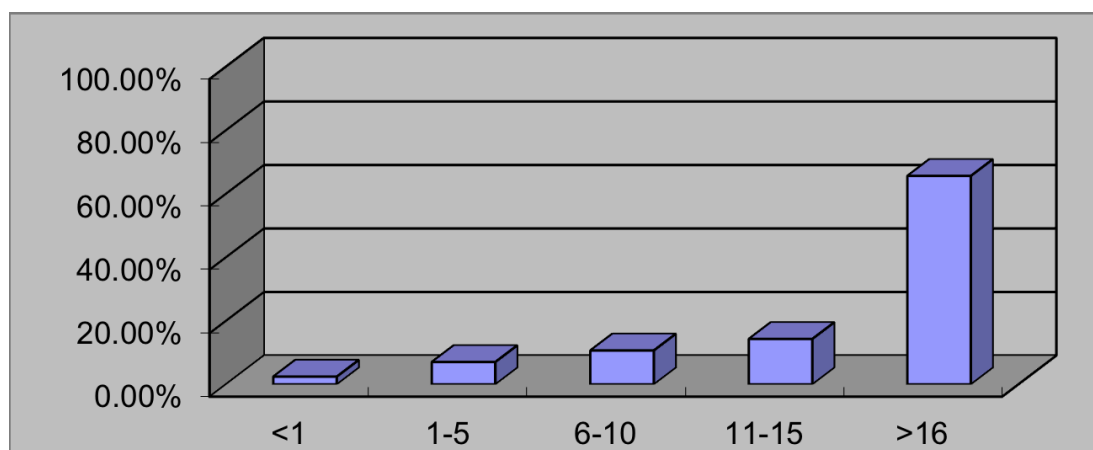


Figure 5-6 showing the percentage of respondents grouped by the number of years they had been employed in the aviation industry

5.3 Quantitative analysis by individual research objective

Table 5-4 shows which survey question relates to the individual objectives and suppositions, and this part of the analysis is laid out by objective in order to address the suppositions associated with each of them. Objective 1 is answered in Chapter 6 where the secondary data analysis is presented. The question numbers relate to the data ‘behind the scenes’ but were not seen in the survey. The questions are in Appendix A, which shows the question number in relation to Table 5-4 as well as the screenshot of the questionnaire as seen by the respondent at the time of completion.

Obj		S _n		Survey
1	Determine if there is a correlation between an increase in the likelihood of an Airprox and changes to aviation regulation.	1	The introduction of regulatory change can increase the likelihood of an Airprox.	n/a
2	Assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation.	2a	Errors occur, but only if left unmanaged do they increase risk.	Q2a Q2c
		2b	Humans make safety through their efforts and expertise; this implies that new regulation can be safely introduced through human endeavour and training.	Q1b
3	Analyse whether humans are the weak link in the aviation safety chain.	3a	It is widely considered in the aviation industry that eradicating human error will achieve safety of operations.	Q2b
		3b	Humans can be subject to information overload during regulatory change.	Q2d
4	Assess if there is an active culture of learning from incidents within aviation.	4a	There is a temptation to rationalize every incident with hindsight bias and not acknowledge that some events are ‘Black Swans’.	Q1a Q3b
		4b	The capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome.	Q3a Q3c
5	Determine if changes are required to regulations to integrate drone operations.	5	There is not enough regulation on the use of drones and more is needed urgently.	Qx

Table 5-4 showing which survey question maps across to which supposition and objective

All of the quantitative data collected is assessed as being categorical; although there could be an argument for the length of service questions to be considered as continuous interval, they are declared as being categorical ordinal at the start of the analysis, with the option to review later if necessary. Table 5-5 shows the classification of the variables associated with each question asked (see Appendix A for the questions).

Question	Variable
Q1a	Ordinal
Q1b	Dichotomous
Q2a (1)	Dichotomous
Q2a (2)	Ordinal
Q2b (1)	Dichotomous
Q2b (2)	Dichotomous
Q2c	Dichotomous
Q2d (1)	Dichotomous (‘N/A’ discounted)
Q2d (2)	Dichotomous (‘N/A’ discounted)
Q2d (3)	Dichotomous (‘N/A’ discounted)
Q3a (1)	Ordinal
Q3a (2)	Ordinal
Q3b (1)	Ordinal (if ‘sometimes’ the middle value) or Nominal
Q3b (2)	Ordinal (if ‘sometimes’ the middle value) or Nominal
Q3b (3)	Ordinal (if ‘sometimes’ the middle value) or Nominal
Q3c (1)	Ordinal (if ‘the same’ the middle value) or Nominal
Q3c (2)	Dichotomous
Qx	Ordinal
World (ATM, Aircrew, Eng, Other)	Nominal
Time in current post	Ordinal
Time in aviation industry	Ordinal
Country where survey completed	Nominal

Table 5-5 showing the classification of the quantitative data variables by survey question

5.3.1 Extra question

The question denoted as ‘Qx’ was an extra question added in, which at the time didn’t relate to one of the original research questions but was seen as being an emergent issue once the research had begun. It was added before ethics approval was gained and supported a stated supposition that had developed from the literature on the exponential rise in Airprox reports in 2015/16. It did not directly relate to one of the four original research questions but was deemed important enough to include as it could be seen that drone regulation was coming to the forefront of aviation discussion, with the UK

Government and EASA⁶⁶ consultations looming and the research that the CAA⁶⁷ was conducting on the subject. The research review in 2017 included this issue as a research objective that directly supported the over-arching Research Question, which verified that this had been a valid question to ask. The data gained from this question was submitted to both the UK Government and EASA public consultations and, therefore, the research directly influenced the position of those organisations when they published their recommendations in late 2017.

5.3.2 Objective 2

The objective is to assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation, by understanding the perceptions of those surveyed. Two suppositions are associated with this objective, firstly (S_{2a}) that errors will always occur but only when left unmanaged do they increase risk to life and secondly (S_{2b}) that humans can make things safer through their efforts and expertise, implying that human endeavour and training can be used to introduce changes safely. These suppositions are addressed by reference to questions 1b, 2a and 2c in the survey which are on pages A-3, A-4 and A-6 in Appendix A.

In question 1b, respondents were given a statement that humans make safety through their efforts and expertise (Woods et al., 2010), and were invited to agree or disagree whether they felt that safety could be ‘made’ through endeavours in their organisation. There are 413 valid responses, of which 395 agreed with the statement and 18 did not, therefore 96% of the respondents agreed that safety can be made. A binomial test⁶⁸ is applied to the following pair of hypotheses:

- *Null hypothesis*: the proportion of respondents who agree with the claim is 0.5.
- *Alternative hypothesis*: the proportion of respondents who agree with the claim is significantly higher than 0.5.

The test shows that the proportion of respondents who answered ‘Yes’, agreeing with the statement, is significantly higher than 0.5 ($p < 0.001$). Therefore, the null hypothesis is

⁶⁶ European Aviation Safety Agency

⁶⁷ Civil Aviation Authority

⁶⁸ A Binomial Test is a nonparametric test that “compares the observed frequencies of the two categories of a dichotomous variable to the frequencies that are expected under a binomial distribution with a specified probability parameter” (IBM, n.d., para 1). It is not necessary to assume the distribution shape, but there is an assumption of random sampling, and that the sample is representative of the population of interest.

rejected, and evidence shows that a significant majority of the population of interest believe that humans can make safety through their efforts and expertise, implying that new regulations can be introduced safely through human endeavour and training.

In question 2a, respondents were shown the supposition and firstly asked if they agreed that errors are an inevitable part of day-to-day business in the aviation industry (*Yes or No*) and then presented with the options of *Not at all, Somewhat and Completely* to gauge how much they agreed with the statement that ‘it is how these errors are managed and dealt with that determines whether or not an error becomes an incident’. The answers to the first question are coded as a dichotomous categorical variable and the answers to the second are measured as a 3-stage Likert scale.

Conducting a binomial test to examine the dichotomous variable in the first part of question 2a, using the same pair of hypotheses, reveals that the number of respondents answering ‘Yes’ is again significantly higher than 0.5 ($p < 0.001$) and the null hypothesis rejected. The results are shown in Figure 5-7.

- *Null hypothesis*: the proportion of respondents who agree with the claim is 0.5.
- *Alternative hypothesis*: the proportion of respondents who agree with the claim is significantly higher than 0.5.

The second part of question 2a is classified as an ordinal variable and a Spearman Rank-Order Correlation test considered. However, the basic scatter plots of the proposed tests show no sign of a monotonic relationship and the test is not deemed appropriate. A binomial test is conducted, but in order to distinguish those who agreed, or somewhat agreed, from those who disagreed, differentiation is made to group ‘Somewhat’ and ‘Completely’ together by using the cut point feature to isolate the ‘Not at all’ response. The results are also shown in Figure 5-7, where it can be seen that the null hypothesis is rejected. 94% of respondents perceive error to be inevitable and 98% perceive that it is how error is managed that is important.

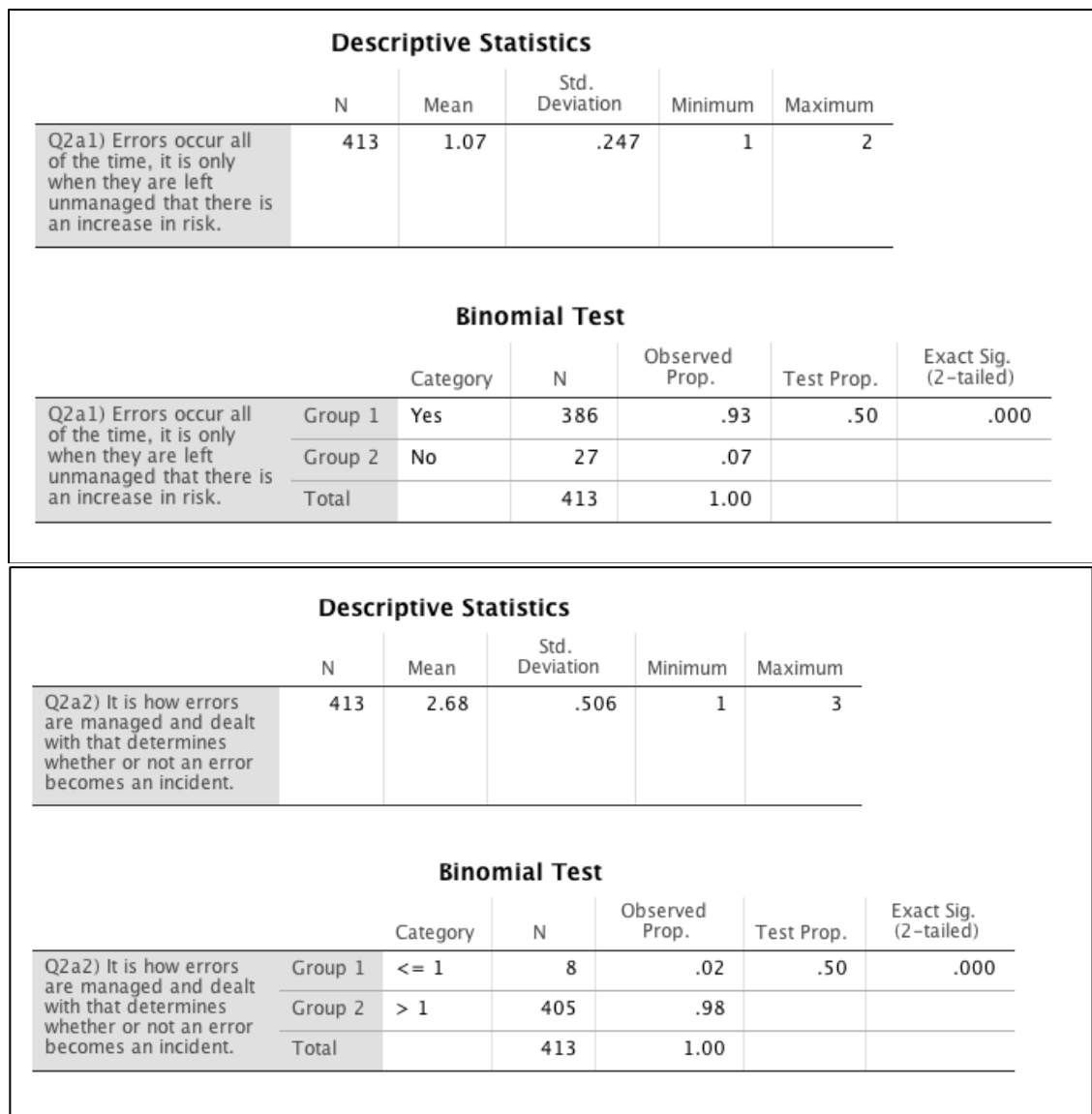


Figure 5-7 showing the results of a binomial test on Q2a using SPSS

Looking at the 27 respondents who answered ‘No’ to the first part of the question, the split across ‘Somewhat’ and ‘Completely’ to the second half is 44% and 52 % respectively. So, these people perceive that error is not a day-to-day inevitability but agree that how an error is managed can impact the outcome. In their majority view (96%), it is not possible to remove human error from the workplace, 82% of them perceive that their SMS captures and analyses errors ‘some’ or ‘most’ of the time and 67% report that they work within a Just Culture. There are no trends seen in relation to country, region or trade and there is a spread of representation from across the length of service data, with each category represented. Of the 8 respondents that said ‘not at all’ in relation to the management of error, 63% answered the survey in the UK, but the remainder of their answers show no specific correlation. The only significant deduction that can be made from cross-referencing their responses is that: this small group (7%) think it impossible to remove human error from the workplace, which implies that errors are inevitable; they disagree

that it is how these errors are managed that stops an incident happening, so it must be their perception that risk does not increase when errors are left unmanaged.

In question 2c, respondents were told that in normal circumstances there are multiple barriers in place to ensure safe operations, and they were asked ‘have you ever witnessed a time when one of these barriers was breached, but the incident was prevented from developing by the presence of another barrier?’ A dichotomous option of ‘Yes’ or ‘No’ was offered. They were also given an opportunity to give an example of this situation in a free text box, analysis of which is presented in Section 6.2. 91% of participants reported that they had witnessed a time when a barrier had been breached, and another barrier had prevented the event from becoming an incident. More interesting than the breakdown by Four Worlds of these ‘Yes’ votes, is the percentage of each world that responded ‘Yes’; 93% of Aircrew said ‘Yes’, 80% of Engineers, 95% of ATM and 90% of Other Support Staff. This shows that most of the operators (Aircrew and ATM) surveyed have seen a situation with multiple barriers where one has failed, and another has stopped it becoming an accident. When a barrier is thought of as a form of safety management, it can be seen that it is how errors are managed that prevents an accident. It is interesting that the ‘Fourth World’ also has a high percentage of respondents that have witnessed this error management in play and the deduction from the lower percentage from engineers is that their procedures are robust enough that on more occasions the error is prevented at the first barrier.

It has been shown that the majority of respondents perceive that:

- safety can be made through individual endeavour within an organisation,
- errors are inevitable, it is only when left unmanaged that there is an increase in risk,
- it is how errors are managed and dealt with that determines whether or not an error becomes an incident,
- they had witnessed occasions with more than one barrier in place, which successfully prevented an error becoming an incident.

S_{2a} and S_{2b} are considered true and the research objective to ‘assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation’ achieved. 96% of respondents believe that safety can be made by individuals, 94% perceive error to be inevitable and 98% think that it is how errors are managed that is important. It is, therefore, deduced that it is possible to introduce change safely through individuals’ efforts in managing the inevitable errors; such endeavours could be things like

ensuring that adequate training is conducted, and supportive management practices occur. Key to preventing an accident is having more than one barrier in place, which links to the management of error. This agrees with the literature reviewed in Section 2.4, and with the opinion of Woods et al. (2010).

5.3.3 Objective 3

In order to achieve this objective, the opinions of survey respondents are analysed to see if humans are perceived to be the weak link in the aviation safety chain. Two suppositions are associated with this objective, firstly (S_{3a}) that it is widely considered in the aviation industry that eradicating human error will achieve safety of operations, and secondly (S_{3b}) that humans can be subject to ‘information overload’ during regulatory change. These suppositions are addressed by reference to questions 2b and 2d in the survey which are on pages A-5 and A-7 in Appendix A.

Question 2b consists of two parts, the first to ascertain if the respondent perceives that aviation operations are intrinsically safe up to the point a human gets involved, and secondly to ask if the respondent believes it possible to completely remove human error from the workplace. Both questions are dichotomous with a Yes/No answer for each. There are 413 valid responses, of which 345 (84%) answered ‘No’ they do not perceive aviation operations to be intrinsically safe and 398 (96%) believe that it is not possible to completely remove human error from the workplace. This is represented in Figure 5-8.

Frequency Table					
Q2b1) Do you believe that aviation operations are intrinsically safe until the point a human becomes involved?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	68	16.5	16.5	16.5
	No	345	83.5	83.5	100.0
	Total	413	100.0	100.0	
Q2b2) In your opinion, is it possible to completely remove human error from the workplace?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	15	3.6	3.6	3.6
	No	398	96.4	96.4	100.0
	Total	413	100.0	100.0	

Figure 5-8 showing a frequency distribution analysis of Q2b using SPSS

Two binomial tests are applied to examine whether a statistically significant majority of the respondents supported the claims, or not. For each test, the following pairs of hypotheses are used:

- *Null hypothesis*: the proportion of respondents who disagree with the claim is 0.5.
- *Alternative hypothesis*: the proportion of respondents who disagree with the claim is significantly higher than 0.5.

The tests show (Figure 5-9) that the proportions of respondents who answered ‘No’ to both questions is significantly higher than 0.5 (both $p < 0.001$). The null hypothesis is therefore rejected for each test. Based on this sample, evidence is shown to conclude that a significant majority of the population of interest do not believe that aviation operations are intrinsically safe until the point a human becomes involved and that it is not possible to completely remove human error from the workplace. In this regard, S_{3a} is not supported by the statistical inference, which is contrary to the opinions in some of the literature reviewed in sub-Section 2.4.1, such as Woods et al. (2010) and Shorrock (2017), but supports others (for example Bainbridge, 1983; Kontogiannis & Malakis, 2009) who posit that humans cannot be removed and that even if it were possible to eradicate human error, this would not achieve the safety of operations.

Binomial Test						
	Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)	
Q2b1) Do you believe that aviation operations are intrinsically safe until the point a human becomes involved?	Group 1	No	345	.84	.50	.000
	Group 2	Yes	68	.16		
	Total		413	1.00		
Q2b2) In your opinion, is it possible to completely remove human error from the workplace?	Group 1	No	398	.96	.50	.000
	Group 2	Yes	15	.04		
	Total		413	1.00		

Figure 5-9 showing the results of a binomial test on Q2b using SPSS

68 respondents believe aviation operations to be intrinsically safe up to the point that a human becomes involved. The country in which these responses were made is shown in Figure 5-10, with GB accounting for 51%. Of these 68, only one person subsequently thought that it is possible to completely remove error from the workplace, which is considered as an outlier. 65 of these respondents answered ‘Yes’ to the question about whether safety can be made through human endeavour and a different 65 (of the 68) answered that errors are an inevitable part of day-to-day business in the aviation industry. These answers seem counter-intuitive; if someone feels that humans make things unsafe,

then surely it would be possible to remove error by removing the human? This is what one person thought, the others it is assumed perceive that it is not possible to remove the human and therefore not remove the error. Presumably this is because 65 of them felt that the addition of a human could make things safer, as long as they were trying to do so through endeavour, even though error is perceived as being inevitable.

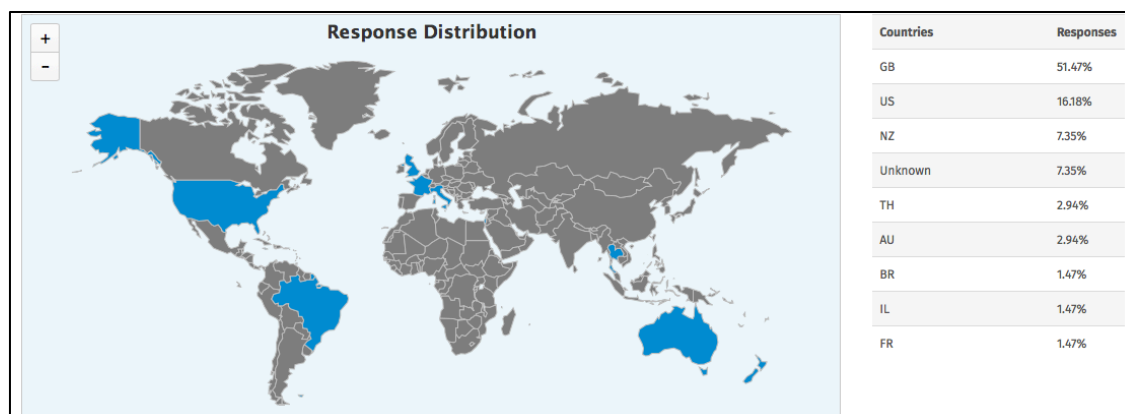


Figure 5-10 showing the global distribution of the 68 respondents that believe aviation operations to be intrinsically safe, until the point a human becomes involved

Question 2d was designed to answer S_{3b}, that humans can be subjected to information overload during regulatory change. Three sub-questions were asked, the first ascertains if the respondent has ever felt overloaded by the amount of change being introduced at once, the second about whether this was due to regulatory change and the third is to seek opinion on whether the changes could have been introduced better. The variables are considered to be dichotomous because an answer of N/A (the third option) is not a meaningful reply in relation to the supposition; the first sub-question asked if the respondent has ever felt overloaded, this should be a straightforward ‘Yes’ or ‘No’ answer, the option of N/A was given in relation to the second and third sub-question for when the answer to the first was ‘No’. Ideally, the survey would have allowed for the staged response of Yes/No to start and then an automatic N/A for ‘No’ answers, but whilst the software professed to be capable, the student licence did not facilitate this advanced feature. As can be seen in Figure 5-11, four respondents chose the N/A option in the first part and the rest of their responses to that question are not valid. However, it can also be seen that 332 (80%) of responses are that ‘Yes’ they had felt overloaded by the amount of change and for 265 of these 332 (80%) positive responses, the reason was regulatory change.

Frequency Table					
Q2d1) Have you ever felt overloaded by the amount of change being introduced at once?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	332	80.4	80.4	80.4
	No	77	18.6	18.6	99.0
	NA	4	1.0	1.0	100.0
	Total	413	100.0	100.0	

Q2d2) If Yes, was this in relation to changes in Regulations?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	265	64.2	64.2	64.2
	No	73	17.7	17.7	81.8
	NA	75	18.2	18.2	100.0
	Total	413	100.0	100.0	

Q2d3) In your opinion could these changes have been managed better?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	336	81.4	81.4	81.4
	No	21	5.1	5.1	86.4
	NA	56	13.6	13.6	100.0
	Total	413	100.0	100.0	

Figure 5-11 showing a frequency distribution analysis of Q2d using SPSS

The majority viewpoint is easily assimilated from the pie charts at Figure 5-12. The global distribution of the respondents who had felt overloaded by regulatory change is shown in Figure 5-13, where it can be seen that GB has the highest percentage at 60%, but seven other countries worldwide are represented, as are all six of the continents from which a response was received. The GB figure is broadly comparable with the overall 53% GB-coded responses to the survey itself. This shows that overload through regulatory change is not restricted to any particular region and applies in many parts of the world.

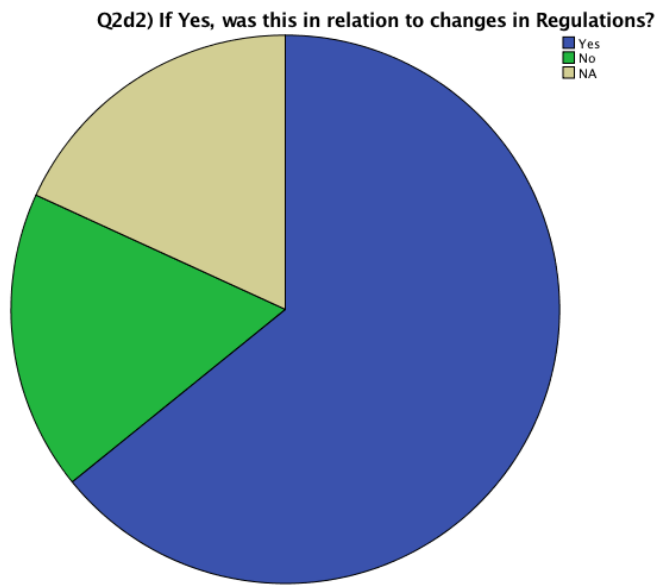
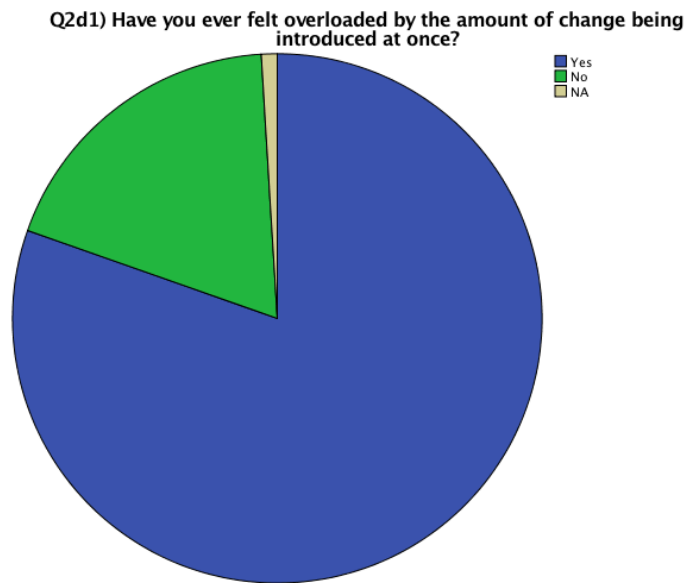


Figure 5-12 showing a pie chart of answers to parts 1) & 2) of Q2d

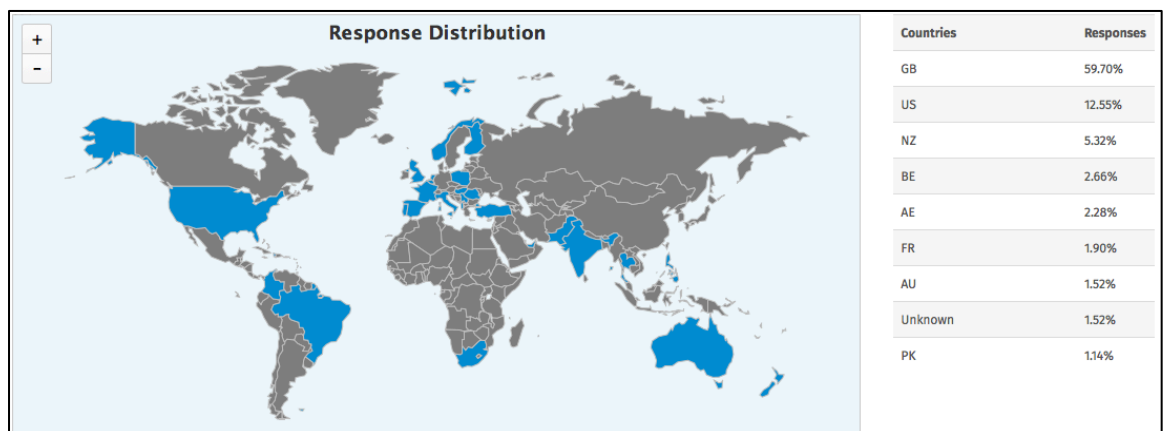


Figure 5-13 showing the global distribution of respondents who answered 'Yes' to both parts 1) & 2) of Q2d

Figure 5-14 illustrates the breakdown of the respondents who reported overload through regulatory change by ‘Four Worlds’, which shows 27% Aircrew, 13% Engineer, 35% ATM and 25% Other Support Staff. This almost exactly matches the breakdown of classifications for the overall survey (Figure 5-4), which shows that overload through regulatory change is equally applicable across each area of aviation.

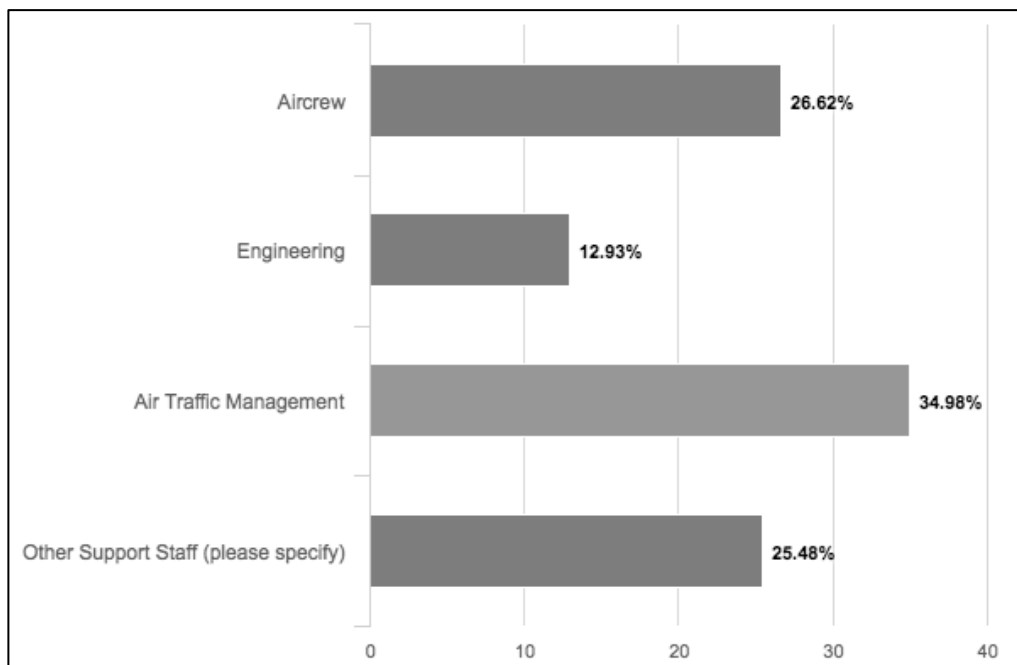


Figure 5-14 showing the worldwide breakdown of the Four Worlds in relation to respondents who answered ‘Yes’ to both parts 1) & 2) of Q2d

When GB is isolated the graph is very similar and is depicted at Figure 5-15, although there is a higher proportion of Engineers and Aircrew in comparison to the worldwide figure. This implies that a higher proportion of the Engineers and Aircrew from GB, in comparison to the rest of the world, reported that they had experienced a time when they had felt overloaded by changes in regulations.

When isolating worldwide Aircrew from Figure 5-14, the length of service within the industry is 57% over 16 years, and only 1% under 6 years. For worldwide ATM personnel, the figures are 73% over 16 years, 3% under 6 years. On the other hand, Engineers have a greater spread of experience, with 41% over 16 years, and 27% under 6 years, but with all of them (100%) suggesting that the changes could have been managed better. 96% of Aircrew and ATM staff are of the opinion that the changes could have been managed better. This implies that irrespective of experience levels, the vast majority of respondents felt that the implementation of regulatory change could be managed better.

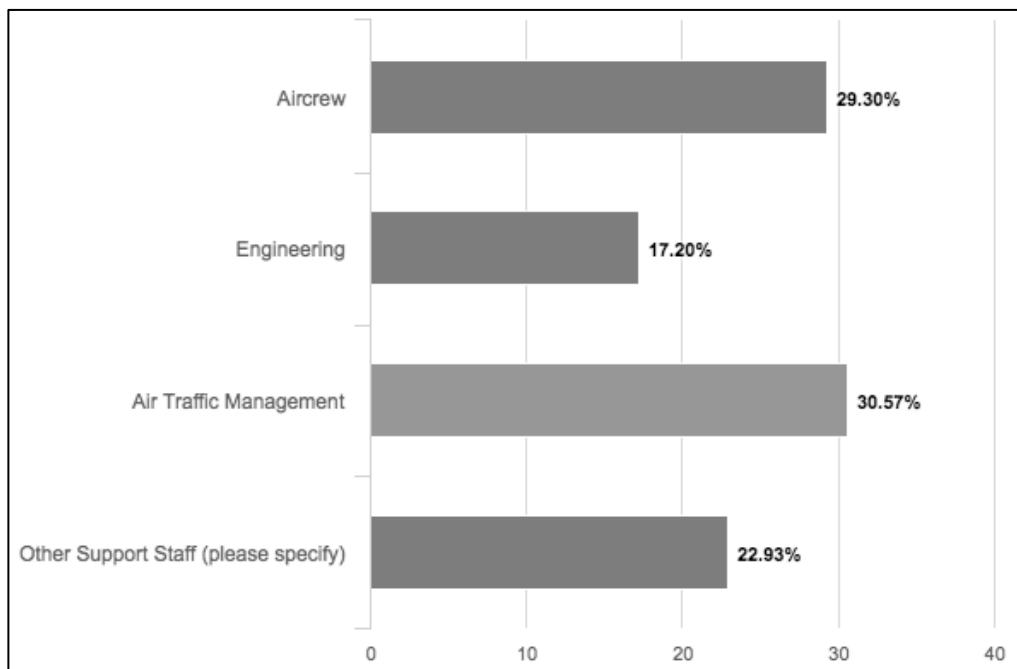


Figure 5-15 showing the GB breakdown of the Four Worlds in relation to respondents who answered 'Yes' to both parts 1) & 2) of Q2d

Three binomial tests are applied to the worldwide data to check the following pairs of hypotheses:

- *Null hypothesis*: the proportion of respondents who agree with the claim is 0.5.
- *Alternative hypothesis*: the proportion of respondents who agree with the claim is significantly higher than 0.5.

Whilst the 'N/A' responses could be considered to be missing data, which in itself can bias statistical inference, given the circumstances of the question and the frequency analysis in Figure 5-11, it is suggested that the proportion of 'Yes' responses to each of the three sub-questions is sufficient to assume a statistically significant result that the majority of the respondents are in agreement.

The cut point feature is used to distinguish the 'Yes' responses from the others, by making Group 1 'Yes' and Group 2 'No' or 'N/A'. The results of these tests are displayed in Figure 5-16. The tests showed that the proportion of respondents who answered 'Yes' is significantly higher than 0.5 ($p < 0.001$) in all three cases, and the null hypothesis is rejected. From this evidence it can be concluded that a significant majority of the population of interest have felt overloaded by the amount of change being introduced at once, that the overload was caused by regulatory change, and that the introduction of the change could have been managed better. Based on these results, S_{3b} is supported, humans can be subject to information overload during regulatory change.

Binomial Test						
	Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)	
Q2d1) Have you ever felt overloaded by the amount of change being introduced at once?	Group 1	<= 1	332	.80	.50	.000
	Group 2	> 1	81	.20		
	Total		413	1.00		
Q2d2) If Yes, was this in relation to changes in Regulations?	Group 1	<= 1	265	.64	.50	.000
	Group 2	> 1	148	.36		
	Total		413	1.00		
Q2d3) In your opinion could these changes have been managed better?	Group 1	<= 1	336	.81	.50	.000
	Group 2	> 1	77	.19		
	Total		413	1.00		

Figure 5-16 showing the results of binomial tests on Q2d using SPSS

A Chi-square test⁶⁹ for independence indicates no significant association between the Four Worlds of aviation and overload due to regulatory change, $\chi^2 (1, n = 413) = 6.73, p = .35, \phi = .128$, as shown in Figure 5-17. This study does not find evidence of any difference in propensity for overload between the ‘Four Worlds’ with which an individual identifies with.

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.732 ^a	6	.346
Likelihood Ratio	6.690	6	.350
Linear-by-Linear Association	.749	1	.387
N of Valid Cases	413		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.54.

Symmetric Measures			
	Value	Approximate Significance	
Nominal by Nominal	Phi	.128	.346
	Cramer's V	.090	.346
N of Valid Cases	413		

Figure 5-17 showing the results of a Chi-square test for independence between the Four Worlds and respondents who answered ‘Yes’ to part 2) of Q2d

⁶⁹ A Chi-square test is a nonparametric statistical test to show if there is significance between two variables and calculates whether or not the pattern of distribution is significantly different to that expected from randomness (Berman Brown & Saunders, 2008). Assumptions of this test are that the sample is large, and that it is not be used when more than 20% of the expected frequencies are less than five.

The objective to analyse whether humans are the weak link in the aviation safety chain has been met, but the supposition (S_{3a}) that removing human error will achieve safety of operations is not supported. S_{3b} is that humans can be overloaded by regulatory change and, from the perceptions of the survey respondents, this is found to be true. The survey results suggest that the respondents perceive that safety is not intrinsic in the system without a human involved, and that humans are not considered to be the weak link, just a component of a system that can fail, as can other components. Both sides of the argument from the literature are presented in sub-Section 2.4.1 and this research shows that it is the perception of the population surveyed that humans are required and that they are not the weak link in the system.

5.3.4 Objective 4

The objective is to assess if there is an active culture of learning from incidents within the aviation industry. There are two suppositions associated with this objective, firstly (S_{4a}) that there is a temptation to rationalize every incident with hindsight bias, thereby not acknowledging that some events can be random or Black Swans. Secondly, (S_{4b}) that the capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome. These suppositions are addressed by reference to questions 1a, 3a, 3b, and 3c in the survey which are on pages A-2 and A-8 to A-10 in Appendix A.

Question 1a introduced the concept of a 'Black Swan' being a random event that should be acknowledged as such (Taleb, 2007), and asked how much the respondent agreed that attempts to identify the cause of a past event was a waste of time in the aviation industry and instead events should just be considered to be random. The first stage in this analysis is to consider frequencies, the results of which are shown in Figure 5-18.

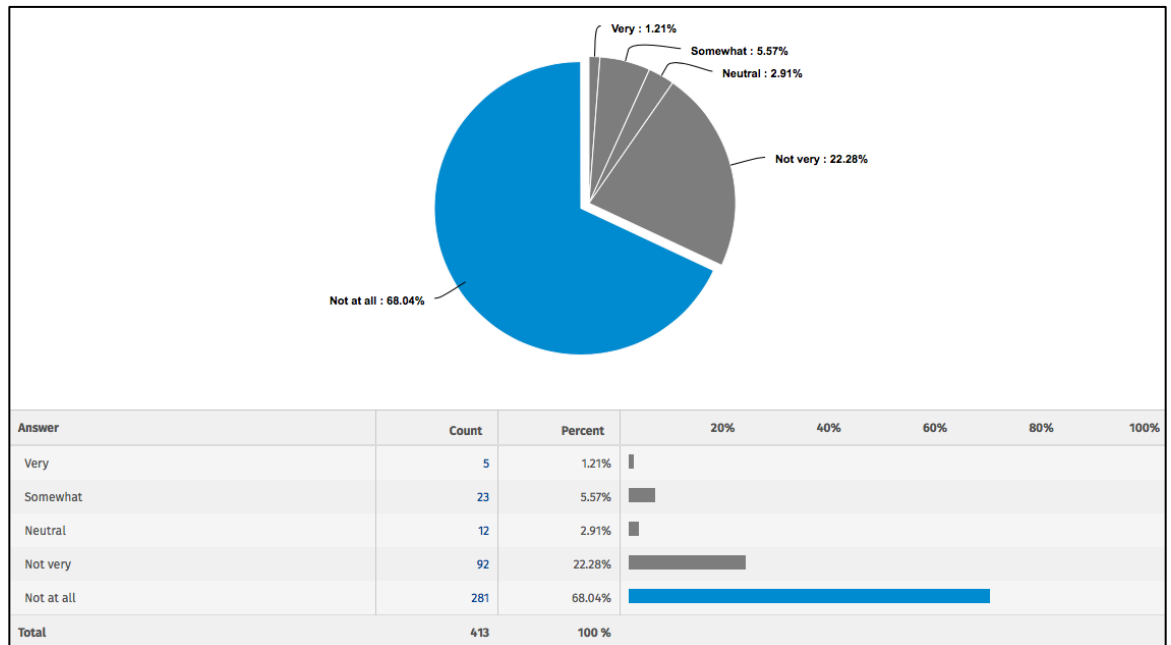


Figure 5-18 showing the frequency analysis of Q1a

With regards to the five incidences of ‘Very’, thereby agreeing that it is pointless trying to establish the cause of an event, each came from a different country and with no trend seen across the rest of their responses the number is too small to make any inference. At the other end of the continuum, of the 281 respondents who answered ‘Not at all’, 16 of them perceived error not to be an inevitability in day-to-day aviation operations, but only one thought aviation operations to be intrinsically safe up to the point that a human becomes involved. The distribution of these 281 responses across the ‘Four Worlds’ is shown in Figure 5-19, which is similar to the overall breakdown in Figure 5-4, but with a higher proportion of Engineers believing that it is not a waste of time to identify the cause of an incident.

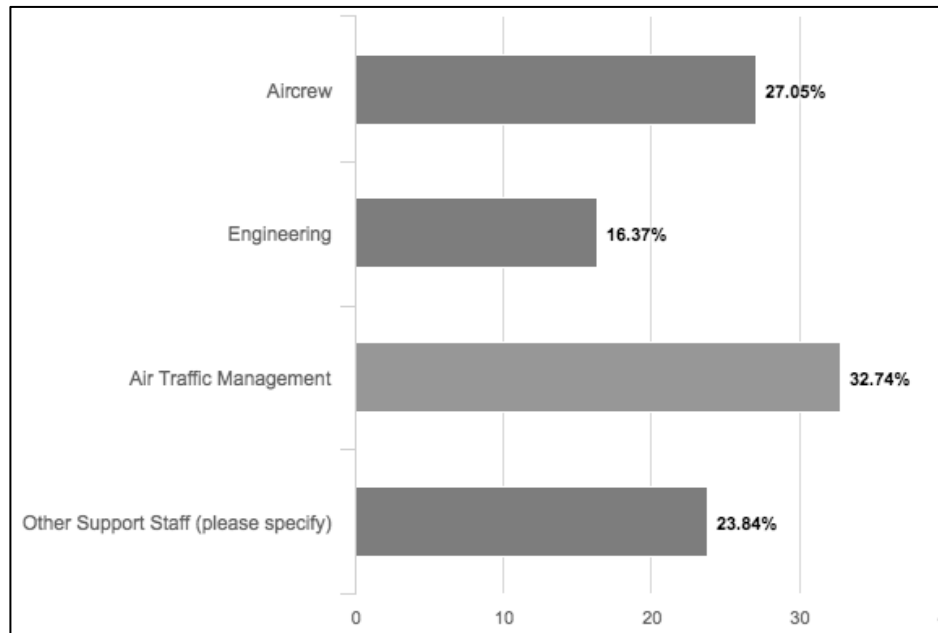


Figure 5-19 showing the distribution of the 281 'Not at all' responses to Q1a between the Four Worlds

To summarize the frequency analysis, there are 413 valid responses, no missing observations, where 7% are positive to the claim, 3% neutral and 90% negative ('Not at all' or 'Not very'). It is easy to see that the majority of the respondents did not agree with the claim; the data is so convincing that whilst a binomial test is considered, it is nugatory to the analysis.

In order to assess the impact of hindsight bias, analysis is conducted on the responses to question 3b, which asked if it is always necessary to find a single cause for an incident, if hindsight bias impacts safety investigations, and if it is normal to blame someone in their organisation. As can be seen in Figure 5-20, 46 respondents reported that it is necessary to identify a single cause for every incident, 85 thought that to be the case 'Sometimes', and 282 (68%) said that it is not necessary to determine a single cause every time. From the respondents' experience, 172 (42%) reported that hindsight bias impacts upon safety investigations, whilst only 88 (21%) said that it didn't (the remaining 37% voting for the middle ground). 78 individuals reported that their organisation has a blame culture, supported by 133 who said that this is the case 'Sometimes'. This means that only 49% (202 respondents) operate in a culture which does not seek to apportion blame.

Frequency Table					
Q3b1) Is it necessary for every event to have a single cause identified?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	46	11.1	11.1	11.1
	No	282	68.3	68.3	79.4
	Sometimes	85	20.6	20.6	100.0
	Total	413	100.0	100.0	
Q3b2) In your experience does hindsight bias impact on safety investigations?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	172	41.6	41.6	41.6
	No	88	21.3	21.3	63.0
	Sometimes	153	37.0	37.0	100.0
	Total	413	100.0	100.0	
Q3b3) In your organisation, is it normal to apportion blame to an occurrence?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	78	18.9	18.9	18.9
	No	202	48.9	48.9	67.8
	Sometimes	133	32.2	32.2	100.0
	Total	413	100.0	100.0	

Figure 5-20 showing the frequency analysis of Q3b parts 1), 2) & 3)

The ‘Four Worlds’ distribution of the 172 respondents who said that hindsight bias impacts safety investigations is shown at Figure 5-21. Whilst the percentage of Aircrew and ATM is broadly as would be expected from the overall representation (Figure 5-4), it can be seen that the number of Engineers reporting bias is less than could be expected, but the number of Other Support Staff is noticeably higher. The global distribution, shown at Figure 5-22, highlights the broad dispersal of these responses and there is no inference to be drawn from country or region, respondents from all over the world perceive that hindsight bias impacts safety investigations.

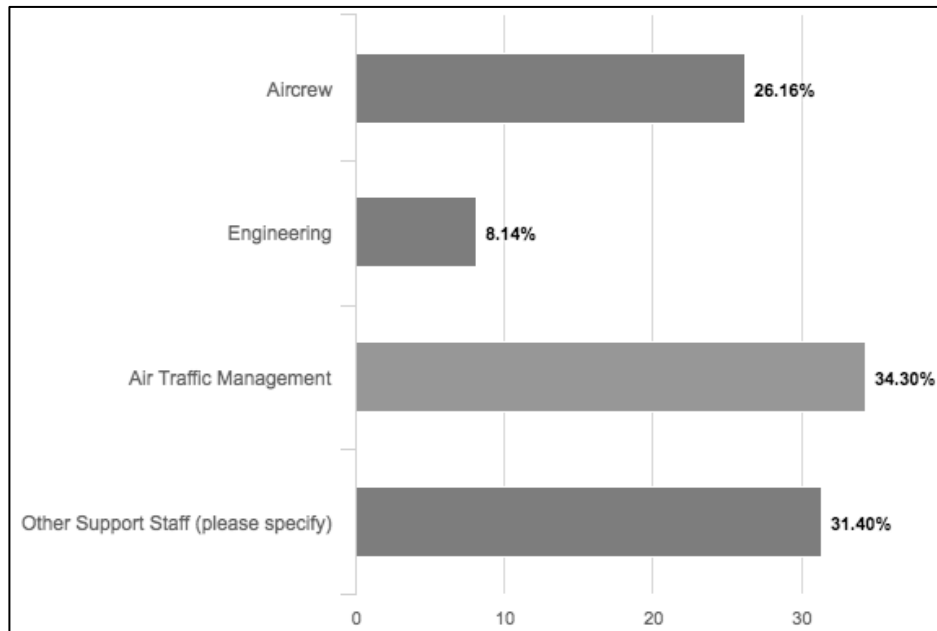


Figure 5-21 showing the distribution of the 172 respondents who felt that hindsight bias impacts investigations

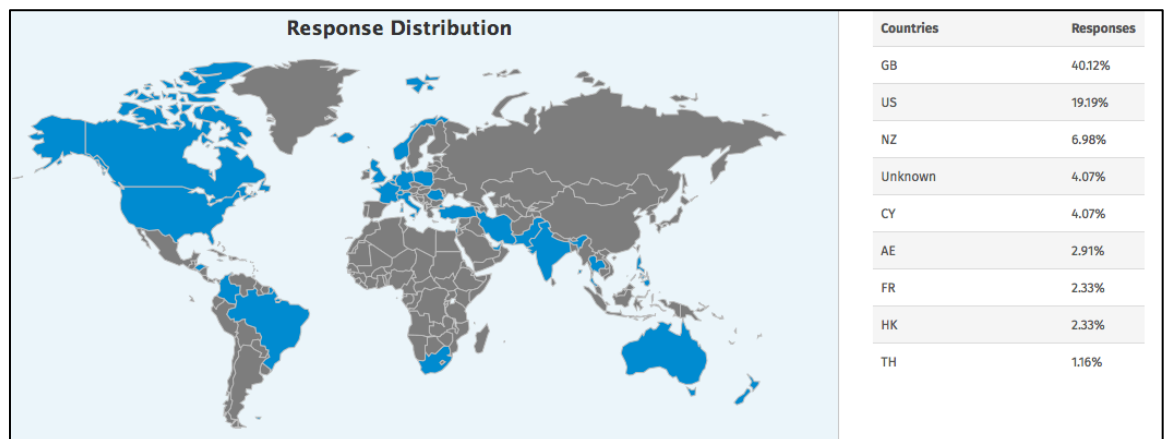


Figure 5-22 showing the global distribution of the 172 respondents who felt that hindsight bias impacts investigations

Although not germane to directly addressing either of the suppositions for this objective, the high proportion of respondents reporting that it is normal to apportion blame either all or some of the time (51%) merits further analysis. In Table 5-6, it can be seen that the top three countries of completed surveys are GB, US and NZ. In contrast to this, the percentages for those that reported ‘Yes’ or ‘Sometimes’ to organisations that apportioned blame reflected GB to have a lower proportion, with both US and NZ increasing theirs. This shows a disproportionately large number of reports from the US, with 54 respondents reporting ‘Yes’ or ‘Sometimes’, and only 12 reporting ‘No’ to a culture of blame. The breakdown by State is shown in Figure 5-23, where it can be seen that the responses came from a wide selection of States. Whilst this may be an indicator of a possible widespread issue, a survey sample of only 66 respondents cannot be considered representative of a Nation the size of the USA, and it would be disingenuous to draw this kind of conclusion.

However, it does show that of the aviation industry personnel in the US who chose to respond to the survey, 82% perceive that they work within a blame culture.

Country	Overall % of responses	% of 'Yes' or 'Sometimes' responses to normally apportioning blame
GB	52.54	38.39
US	15.98	25.59
NZ	5.57	8.06

Table 5-6 contrasting the top 3 countries for overall percentage of responses, against the percentage of respondents who reported 'Yes' or 'Sometimes' to blame

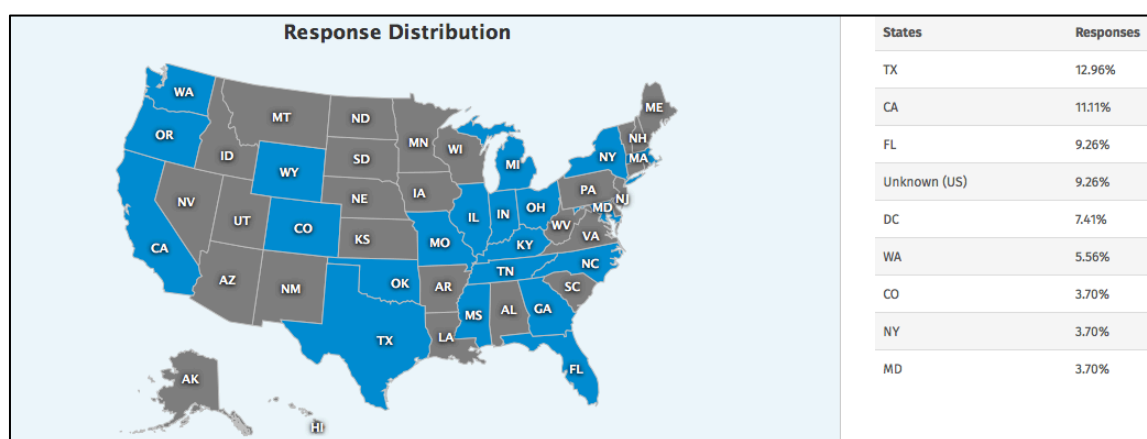


Figure 5-23 showing the distribution of the 54 respondents from the US who felt that hindsight bias impacts investigations

The results of an SPSS crosstabulation of all countries within the survey against this question of blame apportionment are presented in Appendix H. 100% of the responses from Spain (2), Philippines (2), Ireland (1), Jersey (1), and Haiti (1) are 'Yes', as well as 50% of the 2 from Germany; there is no inference to be drawn from this data due to small numbers.

The evidence presented shows that most of the respondents do not believe that it is necessary for every event to have a single cause identified (68%), but most report that hindsight bias impacts safety investigations either some (37%) or all (42%) of the time. Whilst 49% of the respondents do not feel that it is normal to apportion blame to incidents, the other 51% report that it is either normal (19%) to, or that sometimes (32%) blame is apportioned.

S_{4a} is that there is a temptation to rationalize every incident with hindsight bias and not acknowledge the randomness of some events. The results from the survey show that although the majority of the population of interest do not perceive it necessary to identify a

single cause, that hindsight bias is applied in investigations. However, a nuance of the data is that the majority perception is that, consideration of events as being random is inappropriate for the aviation industry and that investigations should always be conducted to identify lessons. So, there is evidence to suggest that S_{4a} is true, but the perception is that it is right not to acknowledge events as being Black Swans.

S_{4b} is that the capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome. Questions 3a and 3c were designed to answer this question and can be found in Appendix A on pages A-8 and A-10. Participants were offered a 5-point Likert scale asking how important they thought it is to identify all errors, no matter how trivial, and if their SMS captures and analyses all errors appropriately. In the second question, they were asked if their Management perceived risk in the same way as the participant and if they felt that there is a Just Culture in their organisation.

To conduct binomial tests on the data from the two parts of Question 3a, the SPSS cut-off function⁷⁰ is used to distinguish *often* (capturing the ‘Always’ and ‘Most of the time’ responses) and *not often* (the other three responses), with the following pair of hypotheses:

- *Null hypothesis*: the proportion of respondents who think that the claim is often true is 0.5.
- *Alternative hypothesis*: the proportion of respondents who think that the claim is often true is significantly higher than 0.5.

As can be seen in Figure 5-24, the tests showed that the proportion of respondents who believe the claims are often true in both questions are significantly higher than 0.5 (both $p < 0.001$). The null hypothesis is rejected for each test. Based on this sample there is evidence to conclude that a significant majority of the population of interest believe that it is important to ensure that all errors are identified, no matter how trivial, in most or all cases. Additionally, from their experience, a well-run Safety Management System captures all errors and analyses them appropriately in most or all cases. Figure 5-25 shows the breakdown of responses to the two parts of question 3a.

⁷⁰ By establishing that the responses were numerically 1, 2, 3, 4 and 5, a cut-off point of 2 means that the first two answer options (‘Always’ and ‘Most of the time’) go into Group 1 and the next three options in Group 2

Binomial Test						
	Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)	
Q3a1) How much do you think that it is important to ensure that all errors are identified, no matter how trivial?	Group 1	<= 2	364	.88	.50	.000
	Group 2	> 2	49	.12		
	Total		413	1.00		
Q3a2) In your experience, does a well-run Safety Management System capture all errors and analyse them appropriately?	Group 1	<= 2	283	.69	.50	.000
	Group 2	> 2	130	.31		
	Total		413	1.00		

Figure 5-24 showing the results of binomial tests on Q3a using SPSS

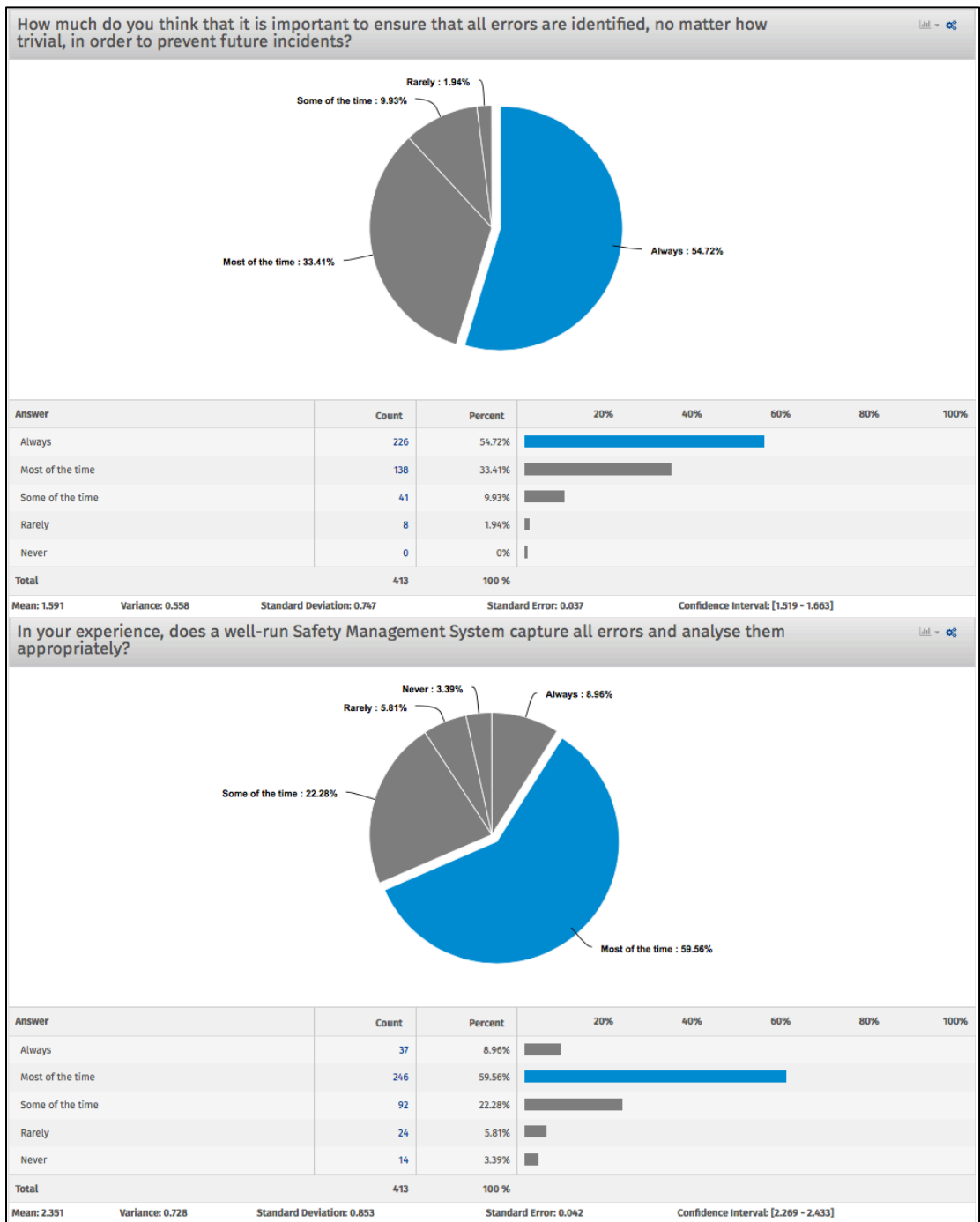


Figure 5-25 showing the responses to Q3a

In question 3c, the first part of the question asked the respondents “do you believe that the Management within your organisation perceive the possibility of risk to be the same as you, higher than you or less than you.” The percentage of people reporting the same perception is 58%, the percentage for Management perception being less is 33% and the percentage for higher perception is 9%; this is depicted in Figure 5-26. The number of people who did not respond ‘The same’ is 175; this means that 42% of respondents reported that their organisation’s Management have a different perception of risk to them. Analysis of countries, and which of the ‘Four Worlds’, produced no trends worthy of presentation.

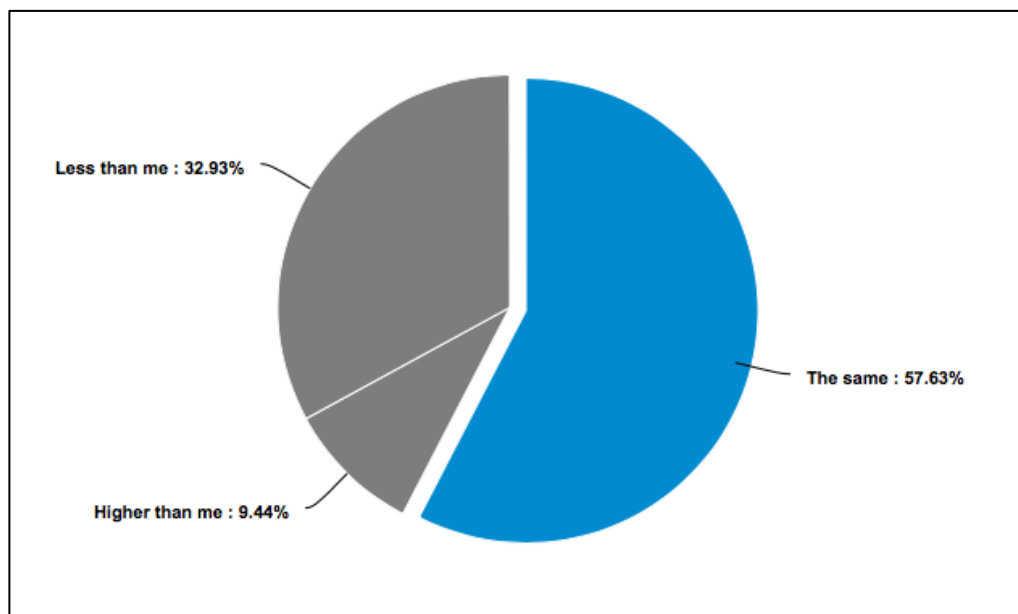


Figure 5-26 showing the percentage values for the Management perception of comparative risk

The second part of the question asks if the respondent perceives that they have a Just Culture for reporting within their organisation’s SMS. The top 3 countries where a ‘No’ response is reported are US (16 ‘No’ responses), GB (15 ‘No’ responses) and AE (5 ‘No’ responses); the other countries with ‘No’ responses are AU, NZ, CY, PH, HK and CA. Figure 5-27 shows the comparison between US and UK respondents, where it can be seen that 24% of US respondents feel that they do not have a Just Culture, whereas only 7% of UK respondents report this. For the purposes of this analysis, UK and GB are considered synonymous abbreviations, as no responses are recorded from Northern Ireland.

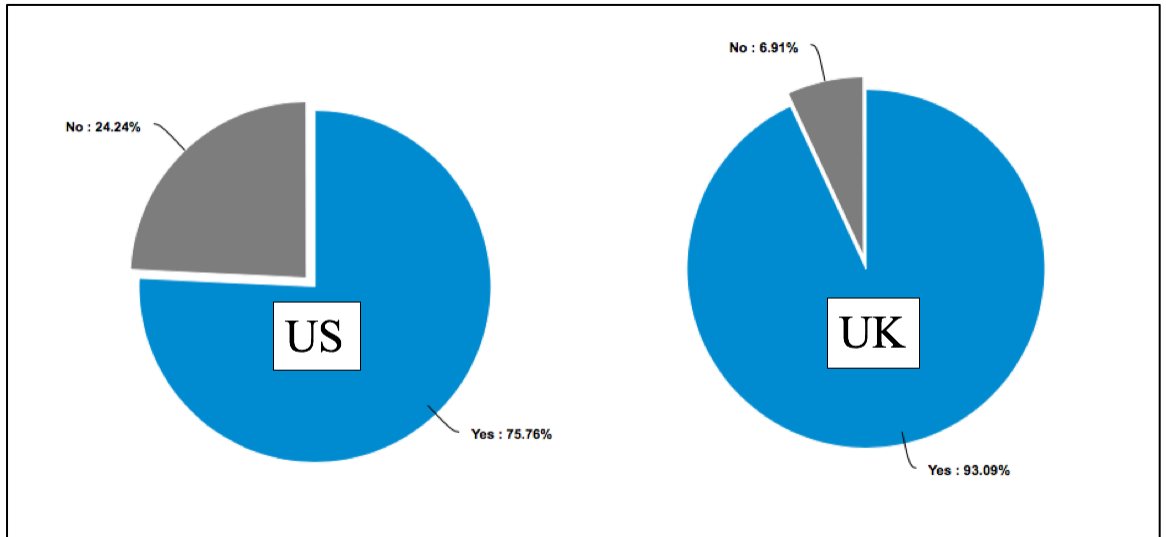


Figure 5-27 showing a comparison between the US and UK responses to the Just Culture question

When comparing the ‘No’ responses to the Just Culture question across the ‘Four Worlds’ for the US and UK respondents, the results are different (Figure 5-28). In the US, Aircrew formed 31% against a UK figure of 13%, whilst Engineers in the US represent 13% but there are zero ‘No’ responses for Engineers in the UK. The percentages for ATM in both countries are broadly similar, however, the difference between Other Support Staff in the two countries is most significant; 25% of those who report not having a Just Culture in the US, versus 53% in the UK. This implies that the UK aviation industry has a significant problem with its Just Culture within organisations that are considered to be part of the ‘Fourth World’.

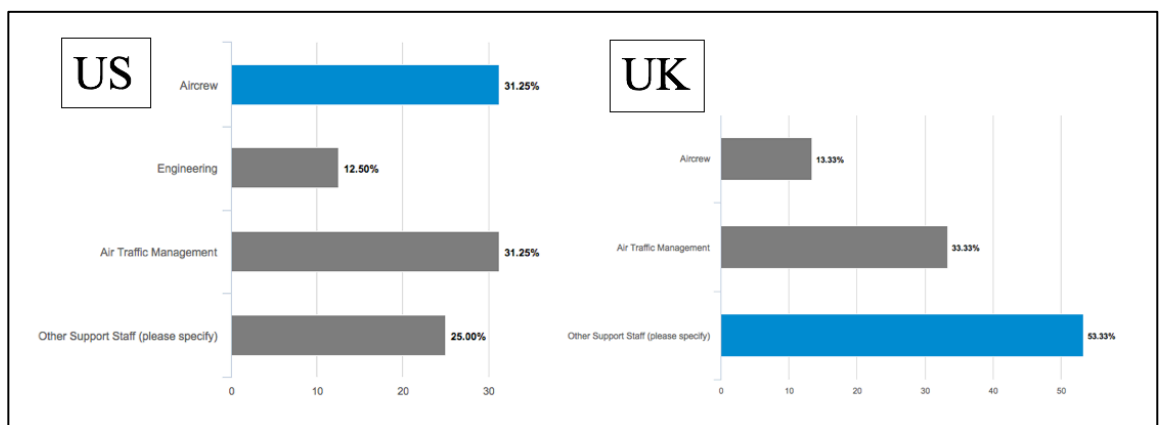


Figure 5-28 showing a Four Worlds comparison between the US and UK respondents to Just Culture

A Chi-square test for goodness of fit is used to examine the distribution of frequencies for part 1) of Q3c, with the null hypothesis set as the distribution of the three options being approximately equal, and the alternative that there is significant disproportion. The test demonstrates that there is significant disproportion ($\chi^2 (1, n = 413) = 143.860, p < 0.001$)

and the null hypothesis rejected. A binomial test is used to examine whether a significant majority of the target population feel that they had a Just Culture for reporting within their SMS, which shows that the proportion who answered 'Yes' is significantly higher than 0.5 ($p < 0.001$). Based on this sample, there is evidence to conclude that a significant majority of the population of interest believe that they work within an organisation that has a Just Culture for reporting safety-related incidents.

Objective 4 has therefore been met; there is a culture of learning from incidents within aviation, because:

- safety-related incidents are being reported (a Just Culture normally exists, and events are not assumed to be random Black Swans),
- SMSs capture and analyse errors appropriately,
- in the majority of cases, Management perception of risk is same as the workforce

However, it is somewhat worrying that hindsight bias features so highly in safety investigations in the industry, and this is certainly an area where further research and education could be focussed.

5.3.5 Objective 5

Determine if changes are required to regulations to integrate drone operations. There is a single supposition associated with this objective (S_5), specifically that 'there is not enough regulation on the use of drones and more is needed urgently'. The survey respondents were asked a direct question to assess how they felt about the current level of regulation, with an ordinal 5-point Likert scale of response, which can be seen in Qx on page A-12 of Appendix A. The frequency distribution of responses is presented in Figure 5-29, which shows that 53% of respondents perceive that there is not enough regulation, and more is needed urgently. 34% feel that current regulations are generally ok but could do with some development, 1% are happy with them as they are, 11% find them confusing and needing to be simplified and 1% believe that there are too many regulations about drones already.

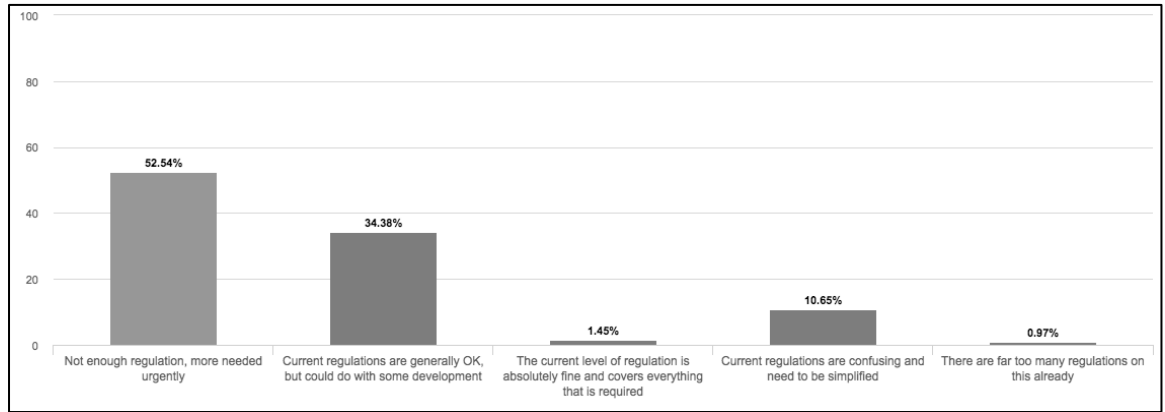


Figure 5-29 showing a chart of responses to the question on feelings towards the level of drone regulation

An SPSS crosstabulation is used to investigate the connections between the ‘Four Worlds’ and the responses, which is shown in Figure 5-30, where it can be seen that the majority of the responses are in the first two categories suggesting that more regulations are needed urgently or that the current ones needed some development. Of the four people who responded that ‘there are far too many regulations on this already’, two completed the survey in the USA, one in South Africa and one in France.

		With the numbers of unmanned aircraft (drones, SUAs, UAVs, UASs, RPAS, models etc) increasing, how do you feel about the					Total
		Not enough regulation more needed urgently	Current regulations are generally OK but could do with some development	The current level of regulation is absolutely fine and covers everything that is required	Current regulations are confusing and need to be simplified	There are far too many regulations on this already	
This last question will help me to put your answers in to context. In which of the following areas of aviation do you	Aircrew	64	33	2	11	1	111
	Engineering	32	17	0	5	0	54
	Air Traffic Management	71	51	3	15	0	140
	Other Support Staff please specify	50	41	1	13	3	108
Total		217	142	6	44	4	413

Figure 5-30 showing an SPSS crosstabulation between the Four Worlds and drone regulation responses

A further crosstabulation is used to see if there are any trends in the data for the sub-continent. From Figure 5-31, it can be seen that North America and Australia/New Zealand stand out as being the only sub-continent where the number of responses for the second option is greater than the first, showing that the majority view in those areas is not to introduce more regulation, instead developing the current rules. However, in Northern Europe 62% of the respondents show that they have serious concerns about the dearth of drone regulation by suggesting that more is needed urgently.

		With the numbers of unmanned aircraft (drones, SUAs, UAVs, UASs, RPAS, models etc) increasing, how do you feel about the					
		Not enough regulation more needed urgently	Current regulations are generally OK but could do with some development	The current level of regulation is absolutely fine and covers everything that is required	Current regulations are confusing and need to be simplified	There are far too many regulations on this already	Total
Sub continent	Australia&New Zealand	9	15	1	6	0	31
	Caribbean	2	1	0	0	0	3
	CentralAmerica	1	0	0	0	0	1
	EasternAsia	3	0	0	1	0	4
	EasternEurope	2	1	0	0	0	3
	NorthernAmerica	21	32	2	11	2	68
	NorthernEurope	141	67	3	18	0	229
	SouthAmerica	1	1	0	1	0	3
	SouthEasternAsia	2	1	0	1	0	4
	SouthernAfrica	0	1	0	0	1	2
	SouthernAsia	3	3	0	0	0	6
	SouthernEurope	5	3	0	2	0	10
	WesternAsia	10	9	0	1	0	20
	WesternEurope	11	5	0	3	1	20
	Unknown	6	3	0	0	0	9
Total		217	142	6	44	4	413

Figure 5-31 showing an SPSS crosstabulation between sub-continent and drone regulation responses

A binomial test is used to examine whether a significant majority of the target population feel that current drone regulations need to be changed. The five answer options are considered from left to right (in Figure 5-31) as being numbered 1 to 5 and using the cut point function set at 2 segregates the proportion of respondents who opted for enhancement, be it major or minor, into Group 1. The following pair of hypotheses are used:

- *Null hypothesis:* the proportion of respondents who think that regulations need enhancing is 0.5.
- *Alternative hypothesis:* the proportion of respondents who think that regulations need enhancing is significantly higher than 0.5.

Figure 5-32 shows that the proportion of respondents who opted for enhancement is significantly higher than 0.5 ($p < 0.001$), and the null hypothesis rejected. Based on this sample, there is evidence to conclude that a significant majority of the population of interest believe that drone regulations need to be enhanced. When the test is run again, but with a cut point of 1 to isolate the respondents who desired an urgent increase of regulation against those less concerned, the proportion is 0.53, only slightly higher than 0.5. However, maintaining the consistent use of $p < 0.001$ throughout the analysis, the null hypothesis can still be rejected, but caution is applied to the strength of the argument.

Binomial Test						
		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
With the numbers of unmanned aircraft (drones, SUAs, UAVs, UASs, RPAS, models etc) increasing, how do you feel about the	Group 1	<= 2	359	.87	.50	.000
	Group 2	> 2	54	.13		
	Total		413	1.00		

Figure 5-32 showing a binomial test on the drone regulation responses

The objective to determine if changes are required to regulations to integrate drone operations is met. The majority of the population believe that the current level of regulation is not fit-for-purpose and needs enhancing.

5.4 Summary of supposition findings after quantitative analysis

To summarise the investigation of the suppositions that are in support of the five objectives, Table 5-7 lists each supposition together with the findings from the quantitative analysis.

S _n		Supposition findings from the quantitative analysis
1	The introduction of regulatory change can increase the likelihood of an Airprox.	Answer will come from secondary data.
2a	Errors occur, but only if left unmanaged do they increase risk.	<p>Evidence suggests that the supposition is true.</p> <p>The majority of the population of interest perceive that:</p> <ul style="list-style-type: none"> - errors occur all of the time, it is only when left unmanaged that there is an increase in risk, - it is how errors are managed and dealt with that determines whether or not an error becomes an incident, - they had witnessed occasions when multiple barriers were in place, which successfully prevented an error becoming an incident.
2b	Humans make safety through their efforts and expertise; this implies that new regulation can be safely introduced through human endeavour and training.	<p>Evidence suggests that the supposition is true.</p> <p>The majority of the population of interest believe that safety can be made through individual endeavour within an organisation.</p>
3a	It is widely considered in the aviation industry that eradicating human error will achieve safety of operations.	<p>Evidence suggests that the supposition is false.</p> <p>The majority of the population of interest believe that aviation operations are not intrinsically safe until a human becomes involved and that it is not considered possible to remove human error from the workplace. They also believe that human error is an inevitable part of day-to-day business in the aviation industry and it is how error is managed that is important.</p>

3b	Humans can be subject to information overload during regulatory change.	Evidence suggests that the supposition is true. The majority of the population of interest have felt overloaded by the amount of change being introduced at once, that the overload was caused by regulatory change, and that the introduction of the change could have been better managed.
4a	There is a temptation to rationalize every incident with hindsight bias and not acknowledge that some events are 'Black Swans'.	Evidence suggests that the supposition is true. The majority of the population of interest perceive that hindsight bias is used in investigations and that it is not necessary to label events with a single cause. However, a nuance of the data is that the majority perception is that the labelling of an event as a Black Swan is not appropriate to the aviation industry and that all events should be fully investigated to establish their cause.
4b	The capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome.	Evidence suggests that the supposition is true. The majority of the population of interest believe that it is important to ensure that all errors are identified and analysed, that this is done by a well-run SMS, the perception of risk is shared with Management, and that a Just Culture exists for reporting.
5	There is not enough regulation on the use of drones and more is needed urgently.	Evidence suggests that the supposition is true. The majority of the population of interest believe that drone regulations need to be enhanced.

Table 5-7 showing a summary of the supposition findings from quantitative analysis

5.5 Chapter summary

In this chapter, the results from the quantitative analysis of the survey questionnaire responses are presented, and the analysis detailed. Firstly Section 5.1 introduces the presentation of results and analysis, split over this chapter and the next. In Section 5.2 the questionnaire data is described, before each objective is subsequently analysed separately (Section 5.3) to address the suppositions established in Section 2.8. The primary data was collected by means of a survey, with 413 completed responses were received from 45 countries; the biggest number of respondents were from Great Britain, the USA and New Zealand. The survey respondents were asked to classify which of the 'Four Worlds' they identified as being part of, and the results were Aircrew 27%, Engineering 13%, ATM 34% and Other Support Staff 26%; the survey therefore reached a representative cross-section of the industry. It also reached a cross-section of experience levels, ranging from those in their first year in the industry to those with many years of service, and is deemed successful at capturing the ideas, opinions and concerns of all.

94% of respondents perceive error to be inevitable and 98% perceive that it is how error is managed that is important. Almost all respondents from Aircrew and ATM have seen a

situation with multiple barriers where one has failed, and another has prevented an incident occurring. The establishment and maintenance of these barriers are important to manage the errors and prevent accidents. It is interesting that the 'Fourth World' also has a high percentage of respondents that have witnessed this error management in play and the deduction from the lower percentage from Engineers is that their procedures are robust enough that on more occasions the error is captured at the first barrier. Analysis of the results supports the deduction that it is possible to introduce change safely through individuals' efforts in managing the inevitable errors.

Analysis does not support the thought that aviation is intrinsically safe until the point a human gets involved, which is contrary to some of the opinions in sub-Section 2.4.1 but supports others who posit that humans cannot be removed and that even if it were possible to eradicate human error, this would not achieve the safety of operations. The majority of those surveyed did, however, report that they had been subject to overload during the introduction of regulatory change. Overload is not restricted to any particular region and is reported from many parts of the world as well as being applicable across each of the 'Four Worlds'. In respect to GB specifically, a higher proportion of Engineers and Aircrew than the overall global figures had experienced a time when they had felt overloaded by changes in regulations. Irrespective of experience levels, the vast majority of respondents also felt that the implementation of regulatory change could be managed better.

Only 21% of respondents reported that hindsight bias does not impact upon safety investigations, and only 49% operate in a culture which does not seek to apportion blame. This implies that in many organisations, there is a propensity to apply hindsight bias in an investigation and blame an individual for an incident. This is not only unjust, but also removes the opportunity to fully identify systemic issues from which to learn lessons. Despite this, the majority of people perceive that there is potential for lessons to be learned from every incident, and that all errors should be identified, no matter how trivial. From their experience, a well-run Safety Management System does this, in most or all cases.

In comparison between respondents from the US and GB, there is a significantly larger proportion of US respondents reporting that they do not have a Just Culture in their organisation. Analysis of the differences between the 'Four Worlds' shows that in the US it is Aircrew who report a lack of Just Culture, whereas in GB it is Other Support Staff that are highlighted as a problem area. In regard to drone regulations, there is evidence from this study that a significant majority of the respondents believe that drone regulations need to be enhanced and that the current level of regulation is not fit-for-purpose.

In analysing the primary data in this chapter, an approach of positivism and realism have been applied by the necessity of quantitative analysis and the testing of hypotheses. Section 3.2 explains the overarching paradigm of critical realism but with a shifting balance between post-positivism and constructionism being favoured dependent on the stage of the mixed methods research. It is acknowledged that there is a richness to the data collected that has not been fully exploited by the binary determination of whether a supposition is believed to be true or false. This data has more potential, some of which is presented in Chapter 6 with a qualitative constructionist viewpoint, and the rest brought out in the discussion in Chapter 7 to enhance understanding and further support the research aim.

The survey also included several optional free text questions that asked for examples to support the answers chosen. Qualitative analysis of the remaining primary data is presented in Section 6.2. Table 5-7 shows which suppositions are believed to be true from the evidence presented, and which ones are either not yet answered or suggested to be false. This table is presented again and added to, in Section 6.3, where the findings from both methods of analysis are shown. Conclusions and recommendations are presented in Chapter 7, with reflections made on every aspect of the research in Chapter 8.



Chapter 6 – Research Results and Analysis Part 2

6.1 Introduction

The aim of this chapter is to present the qualitative analysis conducted on the primary data collected, and also the analysis of the secondary data to answer the elements of research objectives that are not fully covered by the analysis presented in Chapter 5. In Sections 6.1 to 6.5 objectives 2, 3 and 4 are fully met. Section 6.6 supports objective 5 in determining the validity of the associated supposition (S_5), and Section 6.7 supports objective 1.

First to be presented is the qualitative analysis of the free text survey answers and the semi-structured interviews. Following a summary of the position after completing the analysis of primary data, Section 6.6 onwards presents the analysis of the secondary data in the form of a qualitative analysis of Airprox reports from 2015 and 2016, which were harvested from the open source data on the UKAB website⁷¹. From the same source, the data for 2017 drone-related Airprox were downloaded in support of the analysis of objective 5, facilitating a comparison of drone Airprox from 2015, 2016 and 2017. In 2017 there was a change to the way that the UKAB administered their evaluations of drone Airprox, which meant that whilst the completed reports for all Airprox in 2017 are not available at the time of analysis due to a four to six-month delay between event and finalised report, drone Airprox are published the month after the occurrence. After this, the results of the analysis of Airprox reports from 2006 to 2012 is presented as a comparison between the 3-years prior to the introduction of ATSOCAS⁷² in March 2009, and the 3-years after. Then follows a brief analysis of the UK perception of drone regulation, using data obtained from the CAA⁷³ after they conducted surveys of the British public in 2016 and 2017. Finally, a case study is presented where some lessons can be extracted from an account of the introduction of the SERA⁷⁴ regulations across the UK, from the perspective of a UK aerodrome operator.

⁷¹ UK Airprox Board - www.airproxboard.org.uk

⁷² Air Traffic Services Outside Controlled Air Space

⁷³ Civil Aviation Authority

⁷⁴ Standardised European Rules of the Air

6.2 Qualitative analysis of free text survey answers

There were eight opportunities in the survey where participants were asked to type in an answer to a supplementary question. Every one of these free text questions was optional, as the objective of the survey was to garner quantitative data, and the qualitative sections were additional opportunities for examples and clarification in support. The eighth free text question is in relation to those who saw themselves as being part of ‘Other Support Staff’ and was designed to see what elements of the industry this ‘Fourth World’ encompassed; the results of this are presented in Table 5-3. As can be seen in Appendix F, where the answers that were given are presented in full, a significant number of respondents chose to provide responses in the free text boxes. Each of the enabling objectives is revisited in the following sub-Sections to see if the additional free text information either contradicts the quantified data or provides supplementary information that further supports the objective.

6.2.1 Objective 1

The answer to objective 1 is at this point nascent and requires the analysis from Section 6.6 onwards in order to satisfy it.

6.2.2 Objective 2

S_{2a} is that errors occur, it is their management that prevents an incident from occurring, and this is borne out by 184 respondents (out of the total 413) giving an example of a time when they had witnessed the failure of a barrier. 34 preliminary nodes are identified, but these are reduced to four by grouping and association. These four barriers are coded as either Equipment, Systems, People or Supervision, although ‘Supervision’ is subsequently deemed to be a sub-set of ‘People’. ‘Systems’ is used for procedures such as checklists and had no overlap with ‘Equipment’ which is used for automated safety nets such as TCAS⁷⁵ or STCA⁷⁶. All 184 reports are coded against these four nodes, with some being coded twice for ‘People/Supervision’ and ‘Equipment’, but never ‘People’ with ‘Supervision’ or ‘Systems’. The result of this coding is presented in Figure 6-1, showing that the data set contains 121 examples (including supervision) of a person intervening to prevent an incident after an initial barrier has failed, be it a failed procedure, human or mechanical error.

⁷⁵ Traffic alert and Collision Avoidance System

⁷⁶ Short-Term Conflict Alert

Name	References
● Equipment	37
▼ ● People	121
● Supervision	21
● Systems	32

Figure 6-1 showing the frequency of coding of free text examples of secondary barriers

Pertinent extracts from the examples for each of the four categories are in Table 6-1.

Equipment	<i>“An aircraft is cleared to a specific level but the pilot, despite reading back the correct level, climbs through his allocated level into potential conflict with another aircraft. TCAS alerted the pilot of his error and initiated a [Resolution] Advisory that prevent the aircraft climbing further.”</i>
People	<i>“Doing a descending turn over water (intrinsically unsafe). Target fixation caused loss of SA⁷⁷ of altitude and descent rate. Navigator alerted me to situation and I recovered just before impact with water.”</i>
Supervision	<i>“when work was carried out on an aircraft, the supervisor of the task failed to [note] that independent checks were required to be raised. The final supervisor check highlighted this and the work was carried out.”</i>
Systems	<i>“Arming of the thrust reversers are normally completed when cleared for the approach. That is sometimes forgotten but it is backed up with the Before Landing Checklist at a later stage.”</i>

Table 6-1 showing examples of respondents’ answers on barriers

These examples illustrate that errors do occur routinely and that it is how the additional barriers of equipment, people and systems are employed that prevents an event becoming an incident. This suggests that S_{2a} is true, thereby supporting the result of the quantitative analysis. It should be noted that the first two examples given relate to MAC⁷⁸ and CFIT⁷⁹ respectively, where human error by the pilot caused the situation to go beyond normal expectation, but the situation was recovered by safety equipment or teamwork.

S_{2b} is that humans make safety through their efforts and expertise, and respondents were asked to give an example where they had personally made things safer. 189 respondents answered the question by providing an example of their efforts; three examples from this data are reproduced in Table 6-2.

⁷⁷ Situational Awareness

⁷⁸ Mid-Air Collision

⁷⁹ Controlled Flight Into Terrain

<p><i>“Safety Management System developed and rolled out across the business successfully. Full Change Management process followed to ensure everyone was aligned to the new process. SMS is an ongoing and constantly evolving process that requires regular oversight.”</i></p>
<p><i>“I have written a full SMS/FS⁸⁰ program for my aviation employer in attempts to introduce a safety culture in our organization. Despite the owner's resistance to change (“we have done things this way for 15 years, so I don't want to spend time on training for these guys when they didn't need it in the past...”), I see a significant change (dispatchers, baggage loaders, pilots) towards adherence to basic safety principles that were previously ignored due to cultural ignorance and / or resistance to change (via introduction from an out-group (i.e. western culture).”</i></p>
<p><i>“Leading my team through a change process that created new working practices and associated instructions that removed unsafe behaviours.”</i></p>

Table 6-2 showing examples of respondents’ endeavours to improve safety

These are examples when individual endeavour made situations safer and it is believed that there is read-across to the introduction of regulatory changes, thereby supporting the postulation in Section 5.3 that S_{2b} is believed true. 46% of the survey respondents chose to answer the optional question giving an example of a time they personally made things safer; this shows that there is a genuine perception from those respondents that people can make things safer through their own endeavours, and whilst this is less than half, coupled with the quantitative answers it is believed that the hypothesis is supported by the data. It is also highlighted that, the second example given appears to be from the ‘Fourth World’ and shows that the respondent’s own initiative was used to establish an SMS with noticeable achievement, in an organisation that is not regulated to have one but benefits from doing so. The objective is to assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation; the objective has been achieved and qualitative analysis of the data obtained has supported the findings of quantitative analysis.

6.2.3 Objective 3

This objective is supported by two suppositions (S_{3a}/S_{3b}), the first of which is that it is widely considered in the aviation industry that eradicating human error will achieve safety of operations. The survey respondents were asked to provide an example of a company initiative designed to eradicate human error, in order to ascertain if the industry is attempting to do so. 128 respondents (31%) chose to answer this question, although nine responses were to say that it is not possible to totally eradicate human error, or to give

⁸⁰ Flight Safety

examples of failed attempts such as “*using more automation to reduce human intervention but the system totally not understanding average situations*”, “*you will never fully eradicate human error - we are human after all and we learn by our and others mistakes*” and “*of course the system should do all it can to reduce the incidence of human error, but (unfortunately) some errors will still be made*”. An example of a successful company initiative was “*Aviation Security vehicles are no longer permitted to cross a runway, they have to take the airfield perimeter road and only enter taxiways when absolutely necessary*”.

The examples given in the responses support the conclusion from the quantitative analysis that S_{3a} does not appear to hold true for the population of interest, and that the perception is that human error cannot be eradicated and even if the human is removed, the system would not be intrinsically safe.

S_{3b} states that humans can be subject to information overload during regulatory change. Respondents were asked to explain how they would have managed the introduction of change better, after reporting that they had been subject to overload situations. It can be seen in Figure 6-2 that ‘time’ is the most prevalent recommendation in the responses, the context being that regulatory changes should be introduced over a longer period of time, with many people also saying that there should be a period of time set aside for bedding in of new regulations before any more changes are introduced. This accords with EASA’s⁸¹ ambition for a rule making cool-down in 2018-2022 (EASA, 2017b), first presented in sub-Section 2.2.1.

Name	References
● simplify	12
● communication	30
● training	26
● time	69

Figure 6-2 showing the frequency of coding for part 4) of Q2d

⁸¹ European Aviation Safety Agency

Whilst the comments made are presented in full in Appendix F, some pertinent extracts are shown in Table 6-3.

<i>“Unless it is safety critical, there should be no requirement to rush through regulatory change.”</i>
<i>“The pace of change is important. People need to fully integrate change within their workplace before undertaking more changes. Management of change procedures should take this into consideration. It's not unusual to receive dozens of changes (via email) from the regulator at one time. It is a challenge to sift through these and identify the ones which are important to you - then you have to impact assess them and notify the relevant people in your own organisation. Regulators should plan the changes well in advance and 'drip feed' them into industry. They can prioritise these changes to make sure the most important ones are delivered first. They should make sure these changes have been understood and adopted before releasing others.”</i>
<i>“This is simply the desire to introduce too many changes in a short period of time. A number of both EASA and CAA regulations have hit the industry in a conveyor belt like fashion. Resources are simply too short to ensure everything is embedded thoroughly and effectively before moving onto the next regulation.”</i>
<i>“Allow a longer timeframe to fully complete integration with existing procedures. Consult with the current operators of procedures sooner to make sure integration occurs before introduction.”</i>
<i>“Further and more detailed warning of the change. One change at a time rather than mass changes. Better planned process of change. More in depth look into the practical implications of the change for frontline staff.”</i>
<i>“Would have requested a longer intro period to allow time to assimilate and promulgate and train.”</i>
<i>“Both the CAA (EASA) and the MAA⁸² have far [too] much regulation (process). The amount of paperwork with rules and regulations for all processes (aircrew, maintainers, ATC) is too much and adds pressure and complications to people[’s] daily jobs. This needs to be simplified.”</i>
<i>“Change management is handled poorly in this industry with the regulator rushing changes out with too little consultation.”</i>
<i>“Too much regulation and establishments feeling that the best way to mitigate risk is indeed more regulation. We can only absorb a certain amount of information.”</i>
<i>“Stop the proliferation of miniscule changes to rules and compliance that are bogging down the 'four worlds'. The mantra now being 'reduce output to maintain safety' is translated to 'don't fly'...”</i>
<i>“Continuous change continuously, simply causes confusion and alienates staff at all levels. Make one, well-planned and well-considered change, then allow it to take effect. Do not make further changes until this process is complete.”</i>
<i>“...you are never given time at work to get up to speed on any updates. What I am describing is change fatigue.”</i>
<i>“No1 risk held on my RR⁸³ is the frequency of change - it's too much”</i>
<i>“The effect of change is cumulative. Small amounts of coincident change in different areas (technical, procedural, management) can combine to overwhelm individuals. The potential impact of change should be predicted, and managed and coincident change should be reduced.”</i>

⁸² Military Aviation Authority

⁸³ Risk Register

<p><i>“In the USA, the FAA⁸⁴ often dumps new regulations on pilots without fully explaining them. The regulators could do a better job of providing online instruction, local presentations, or other instructional material so those subject to the regulation could better understand them - BEFORE the regulation is implemented.”</i></p>
<p><i>“Applying basic concepts of project and change management”</i></p>

Table 6-3 showing examples of respondents’ perceptions of managing change

The supposition against which the analysis is conducted is that humans can be subject to information overload during regulatory change. The examples provided in the free text box give ample evidence that this is the predominant perception amongst those that completed the question. S_{3b} is therefore believed to be true, which supports the findings of the quantitative analysis of the data. However, the analysis should not stop there, and the richness of the data provided acknowledged. Change fatigue is mentioned, which accords with anecdotal malaise that people are fed up with change. The comment about only being able to absorb a finite amount of information suggests that people are at saturation point, which will mean that management and supervision will be vitally important for future safety of operations. It is also a really good point that change is considered cumulative, although this is perhaps best related back to change fatigue and it is this fatigue that is cumulative.

Objective 3 is to ‘analyse whether humans are the weak link in the aviation safety chain’. S_{3a} is that eradicating human error would achieve safety, and that is again not supported by the evidence. S_{3b} is that humans can be overloaded by regulatory change, and overwhelming evidence is provided in support of this being true, with a lot of examples describing situations where people from all aviation elements around the world are facing overload when it comes to changes in regulations. The qualitative analysis supports the findings in sub-Section 5.3.3, in that human error could never be removed, that aviation operations are not intrinsically safe, and that it is how errors are managed that is important. This suggests that humans are not considered to be the weak link, they are often the mitigation for managing inevitable errors. The objective has been met, with the same conclusion that humans are required in key roles within the industry, despite their propensity for error.

⁸⁴ Federal Aviation Authority – America’s CAA

6.2.4 Objective 4

To assess if there is an active culture of learning from incidents within aviation, with supporting supposition (S_{4a}/S_{4b}) based around the rationalization of incidents through hindsight bias, and the importance of capturing all errors, in order to prevent future occurrences. 141 respondents (34%) provided an example of the oversimplification of an incident, where the root cause is much deeper than widely concluded.

The extracts in Table 6-4, from the full responses at Appendix F, show examples where in several differing contexts, investigations have initially stopped at the point where an obvious cause has been identified, without delving deeper to establish the root cause and actually understand the circumstances. Identifying the deeper reasons why an event occurred, leads to better opportunities to learn from these errors before they happen again with a potentially even worse outcome. These examples support the supposition that human nature is to attempt to rationalize every incident and not accept them as random (S_{4a}), because they say that investigations are looking to pigeon-hole the event by allocating a rational reason as to why it happened, and do not accept that there might be much deeper entrenched reasons, or indeed it may just be a random event.

<i>"I consider that the effect of the so-called 'startle effect' in the Air France crash off Brazil is massively overstated⁸⁵. It is too simplistic and ignores the much more likely scenario that sleep inertia prevent the captain from responding in the appropriate manner when roused from his bunk and called to the flight deck."</i>
<i>"The recent RAF Voyager incident where a personal camera was lodged between armrest and sidestick⁸⁶. The root cause may be a systemic acceptance of PEDs⁸⁷ used by crews on the flight deck."</i>
<i>"I investigated an incident where an employee [severely] cut his finger on an aircraft pallet. [The] initial investigation concluded the finger was cut because the employee did not wear his protective gloves, where in reality [the] pallet had been damaged leaving tears in the pallet which made the pallet dangerous to use. PPE⁸⁸ is not issued to allow damaged and dangerous equipment to be used."</i>
<i>"An aircraft overrun incident at a UK airport which was piloted by two captains, one a training captain. The aircraft didn't touch down until in the final third of the runway and a go-around should have been executed much earlier. Nobody was injured, and the aircraft was recovered, but the closed runway put pressure on a busy London airspace. Although not revealed in the final investigation report it was thought, by some close to the incident, some elements of the auto-pilot were not disengaged, neither captain took control to make the necessary decision to abort the landing."</i>
<i>"Most that stop at error without understanding the circumstances."</i>

⁸⁵ <https://flightsafety.org/asw-article/startle-effect/>

⁸⁶ <https://www.telegraph.co.uk/news/2017/02/06/bored-raf-pilot-sent-187-passengers-nosedive-playing-camera/>

⁸⁷ Portable Electronic Device

⁸⁸ Personal Protective Equipment

<i>“In third world countries accident investigation is not done until root cause analysis and eventually similar events keep on happening”</i>
<i>“Egypt air accident, in which the NTSB investigation related the cause to deliberate action by the pilot, based on him saying “I rely on God”, problems with the elevator, and repeated resetting of the Auto pilot during previous flights, were down played during the investigation, and no testing was done to evaluate history of stresses on the broken elevator.”</i>
<i>“Any event attributed to ‘pilot error’. Unless having suicidal tendencies, no pilot sets out on a flight with the intention of crashing. ‘Pilot error’ may be the immediate accident cause, but what led the pilot to make the error? All kinds of latent conditions could have contributed - poor training, poor procedures, fatigue etc.”</i>
<i>“Alaska Airlines flight 261- Catastrophic crash of an MD 83 in [2000]⁸⁹. Crash originally blamed on a failed jack screw leading to the stabiliser getting torn off in flight. What the later investigation uncovered was a culture of poor discipline, cutting corners, inadequate supervision, FAA oversight, design and cert issues and unauthorised maintenance [procedures] that all led to the crash.”</i>

Table 6-4 showing examples of investigations that stop too early

Several of the respondents suggested that an example of this rationalization is with the disappearance of Malaysian Airlines Flight 370. There are many people around the world attempting to rationalize the event, and declare exactly what the cause of it was, without accepting that it may just be a Black Swan event. In this case, hindsight bias is being applied to the cause first, before any investigation of the crash site, in order to try and locate it! The examples provided also support S_{4b} that it is important to investigate all errors in order to try and learn from them, and that stopping an investigation too early can lead to the wrong lessons being identified which could exacerbate a situation. Both suppositions are believed to be true and the objective to assess if there is an active learning culture has been achieved, again with a richness to the data that demonstrates perceptions that these are key issues that people are facing.

6.2.5 Objective 5

To determine if changes are required to regulations to integrate drone operations. There were no free text questions designed to support this objective, and none of the existing ones are found to be pertinent.

6.3 Summary of supposition findings after sequential qualitative analysis

To summarise the answers from the primary data, Table 6-5 lists each supposition with the findings from the quantitative and qualitative survey analysis.

⁸⁹ <https://www.nts.gov/investigations/AccidentReports/Pages/AAR0201.aspx>

S _n		Supposition findings from the quantitative analysis	Supposition findings from the qualitative analysis
1	The introduction of regulatory change can increase the likelihood of an Airprox.	Answer will come from secondary data.	N/A
2a	Errors occur, but only if left unmanaged do they increase risk.	<p>Evidence suggests that the supposition is true.</p> <p>The majority of the population of interest believe that:</p> <ul style="list-style-type: none"> - errors occur all of the time, it is only when left unmanaged that there is an increase in risk, - it is how errors are managed and dealt with that determines whether or not an error becomes an incident, - they had witnessed occasions when multiple barriers were in place, which successfully prevented an error becoming an incident. 	<p>Evidence suggests that the supposition is true.</p> <p>Examples were provided of situations where errors have occurred, and it is how they have been managed by other factors, such as equipment, people and systems, that has prevented the error developing into an incident.</p>
2b	Humans make safety through their efforts and expertise; this implies that new regulation can be safely introduced through human endeavour and training.	<p>Evidence suggests that the supposition is true.</p> <p>The majority of the population of interest believe that safety can be made through individual endeavour within an organisation.</p>	<p>Evidence suggests that the supposition is true.</p> <p>From the examples provided, it is seen that there are many occasions when individual endeavour made situations safer.</p>
3a	It is widely considered in the aviation industry that eradicating human error will achieve safety of operations.	<p>Evidence suggests that the supposition is false.</p> <p>The majority of the population of interest believe that aviation operations are not intrinsically safe until a human becomes involved and that it is not considered possible to remove human error from the workplace. They also believe that human error is an inevitable part of day-to-day business in the aviation industry and it is how error is managed that is important.</p>	<p>Evidence suggests that the supposition is false.</p> <p>The examples given in free text responses suggests that even on the occasions when a company initiative to eradicate error is introduced, it rarely if ever succeeds. Many of the respondents took the opportunity to provide examples of the antithesis which further supports the rejection of this supposition.</p>
3b	Humans can be subject to information overload during regulatory change.	<p>Evidence suggests that the supposition is true.</p> <p>The majority of the population of interest have felt overloaded by the amount of change being introduced at once, that the overload was caused by regulatory change, and that the introduction of the change could have been better managed.</p>	<p>Evidence suggests that the supposition is true.</p> <p>The strength of feeling amongst the 177 free text responses is that the four main factors that should be addressed in future changes are 'time', 'training', 'communication' and to 'simplify' them.</p>
4a	There is a temptation to rationalize every incident with hindsight bias and not acknowledge that some events are 'Black Swans'.	<p>Evidence suggests that the supposition is true.</p> <p>The majority of the population of interest perceive that hindsight bias is used in investigations and that it is not necessary to label events with a single cause.</p>	<p>Evidence suggests that the supposition is true.</p> <p>The qualitative analysis shows many examples of this temptation to rationalize and label every event with a cause, often as quickly as possible and without establishing the root cause of the error.</p>

		However, a nuance of the data is that the majority perception is that the labelling of an event as a Black Swan is not appropriate to the aviation industry and that all events should be fully investigated to establish their cause.	
4b	The capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome.	Evidence suggests that the supposition is true. The majority of the population of interest believe that it is important to ensure that all errors are identified and analysed, that this is done by a well-run SMS, the perception of risk is shared with Management, and that a Just Culture exists for reporting.	Evidence suggests that the supposition is true. The evidence shows that the analysis of errors is important to establishing lessons that can be applied to future situations, with the expectation of the error not happening again. The wrong lesson can be identified if an investigation stops too early.
5	There is not enough regulation on the use of drones and more is needed urgently.	Evidence suggests that the supposition is true. The majority of the population of interest believe that drone regulations need to be enhanced.	There were no free text questions designed to support this objective, and none of the existing ones are found to be pertinent.

Table 6-5 showing a summary of the supposition findings from both mixed methods of analysis of the primary data collected in the survey

6.4 Qualitative analysis of semi-structured interviews

Five interviews were carried out with key personnel selected from the aviation community in the UK, representing Airprox investigation, a UK commercial airline (that had not participated in the final survey itself), a UK ANSP⁹⁰ and both of the UK military and civilian regulators. Flybe was approached as the commercial airline because the safety department staff had assisted with the initial piloting of the survey questionnaire and had therefore not been invited to complete the public survey; this added a level of independence to the validation phase. Two of the representatives are leading exponents of safe drone integration, two are pilots, two Air Traffic Controllers, one of which employed in a Support Staff role, and one an Engineer; this combination of experience is deemed to be fair representation across the industry.

The interviews all took between 60 – 90 minutes and were conducted one-on-one, with the interviewer taking notes. A redacted extract of the interview responses is in Appendix C. In the first interview, the initial question asked was “can new regulation be introduced without a decrease in safety?” This is an open question and led to a poorly structured discussion of the introduction of regulatory change in general, with the interviewee providing anecdotes of the management of some change programmes. The survey was covered latterly, but many of the points made in relation to the questions had already been

⁹⁰ Air Navigation Service Provider

discussed previously, leading to disjointed notes. In post-interview reflection, it was decided that whilst this one had been successful in achieving the aims, a better way of structuring subsequent interviews would be to go through the survey questions first and then delve deeper where necessary.

The interview reports are analysed using NVivo, where they are coded against the individual suppositions that comments supported. The analysis of the reports is presented by each of the five objectives.

6.4.1 Objective 1

When asked about any trends in Airprox relating to regulatory changes, Interviewee D commented that the transition from APATC-1 to PANS-ATM regulations⁹¹, and specifically the changes to Approach criteria that this brought, was poorly introduced and could have caused an accident. This then led to a discussion about a study that was conducted 3-years after the introduction of ATSOAS changes, and a copy of the data was subsequently provided for secondary analysis. D also mentioned the recurring debate on the use of QFE rather than QNH⁹² and recalled that in the late 80s, early 90s, the UK military changed over to QNH completely, but this change was rescinded a few years later; there is no record of the reasoning why, it can only be assumed that it was deemed dangerous. In 2016 the question was being asked again and consideration given to a change to regulations, to bring military flying in line with the civilian use of QNH.

These examples show two types of regulatory change, the first being the poor implementation of the change reduced safety and the second implying that the regulation itself was what was unsafe. This supports objective 1, but doesn't fully answer S₁, which is addressed with the analysis of secondary data in Section 6.6 onwards.

⁹¹ APATC-1 is the old regulation for the design of aerodrome approaches, PANS-ATM is the new standard

⁹² When an altimeter has QFE set, the readout will show the height of an aircraft above the runway. When QNH is set, an altimeter will show the altitude Above Mean Sea Level (AMSL)

6.4.2 Objective 2

S_{2a} is that ‘errors occur, only if left unmanaged do they increase risk’ and Figure 6-3 shows the respondents’ answers to the relevant survey questions.

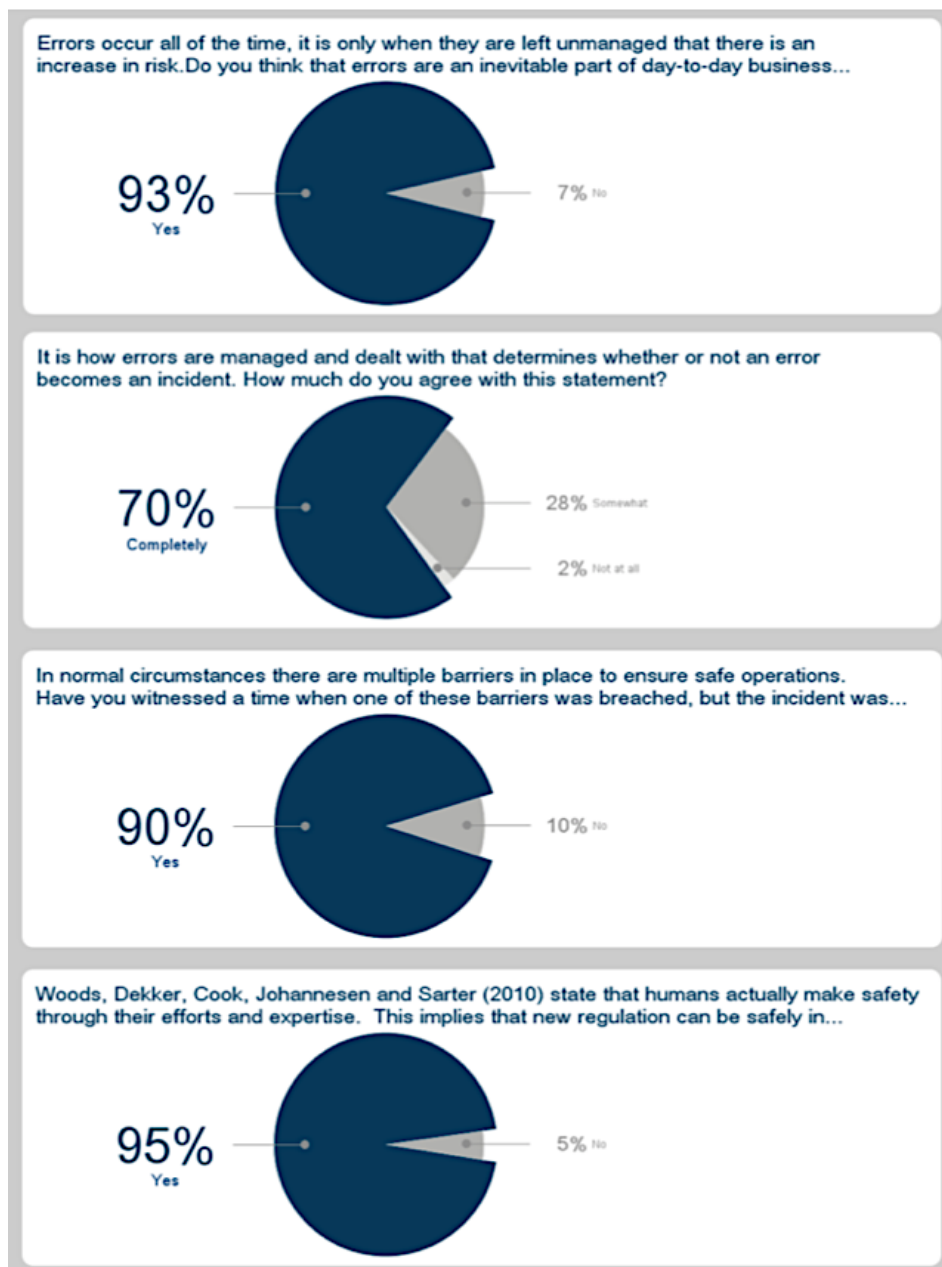


Figure 6-3 showing respondents’ answers to the questions associated with objective 2

Interviewee B agreed that errors are inevitable and said that “*by nature humans are inconsistent biological machines*”. He completely agreed that error management is what is important and commented that there must be a severity aspect. He also agreed that there are many times when one barrier fails, and another prevents an error becoming an incident. Interviewee C was not at all surprised that 90% of respondents had witnessed this, and that he would have been surprised if this was much less. Interviewee E felt that errors were always an inevitability but for the question on it being more important how errors are managed, he took a halfway viewpoint saying that he was “*sometimes to completely*”⁹³ and that the “*system couldn’t cope with speed of development*”. If it had been a five level Likert (instead of the three options given) he would have been at level four. His point was that “*something can happen too quickly for an SMS to stop the outcome, measured in a matter of seconds or years!*” His point related to events like the recent issues with a military aircraft type, where the organisation only just prevented a potential accident, despite the system to do so being in place for many years.

S_{2b} is that humans make safety through their efforts and expertise; this implies that new regulation can be safely introduced through human endeavour and training. Interviewee B agreed that an individual can make safety within their organisation but stated that this needed to be at management level to be fully successful as without leadership the individual’s efforts would likely fail in the long run. Interviewee C agreed with the majority view and was again not surprised at the strength of the ‘Yes’ response (95%). Interviewee E was not totally convinced with the majority opinion that safety can be made and said that he fell halfway in that “*subsets of effort*” were required and that it was a function of “*guidance, leadership and time to imbed change management*”. For it to work and actually make safety required “right person, right place, right background” and therefore not everyone would be able to make things safer.

These statements support the answers found in sub-Section 5.3.2, the two suppositions are believed true and the objective met, although Interviewee E’s point of view is noted that attempts at management of error are not always successful and, equally, dynamic events might not be able to be managed. The five interviewees considered the survey results to be a valid representation of the industry.

⁹³ The response options were ‘completely’ (70%), ‘somewhat’ (28%) and ‘not at all’ (2%)

6.4.3 Objective 3

S_{3a} is that ‘it is widely considered in the aviation industry that eradicating human error will achieve safety of operations’ and Figure 6-4 shows the respondents’ answers to the relevant survey questions.

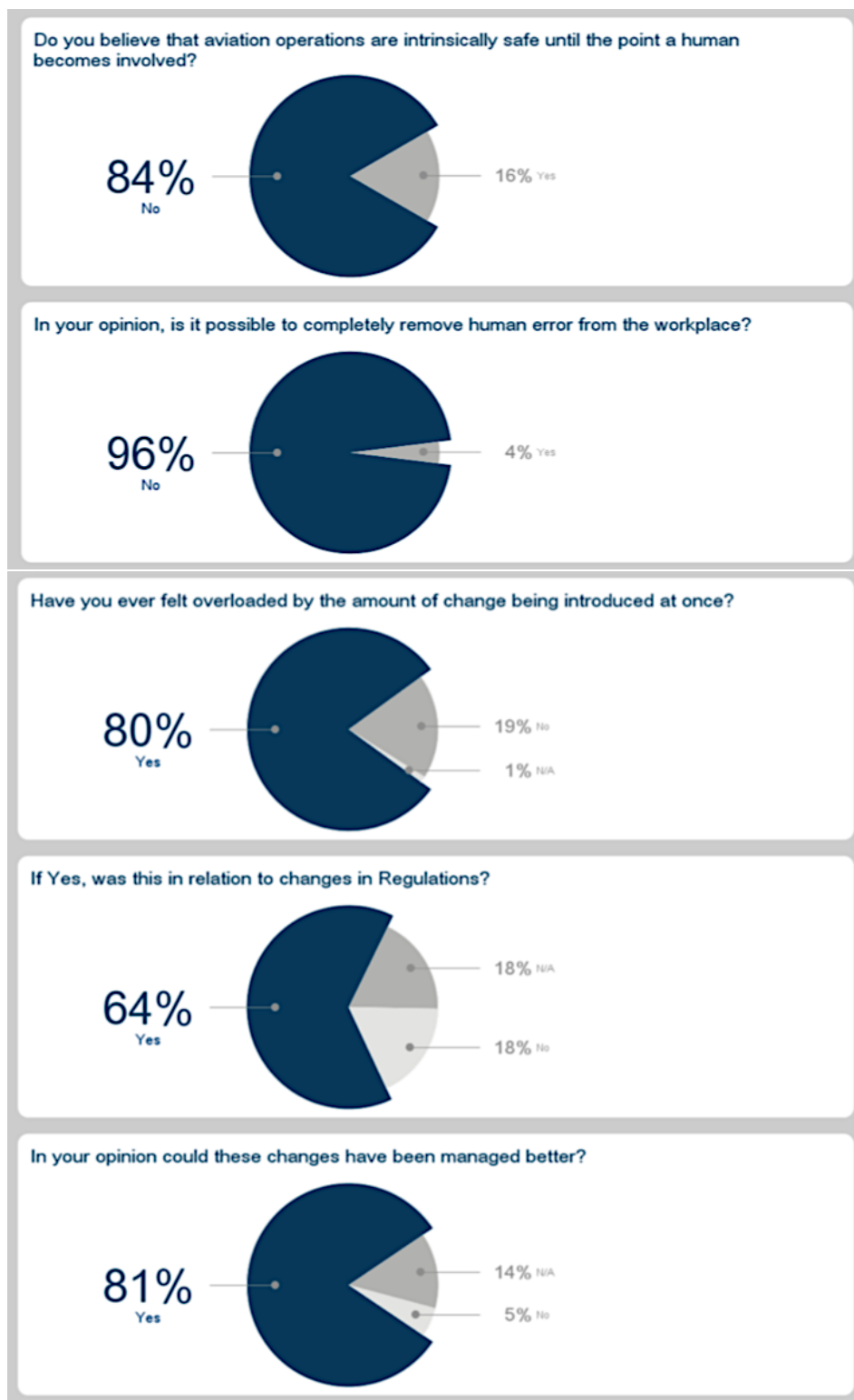


Figure 6-4 showing respondents’ answers to the questions associated with objective 3

Interviewee A was very surprised that the ‘Yes’ response to the question on whether aviation is intrinsically safe until the point a human becomes involved hadn’t been higher than 16% and would have expected a more 50/50 result. His point was that the technology associated with modern aviation operations is very well advanced and is backed up with other equally advanced systems, therefore the overall ‘System’ is intrinsically safe and it is only when you introduce humans do you get human errors taking place. He said, “*computers don’t have a bad day*”. The follow-on question about removing human error from the workplace, he felt was an easy one to answer – remove the human! He was surprised at the somewhat “*defeatist*” ‘No’ answer.

Despite Interviewee B’s knowledge of UAS and UTM⁹⁴, against expectation he was emphatically ‘No’ to the question of operations being intrinsically safe without a human, agreeing with 84% of respondents. B focussed on the word ‘operations’ in forming his argument saying that “*this word bounds the question by a condition of use*”. He gave an example to support his argument, and suggested that a parked aircraft, which is generally considered to be safe, does not become potentially unsafe until the human climbs in. When asked about drones, he said that perhaps both sides were true, all operations are only “*safe to a point*” but as drones are “*not yet assured to a high level*” that point is currently lower. When asked if it is possible to completely remove human error from the workplace his answer was ‘No’ (agreeing with 96%), there will always be a human involved somewhere in the chain. He said, “*Humans design the workspace*” and therefore define what is (or is not) addressed by the design, and that “*software is a series of instructions written by humans*” or via tools written by humans, hence there are opportunities for mistakes and errors that will be revealed during operation. The main point being what is unknown or misunderstood cannot be addressed properly in design and may lead to errors or unexpected situations and hence unsafe conditions. [NB, when asked to review the extract, B made the following additional comment in retrospect: “*there is question of what level of safety is appropriate as nothing is totally (intrinsically) safe – but the focus was about the human element and when this may compromise safety – and my view is that this is not only during operation – but decisions and actions taken before this, e.g. design, maintenance, can pre-set a situation*”].]

In relation to the question about being intrinsically safe, Interviewee C’s response was that “*the failing in the system is always the human*” and that “*we are all individuals and react differently*”. When asked about the possibility of removing human error from the

⁹⁴ Unmanned Air System and UAS Traffic Management

workplace, C stated that “*there will always be a human in the chain somewhere*”. The discussion about multiple barriers centred around reporting cultures and C described how his organisation handles a report and how the multiple barriers were considered as a ‘big thing’.

The word ‘intrinsic’ led Interviewee E to be absolute about the ‘No’ answer, but he said that if the question had been replaced by ‘mostly safe’, he would have said ‘Yes’. An example he gave was a catastrophic ‘birdstrike’⁹⁵ at low level, the result is the same whether there is a human in the aircraft or not. He went with the majority view that it is not possible to remove human error from the workplace and agreed that he had seen plenty of occasions when one barrier was breached but others saved the day. This led to a discussion on reporting (lots of people have witnessed an event where a barrier failed, but how many reported it?), and E opined that there “*is often too much emotion*” in a report and that “*often people jump to defensive and blame emotions*”. He also said that he has seen occasions where the way in which a report is handled within the leadership of a squadron, can set the whole safety culture back by 5 years!

S_{3b} is that humans can be subject to information overload during regulatory change. Interviewee A was unsurprised at the high percentage having felt overloaded and cited an example of when air traffic operations were moved to a new centre and the military controllers had to convert to using electronic flight progress strips instead of paper and pen. The changeover was challenging but was handled by calling for a support controller earlier than you might otherwise. Civilian controllers have only recently converted over to an electronic system and the change was introduced much slower with significantly more training. The change went extremely smoothly and in hindsight it could be thought that perhaps some of the restrictions were unnecessary, but “*when does cost balance against safety*”. This example was used to suggest that change can be introduced safely, but also said that to ensure 100% safety in aviation requires only one aircraft in the sky at a time – a totally unpalatable scenario.

Interviewee B had at times felt overloaded in his work and it had on occasion been down to Regulations. He made a valid point about ‘Regulation’ vs ‘regulation’ in that formal Regulation from state authorities such as ICAO, CAA or EASA can be different to local regulations such as airfield or flying unit specific instructions. When asked about the

⁹⁵ The term for an aircraft hitting a bird

introduction of Regulations he felt that the CAA were “*very good at engaging with industry*” and working with them in partnership.

Interviewee C agreed with the majority opinion that ‘Yes’, he had suffered from overload at points during his career, and that ‘Yes’ it was from regulatory change, although he also pointed out that this could both be in relation to Regulation with a capital R (from higher authority) but also regulation with a small r at a more local level. He stated that there were many times when he had been subject to nugatory changes to local orders which exacerbated a situation rather than resolve it. The main point C made in relation to managing changes better was the lack of reflection that was often missed after a change has been introduced, saying “*its all about moving on to the next change rather than taking time to reflect on what has happened*”.

Interviewee D commented that the AIRAC⁹⁶ cycle was problematic when changes to regulation are slaved to it, with the potential for changes being introduced too rapidly in order to meet the AIRAC cycle deadline. He also mentioned the newly published Skyway code, that would be a live document online but invariably out-of-date when in print.

When discussing change, Interviewee E agreed that he had felt overloaded, which had been due to regulatory change but not always. He described it as just being part of the system. He did comment that the problem is the “*constant drip feed of minor changes*”, using the phrase “*trivial water-boarding*”. He suggested that important changes can often be missed in amongst the trivial and suggested that the community suffers from “*change fatigue*” and that often the changes are nugatory.

These statements support the answers found in Section 5.3, although there is some support from the interviewees about the first supposition, on balance S_{3a} is still considered to be false. The second is considered to be true, with unanimous agreement from the interviewees and several examples provided. The objective has been met, and the five interviewees considered the survey results to be a valid representation of the industry.

6.4.4 Objective 4

Objective 4 is to assess if there is an active culture of learning from incidents within aviation. S_{4a} is that there is a temptation to rationalize every incident with hindsight bias

⁹⁶ Aeronautical Information Regulation And Control – defined dates when Aeronautical Information Service (AIS) documents are amended

and not acknowledge that some events are ‘Black Swans’. Figure 6-5 shows the respondents’ answers to the relevant survey questions.

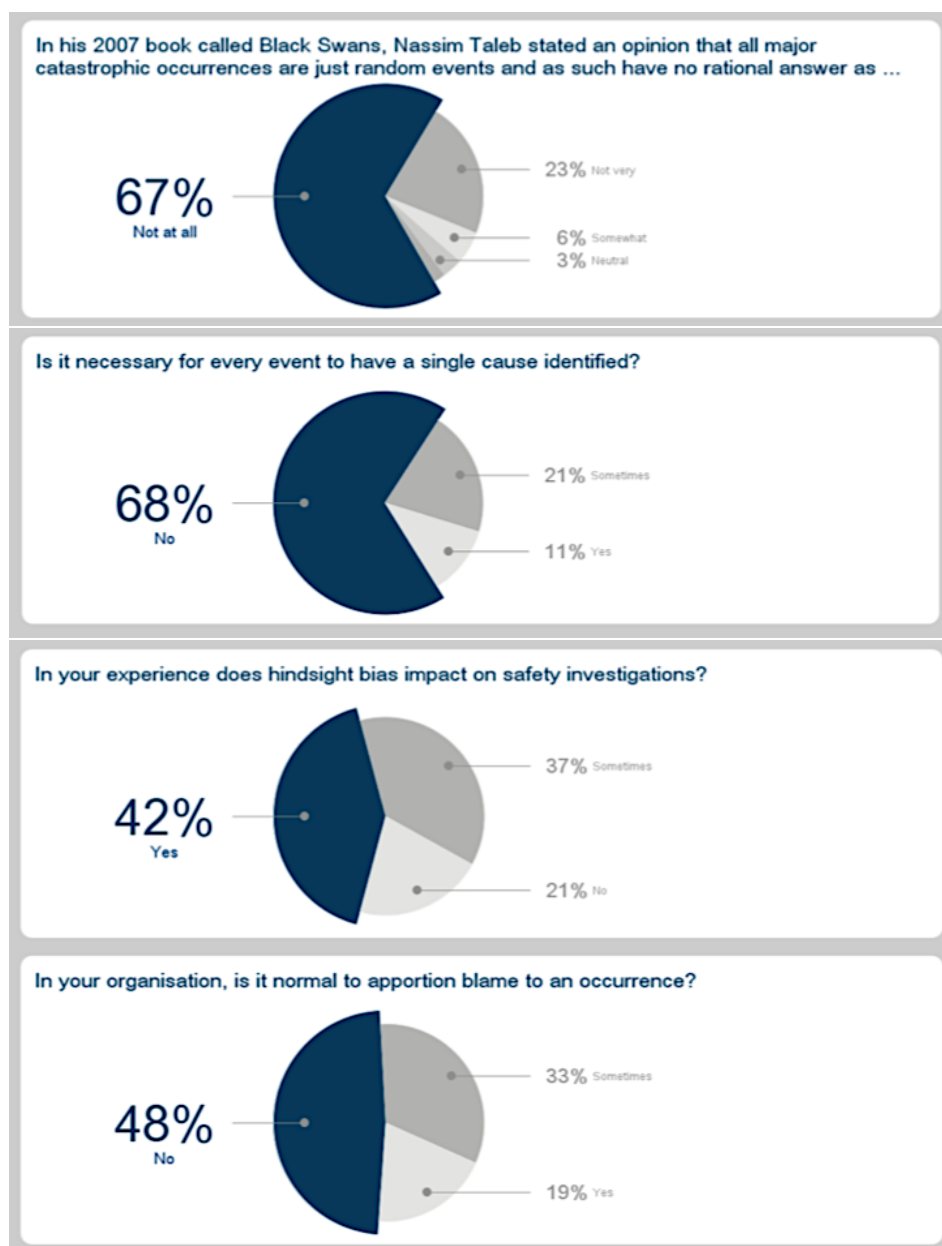


Figure 6-5 showing respondents’ answers to the questions associated with S_{4a}

With regards a single cause, Interviewee A agreed with the majority (68%) that one cause is not always the right answer and cited the Nimrod crash report as being an example of a large number of causes being found. In relation to hindsight bias, there was an emphatic YES from A in both opinion and experience. The substitution test was discussed as being the fairest foil to his example of when he has investigated in the past and the ‘hierarchy’ put hindsight bias on to scenarios and then blamed the controller. His other example was that of the Hudson River landing, whereby he had been told that the pilot was initially lambasted for not turning the aircraft around and landing back on the runway because every pilot who had faced the same circumstances in the simulator had managed to land

ok. It was apparently the pilot himself who pointed out that the simulator pilots were already aware that they were about to hit the birds and knew what actions to take, in the real scenario he had had to assimilate the events as they unfolded before making the decision as to where to land the plane. When a delay was introduced before simulator pilots were allowed to react, they crashed every time. The next answer also elicited a strong response from A; he said that of course it is normal to apportion blame because we live in such a “*blame-culture society*”.

Interviewee B stated that the quest for determining cause was part of the “*cultural makeup of aviation*” and that there was an “*attitude of safe operations*”. He agreed that No, it was not necessary to identify single causes, commenting that “*sufficient understanding to deduct or induce the important*” and that “*too many chase root cause at disproportionate effort*”. He postulated that without infinite resources and time there is a need to prioritise. B commented that “*some of the best investigators recognise and balance against hindsight bias, but training could be better*”. No, it is not normal to apportion blame in his organisation and it was down to “*culture and attitude*”.

Interviewee C agreed with the majority view and was not at all surprised by the percentage splits and was emphatic that he did work within a Just Culture and he felt that the statistics reported in the survey results were realistic. Interviewee D said it was disappointing that so many had a blame-culture and he asked, “*how mature is their SMS*”. He felt that the previous question on hindsight bias was “*realistic, as this is human nature*” and with the desire to “*rationalize, this figure could have been higher*”.

In relation to Black Swans, Interviewee E agreed with the majority viewpoint (67%) that they were not at all appropriate to aviation and stated that there is always a benefit from investigating an incident fully. E thought that sometimes (37%) hindsight bias impacted investigation, especially unconsciously. He highlighted the Hudson River example as well, whereby the substitution test in the simulator had the aircraft turned back and landed safely every time, until hindsight bias was removed, then it always crashed. For causation he said “*No, not a single cause, we should look for Root Causes.*” E thought that it is not normal to apportion blame within military aviation, as aircrew acknowledge human error and engineers have systems for consistent and ingrained processes. He opined that the ‘Yes’ contingent might be commercial aircrew who faced far more competitive agendas than military.

S_{4b} is that the capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome and Figure 6-6 shows the respondents' answers to the relevant survey questions.

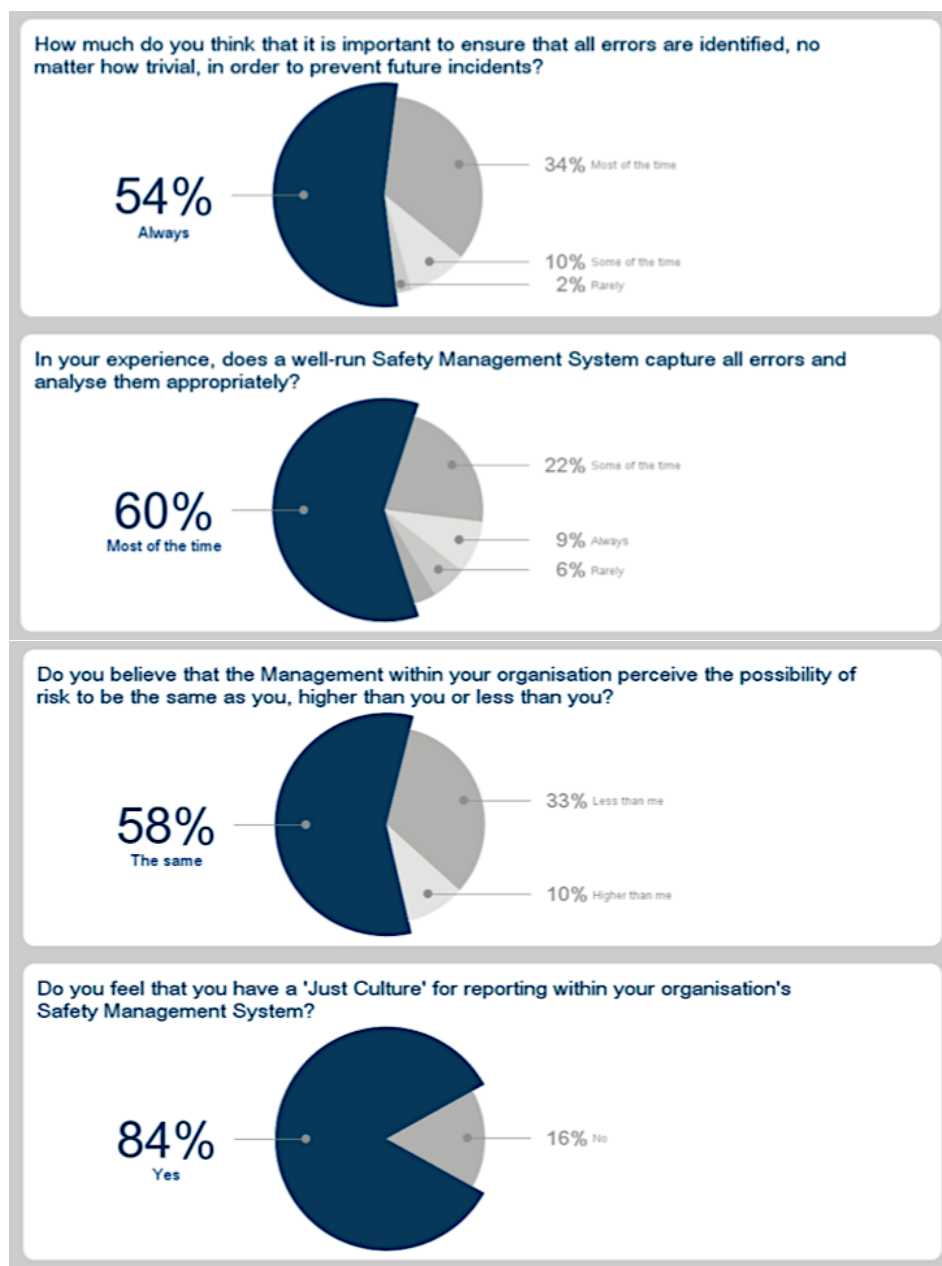


Figure 6-6 showing respondents' answers to the questions associated with S_{4b}

Interviewee A was surprised that the 'Always' percentage to the first question was not higher than 54%; why would you not try to identify every error in order to learn from it? He was dismayed at the 2% who said 'Rarely' and wondered which of the 'Four Worlds' those respondents were from, and if there were any trends across their answers in respect of region perhaps. [Analysis revealed no geographic trend and a 50/50 split between Aircrew with Other Support Staff]. He was unsurprised by the percentages in respect to SMS, except again for the 6% Rarely; what job and which country?

Interviewee B focussed on the word ALL and commented that it was a matter of “*scaling; lose ability to see the important stuff in the noise*”. He also said that “*too much data and you’ll drown*” and “*capacity of understanding*”. The next question on SMS caused the same debate about ALL; B’s answer was “*No – and it shouldn’t!*”. “*You will spend most time capturing data and no capacity for analysis*”. Aviation management share the same perception of risk in general and look to “*identify which risks are important*”. There is not always the clarity though across all levels of the organisation, and management could do better at describing the risks cohesively to different audiences/groups/layers. He finished by saying that the “*best run SMS knows key risks and collects appropriate data*”.

Interviewee C was surprised at how low the majority figure was for ‘Always’ in the first question at only 54%, the expectation would have been higher. He did notice though that taken as the ‘top 2’ including ‘most of the time’ this was 88% and is more like the order of magnitude that he would have expected for wanting to identify errors. The question about an SMS capturing all errors sparked a debate as to the realistic utility of capturing all of the trivia and he opined that perhaps things had gone a little too far, giving the example that “*a 100% increase in the reporting rate has made a disproportionate draw on existing limited resources*” and saying that there is “*a need to balance headcount with workflow*”. When questioned about a single cause being identified, C commented that “*an SMS can’t accept when someone just [makes a mistake]*” and he therefore understood why the majority viewpoint was ‘No’. C went on to describe some aspects of his organisation’s SMS and how Flight Data Monitoring is used a lot and has proven useful, albeit that reporting has increased because of it, especially amongst the engineers. He finished this section with a comment that “*when people are reporting that the Pringles were in the wrong drawer, you know that you are getting all the information*”.

Interviewee D made a very interesting point in relation to the question on how important it is to ensure that all errors are identified – the power of the phrase ‘no matter how trivial’ in this question had not been considered before. D thought that this may have swayed some respondents away from the ‘Always’ response because really some errors are incredibly trivial and do not warrant reporting or explanation. A debate ensued as to where the line is drawn though and how subjective this is. Comments made included the concept of having too much data to analyse because of the inclusion of the trivial, but this needs to be balanced against the desire to capture evidence of near-misses that can be learnt from and trend analysis. D stated that his own answer to the question of management’s perception

of risk would be to agree with the middle figure ‘less than me’ but was pleased that the majority view was ‘the same’.

Interviewee E focussed on both ‘all errors’ and on ‘trivial’ in the question. “*Where is the line, and how do you know when you reach all errors*” he asked? He went on to state that it was a law of diminishing returns and the potential for disproportionate effort to be expended for little return. He said that there was potential for “*flogging a dead horse*” and he felt that strong leadership should say “*enough, we can’t keep investigating with finite resources available*”. His answer was, therefore, “*Most of the Time*” (34%). On SMS, his opening statement was that “*it would be naïve of anyone to answer Always*”, especially as there will no doubt be human error within an SMS, and if the SMS is actually only one individual then this would also be exacerbated. His answer was again ‘Most of the Time’ (the majority answer – 60%). For the management perception and Just Culture questions, E agreed with the majority answers. He did express surprise at the relatively high response (16%) from those saying No!

These statements support the answers found in Section 5.3, the two suppositions are believed true and the objective met. The five interviewees considered the survey results to be a valid representation of the industry.

6.4.5 Objective 5

S₅ is that there is not enough regulation on the use of drones and more is needed urgently. Figure 6-7 shows the respondents’ answers to the relevant survey questions.

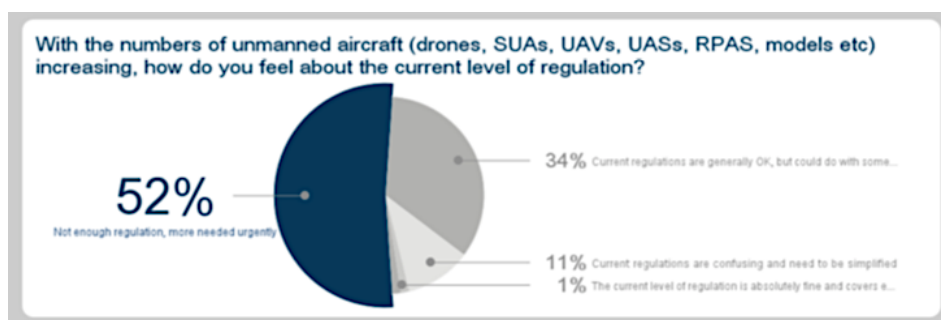


Figure 6-7 showing respondents’ answers to the questions associated with objective 5

Interviewee A stated that more regulation is needed urgently. The regulators believe that there is a need to gain evidence to develop regulation, the manufacturers want regulation now so as not to waste money later. “*Need for standards to be established for manufacturers to build UAVs to. Either that or manufacturers should develop a set of*

universal protocols to inform the regulators.” He made a very valid point about Brand Protection and used Amazon as an example. He opined that one mistake from Amazon (or similar) and they will be hit hard (bad press), and in general the UAV markets are non-aviation with big brands unwilling to risk reputations and bad press. Therefore, developmental progress is slower than it could be. The EASA proposals of introducing categories was seen as a good thing as manufacturers can then focus on deciding what product to aim at individual markets within a category to fit with appropriate regulation. They need guidance, which has not been forthcoming. The GUTMA⁹⁷ group of manufacturers and operators are trying to lead the regulators by developing these protocols, whereas ICAO⁹⁸ are focussing on interoperability.

Interviewee B felt that the current regulations are mostly fit-for-purpose but need some tweaks. *“Regulatory aspects are fairly well understood”*, the difficult part is in the implementation and an *“international interoperability challenge”*. He agreed that electronic conspicuity (EC) and registration are the way ahead, and necessary, but said that EC must include GA⁹⁹ and that registration will be of maximum use if there is cross-border accessibility and interoperability – people will take their drones on holiday. In regard to the proliferation of drones and the current level of regulation, Interviewee C felt that the current regulations needed some bolstering but were in general fit-for-purpose.

Interviewee D felt that current regulation is confusing but needs development rather than having too much regulation. He said *“it is barking that you can fly drones in CAS¹⁰⁰ at any height, this is endangerment. Regulation should be more explicit.”* D was somewhat ‘hot/cold’ in regard to the benefit of registration because we *“haven’t caught a single person in relation to an Airprox with a drone”*. If registration is introduced, then he suggested that it might be in the form of a SIM card. D thought UTM was the right development line and that the key would be the integration of UTM with ATM¹⁰¹, which must come. It would not be possible, or right, to prevent drone development, but it must be done safely and with the safety of manned aviation at the forefront. *“At the moment this is lagging well behind the advances of drone technology and proliferation”*.

⁹⁷ Global UTM Association

⁹⁸ International Civil Aviation Organization

⁹⁹ General Aviation (normally used to describe non-commercial flights)

¹⁰⁰ Controlled Airspace – Class A to E airspace where restrictions apply to its use

¹⁰¹ Air Traffic Management – in this context used to describe the current Air Traffic Control system

Interviewee E commented that this issue was far wider than drones and needed to be addressed across GA and gliders too. “*The entire regulation set needs boosting*” was his comment in support of the statement that drone regulations were generally ok, they just need a tweak.

These statements support the answer found in Section 5.3 that whilst the majority perception is for an urgent bolstering of the regulations overall, a sizable proportion (34%) just see a need for some minor amendments to the current ones. The supposition is considered to be true and the objective met. The five interviewees considered the survey results to be a valid representation of the industry.

6.4.6 General comments

After validating the survey results, questions were asked about regulatory change in general and examples of how it might be done better. When asked about his thoughts on the way that MAA regulations are introduced, an Interviewee said he had personally witnessed a significant improvement in the way that the MAA does its business over the last 18 months. An example of this is the fuller collaboration with the CAA in such areas as display flying. On a negative point, he said that “*we are changing regulations for the wrong reason*” such as blindly exchanging the word Aircraft for Air System. He finished by saying that “*the aspiration to give people a period of stability is never achieved due to external pressures from bodies such as EASA etc.*”

Interviewee C highlighted the Transition Altitude change programme as being a particularly good example of a poorly handled change and he was relieved that it had been put on hold for now. Interviewee D was very concerned about the possibility of the UK diverging from EASA post-Brexit but suggested that if we do so then the key will be a direct link with ICAO. When asked if this would open the door to the UK adoption of ICAO ATS¹⁰² instead of UK FIS¹⁰³ he felt that this would be “*a backward step as we have come a long way on the journey with ATSOCAS/UK FIS and it would be a shame to introduce a new set of services that could be seen to be less safe*”. That said, he acknowledged that there was potential that this would be the case anyway if we did remain tied with EASA, in that the ATM IR¹⁰⁴ stipulates this change and the UK may not be able

¹⁰² Air Traffic Service

¹⁰³ UK Flight Information Services is the revised name for ATSOCAS

¹⁰⁴ EU Regulation 2017/373, the “Air Traffic Management Common Requirements Implementing Regulation” (ATM IR), entered into EU law on 1 March 2017 (CAA, 2017a)

to achieve a derivation. D was also concerned about the perception of change, and he stated that the normal response was always “*not more change!*” and then talked about change fatigue. He answered that he had witnessed this aspect many times in his flying career and there were distinct periods where it had greater impact than others; he felt that we had been through a tough time over the last few years with regards to regulatory change, but the worst was yet to come with the potential upheaval from Brexit, the changes for drones and general European airspace changes (SES/SESAR¹⁰⁵).

6.5 Summary of primary data analysis

Objectives 2 to 4 are fully met by the analysis of the quantitative and qualitative data, which has shown consistency between the literature, the survey and interviews. The qualitative data has complemented the quantitative, providing the enrichment predicted by Bazeley (2018), exposed in Section 3.3. Objectives 1 and 5 have thus far only been partially met and analysis of secondary data is required to complete these two. Whilst Chapter 5 necessitated a positivist stance in relation to quantitative analysis, the richness of the data in this chapter has allowed a balance between the positivist desire to absolutely declare something as true or false, and the constructionist view of analysing the depth and meaning of the data collected. The only amendment to Table 6-5 presented earlier is that qualitative analysis of primary data has found some evidence to support S₁.

The aim of using mixed methods in the research was to provide triangulation and validation of the results, whilst also giving some depth of understanding; this has been achieved and presented in this chapter. Two elements are carried forward to the next sections for further analysis within the research. However, two other elements have been identified which are troubling, but not part of this study. These are the prevalence of hindsight bias featuring so highly in investigations across the global industry, and in Britain the worrying lack of a Just Culture for reporting amongst organisations that support the aviation industry (‘Fourth World’).

The outstanding suppositions that need addressing are S₁ ‘The introduction of regulatory change increases the number of near-miss events’ and S₅ ‘There is not enough regulation on the use of drones and more is needed urgently’.

¹⁰⁵ Single European Sky and SES ATM Research

6.6 Qualitative analysis of Airprox data

...without doubt, the defining feature of 2015 was the dramatic increase in drone/objects that were encountered by aircraft. In 2014, there were only 9 such incidents ... whereas, in 2015, there were 40 incidents ... (UKAB, 2016a)

Many of the statistics presented on the UKAB's website¹⁰⁶ are numerical with respect to the overall numbers of Airprox that have occurred in UK airspace, but this section of the thesis will analyse the data with reference to UK flying hours. The UKAB reports that in 2016 there were 265 Airprox overall, which they declare as an average of about one per working day, and when focusing on the 123 risk-bearing incidents (Cat¹⁰⁷ A or B; see Figure 2-1) the average is a near-collision more than twice per week (UKAB, 2017a). Even with drones removed from the data, there were 58 near-collisions in 2016, "*meaning aircraft nearly collided every week*" (UKAB, 2017a, p. 13).

In order to normalise the numerical data, the flying hours shown in Table 6-6 are used; these are taken from the UKAB report on 2016 Airprox (UKAB, 2017a) where it is acknowledged that the GA hours are a little low because they do not include sport flying, and the military hours have an element of estimation.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CAT Hours x 10K	162.0	163.5	149.4	141.6	147.1	145.4	149.0	151.5	154.8	161.5
GA Hours x 10K	134.6	135.1	131.2	113.0	104.0	96.2	92.3	93.2	88.0	83.9
Mil hrs x10K	43.4	40.1	43.2	31.8	31.1	25.6	24.2	25.0	24.2	25.6
Total Hrs x10K	340.0	338.7	323.7	286.4	282.3	267.2	265.6	269.7	267.1	270.9

Table 6-6 showing the UK flying hours (expressed in 10,000) by category and year
Copyright 2017 by the UK Airprox Board¹⁰⁸

UKAB analysis of the 10-year trend for non-drone Airprox, shown in Figure 6-8, states that although the flying hours have remained relatively consistent in recent years, there is no correlation to the number, or severity, of Airprox.

¹⁰⁶ www.airproxboard.org.uk

¹⁰⁷ Throughout this analysis the terms CAT and Cat will be used consistently to mean CAT (Commercial Air Transport aircraft) and Cat (Airprox Category, akin to severity)

¹⁰⁸ <http://www.airproxboard.org.uk/Learn-more/Copyright/> grants permission for any material found on the UKAB website or database to be reproduced for research purposes, on the understanding that it must not be sold or used commercially

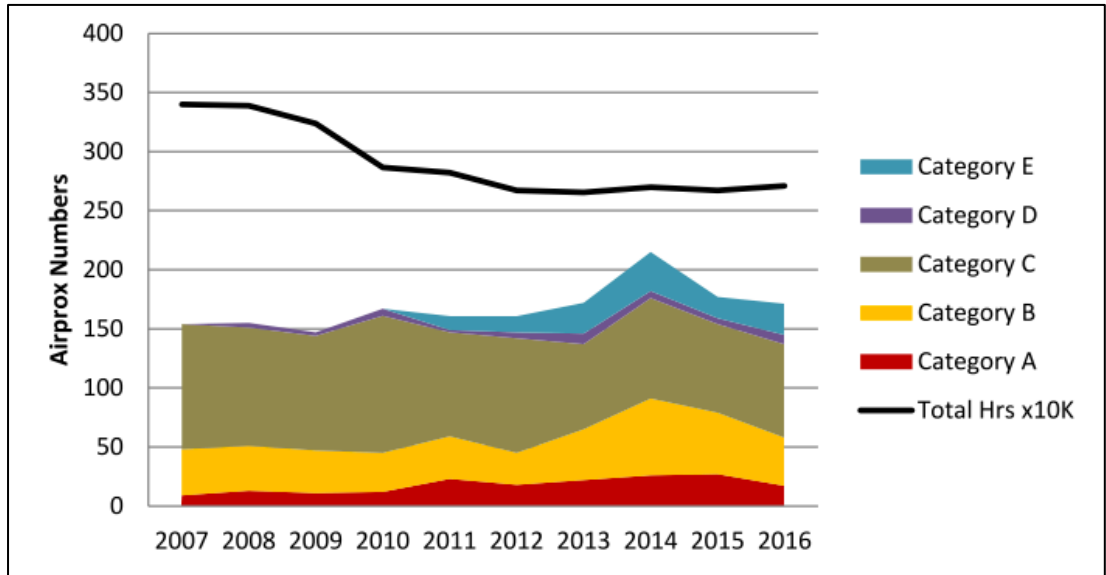


Figure 6-8 showing the overall non-drone trend compared with total flying hours
 Copyright 2017 by the UK Airprox Board

Using the data for the total number of non-drone Airprox per year over the 10-year period (UKAB, 2017a) to cross reference with the total flying hours from Table 6-6, the Airprox rate is calculated as 1 per 22,078 flying hours in 2007, and as 1 per 15,842 flying hours in 2016. This shows that Airprox are more frequent in 2016, as less hours need to be flown to have one, and the likelihood of an Airprox has increased, even when drones are not included. A chart showing the flying hours per Airprox over this 10-year period is shown in Figure 6-9, where improvement, in terms of more hours per Airprox, can be seen in the latter two years after a general increase in likelihood between 2009 - 2014.

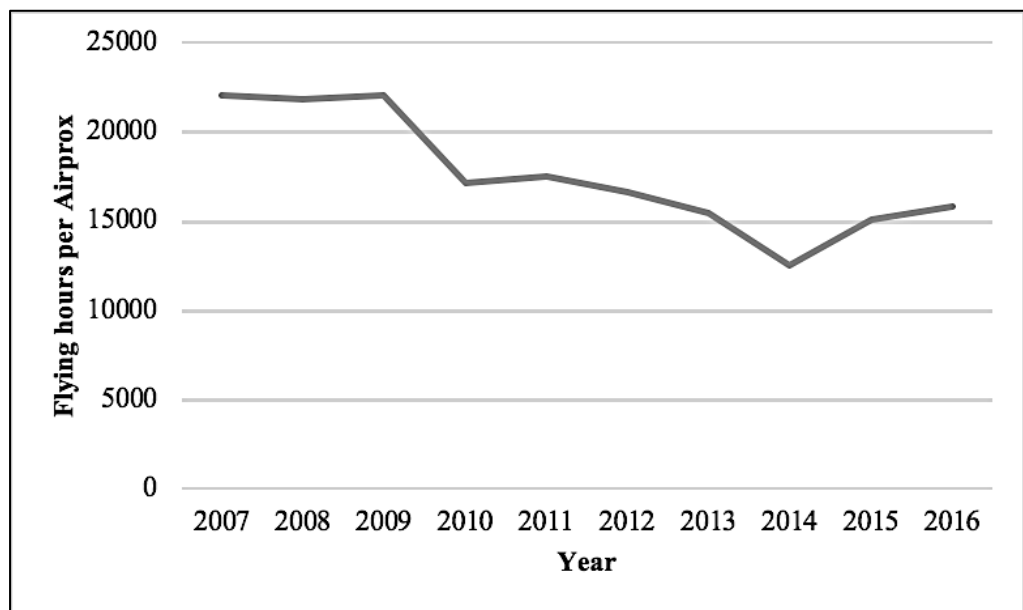


Figure 6-9 showing the Airprox rate for the total flying hours from 2007 to 2016, irrespective of Risk Cat or aircraft type

Figure 6-10 shows the trend of Airprox reports involving drones and other objects between 1st January 2010 and 31st January 2018. It is conceivable that the events categorised as ‘unknown’ are also drones, as ‘unknown’ is used where there is doubt as to whether it was a drone/balloon/model or not. The flying hours for drones are not known and, therefore, the statistics are reported as numbers in this case, where it can be seen that the number of drone-related airprox has risen substantially whilst also surmising that this is likely to be in line with their proliferation. Drone Airprox are often assessed as a Cat A because, by the time the pilot sees the drone it is already too late to avoid it, and it is not normally possible to trace the drone operator to gain a report from their perspective. This means that the most likely outcome is that they miss each other by luck, however, the Board do account for the relative trajectories and if there is no perceived immediate risk of collision then a lower Category is given; i.e. it is not automatic to award a drone a Cat A.

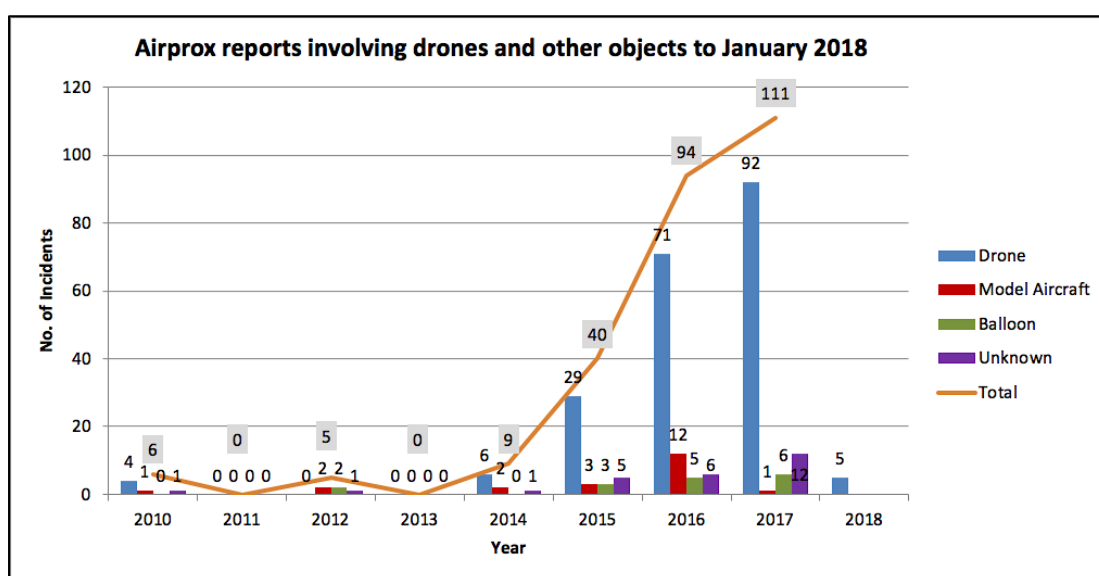


Figure 6-10 showing the number of Airprox involving drones and other objects from January 2010 to January 2018. Copyright 2018 by the UK Airprox Board.

Analysis of drone-related Airprox reports from 2015, 2016 and 2017 is presented in sub-Section 6.6.2, where trends are considered, and any possible lessons looked for.

6.6.1 Analysis of all Airprox in 2015 and 2016

The number of Cat A Airprox decreased from 2015 to 2016 (Figure 6-8). Assessed against total flying hours, the Airprox rate in 2015 was 1 Cat A per 98,926 flying hours and in 2016 was 1 Cat A per 159,353 flying hours, and the overall Airprox rate in 2015 was 1 per 15,090 flying hours and in 2016 was 1 per 15,305 flying hours. So, in 2016 there was significantly less likelihood of a Cat A Airprox, however, the chance of any Cat of Airprox remained broadly similar to the previous year, albeit with a slight improvement.

Detailed analysis of the Airprox reports from 2015 (217 Airprox) and 2016 (266 Airprox) is conducted to identify any elements relevant to regulatory change. Table 6-7 shows the breakdown by class of the number of UK non-drone Airprox per million flying hours (mfh), with the number of risk bearing (Cat A&B) per mfh in brackets. 2014 statistics are included for trend purposes. It must be noted that when analysing the categories, the total number will invariably be greater than 100% of the Airprox that occurred because, for example, an Airprox between CAT and GA is counted as one of each, whereas Mil to Mil is counted just once.

Class / year	2014	2015	2016
Commercial Air Transport (CAT)	18 (3)	14 (2)	12 (1)
General Aviation (GA)	175 (84)	159 (73)	156 (55)
Military (Mil)	380 (124)	277 (120)	270 (86)
Total	573 (211)	450 (195)	438 (142)
% Cat A&B	37%	43%	32%

Table 6-7 showing the number of UK non-drone Airprox, for each class, per million flying hours and, in brackets, the number of risk-bearing (Cat A &B) Airprox per million flying hours

It can be seen in Table 6-7 that the general trend is for less incidents over the three years, for each of the sets of data, except for the proportion of Cat A&B. The UKAB's assessment of barriers was introduced in sub-Section 2.2.2; from a regulatory change perspective, the barrier of greatest interest is the airspace design/procedures one, where the UKAB categorise the barrier as 'ineffective', 'partially effective' or 'fully effective'. This methodology of investigation was only introduced during 2016 and 71 Airprox were assessed in this way. For 76% of these the airspace and procedures were found to be fully effective, in 17% partially so and in 7% they were ineffective, which means that they contributed towards the Airprox happening. To include the drone statistics would show a rising trend in risk-bearing Airprox, which is already obvious from the raw numbers; for instance, in 2016 the drone-related Cat As accounted for 67% of the total Cat As for the year. Also of note from the 2016 UKAB report (UKAB, 2017a, p. 22), is that 'ATC high workload/error' factored in 13 of the Airprox and 'did not obey instructions/procedures' in 34 cases. The 2016 report has provided the detail required for this analysis so far, although the 2015 report (UKAB, 2016a) does have the 2006 statistics which are required in Section 6.7.

Having investigated the overall picture, Nvivo is used to explore the detail of the individual Airprox reports from both years. Initial coding nodes are communication, failure to follow process (F2FP), gliders, human error, learning lessons, training/student, workload/manning levels, perception (including assumption and ‘concerned by the proximity of’ as sub-sets), procedure at fault, new procedure after Airprox, airspace change/design and drones. From this coding list, in focussing on the research objective and S₁, the coding nodes shown in Figure 6-11 are selected for further analysis. Across the two years of reports (483) four contain a specific reference to airspace design or an airspace change being contributory, one in 2015 (Airprox 2015055) and three in 2016 (Airprox 2016165, 2016171 and 2016212).

Name	Sources
● airspace change or design	4
● F2FP	31
● human error	1
● new procedure post-airpr...	8
● procedure at fault	11

Figure 6-11 showing the coding report for selected nodes

Airprox 2015055 happened on 2 April 2015, which is coincident with the date that the new SERA regulations discussed in Section 6.9 were introduced, but in this case the controllers’ knowledge of the implications of the changes made to the Southend Airport airspace are cited as a contributory factor, with no mention of SERA. The date is coincident because changes within aviation are invariably tied to the AIRAC cycle (explained in Appendix I), so happen on the same date announced in advance, so that all publications are amended at the same time. The pertinent paragraphs of the Airprox report are shown in Figure 6-12.

Analysis of the information shown suggests that the changes made to the airspace were introduced in such a way as to cause confusion and led to the air traffic controller giving an instruction to one airliner to descend into conflict with another. The aircraft came no closer than 300ft/2nm and the incident is classified as Cat C. In this Airprox, a change of airspace (regulatory change) contributed to the incident because it meant that a previous fail-safe procedure (climbing the departing aircraft to 3000ft and the inbound one descending to 4000ft) could not continue to be used as controllers had to avoid the new airspace which was from the ground up to 3500ft. The controllers on this day, were on their first shift since the change had been “*rushed*” into place (Figure 6-12, para. 2), and

that training for the scenario had been very limited. The report implies that if the change had been better introduced, with adequate training and supervision, then the incident might not have happened.

Internals\2015\Airprox Report 2015055
5 references coded, 12.91% coverage

Reference 1: 3.45% coverage

A controller member with knowledge of this incident informed the Board that the changes in airspace that had been introduced as a result of the introduction of the Southend CTR/CTA had required the modification of previous deconfliction measures between aircraft arriving and departing LCY. In the past, departing aircraft had been climbed to 3000ft, whilst arriving aircraft had been correspondingly coordinated in descent to 4000ft. It was explained that on 2nd April (some 21 days before the event) the CAA had introduced the Southend CTR/CTA, which extended up to 3500ft near to the LCY CTA. This meant that, without positive control, southbound departures that had previously been climbed to only 3000ft were now in danger of penetrating the Southend CTA. The member explained that various methods of tackling this problem had been employed by different controller shifts such as issuing a heading to avoid the airspace, or climbing the aircraft above the airspace, as happened in

Reference 2: 2.83% coverage

this instance. These methods were new (in respect of the Southend airspace change) and both controllers concerned in the incident had not controlled, due to annual leave and other commitments, since the introduction of the Southend CTR/CTA – the incident occurred close to the start of their first shift. The controller member noted that the perception of the controllers was that, although they had been informed of the impending airspace changes, it was perceived within the operational environment that the introduction had been rushed; it was reported that although training was given in the form of briefings and written instructions, simulator time was only provided if it had been specifically requested by an individual controller (which had been taken up by some, but not all, of the controllers).

Reference 3: 3.76% coverage

For their part, the NATS representative subsequently reported that the London Southend airspace change had been implemented by the unit some three weeks before the Airprox, and that in their opinion the airspace change was therefore not contributory to the Airprox event. They stated that NATS had fully complied with all the necessary processes to support the implementation of the London Southend changes into their operation. They also confirmed that NATS had obtained specific agreement from the CAA to offer simulated familiarisation to any controller who believed they would benefit from undertaking a simulated exercise of the new airspace procedures. This offer was made to all appropriately valid controllers and was accepted by some. The same briefing material and instructions were provided to all five Terminal Control watches. Because Swanwick is a very large unit, NATS commented that significant lead times are required to prepare for change, including the need to consider and prepare any specific briefing or training material for operational staff.

Reference 4: 2.55% coverage

The Board noted the differing perspectives of how the airspace had been introduced and its bearing on the Airprox. Members also noted that this had been the first shift that these controllers had operated after the change and that, although written instructions and briefings had been given, simulator training was not a mandatory part of the introduction. They therefore concluded that the lack of familiarity with the new airspace may have been a factor in the Airprox in that, under the pressure of their first experience with the change, the controllers may have unconsciously reverted to many years of previous practice and transmitted and heard what they expected, rather than what they had agreed to in their coordination.

Reference 5: 0.32% coverage

4. Neither controller were practised in the implications of the Southend airspace change.

Figure 6-12 showing the pertinent paragraphs of Airprox report 2015055

The pertinent details from Airprox 2016165 are shown in Figure 6-13, in which the airspace design around RAF Brize Norton and London Oxford Airport are considered to be ineffective. The way that the two adjacent aerodromes' patterns and procedures conflict with each other is seen as a flaw in their design. The ACPs¹⁰⁹ have now been prepared and are at the public consultation stage (GATCO, 2018).

Internals\2016\Airprox Report 2016165
4 references coded, 1.59% coverage

Reference 1: 0.26% coverage

London Oxford Airport and Brize Norton are both in the process of producing an Airspace Change Proposal (ACP) which may allow for engagement on new procedures and ways of working.

Reference 2: 0.93% coverage

C182 pilot had not expected the A400 to leave the Brize CTR, but the Board noted that the Brize controller was perfectly entitled to manoeuvre the aircraft outside the confines of the CTR provided it complied with normal Rules of the Air when doing so. The Board then had a discussion about the proximity of the Oxford Missed Approach Procedure and the Brize radar patterns, and noted that they were very adjacent. Noting that there were Airspace Change Proposals (ACP) in place for both Brize and Oxford, the Board thought that it was not its place to comment on these but hoped that any changes would facilitate for greater cohesion between the two units.

Reference 3: 0.36% coverage

Airspace Design and Procedures were considered ineffective because the Brize CTR did not stop the A400 from spilling out into Class G airspace, and the Brize/Oxford LOA regarding liaison in such circumstances did not apply to the single-engine C182.

Reference 4: 0.04% coverage

Airspace Design & Procedures

Figure 6-13 showing the pertinent paragraphs of Airprox report 2016165

Airprox 2016171 involved military fast-jet aircraft coming into close proximity with each other at their base at RAF Lossiemouth in Scotland. In brief, the visual circuit direction had previously been 'left-hand' (anti-clockwise), but the change of aircraft type from Tornado to Typhoon had triggered a change of local regulation to make this a 'right-hand' (clockwise) circuit. However, due to the need to avoid overflying Lossiemouth village, this new circuit direction meant that the fourth fast-jet of a 4-aircraft formation returning to the aerodrome came close to a separate departing aircraft. After the incident the circuit direction was reversed back to the original direction to prevent a recurrence of this Risk B Airprox. Figure 6-14 shows an extract from Nvivo analysis, which also highlights that the airspace design and procedures were ineffective after the original change of circuit direction, with a regulatory change meaning that two aircraft came close to colliding with each other.

¹⁰⁹ Airspace Change Proposal

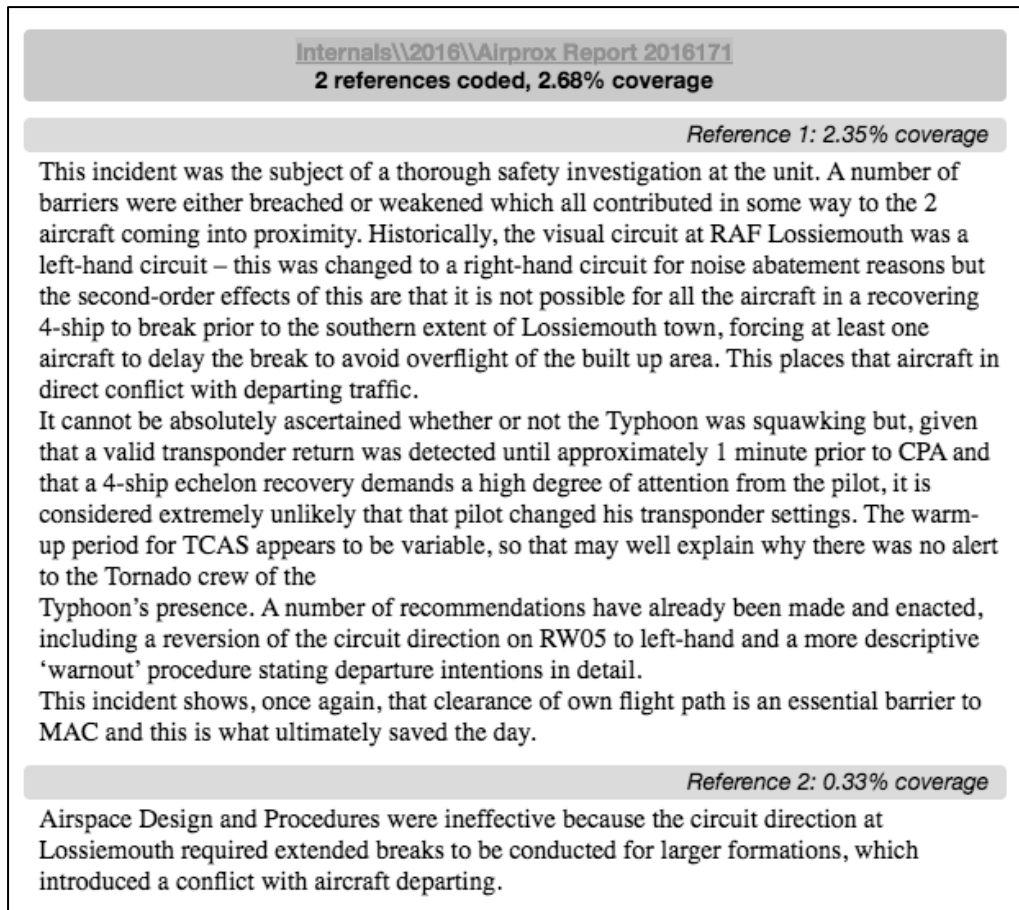


Figure 6-14 showing the pertinent paragraphs of Airprox report 2016171

In the last of the four Airprox implicating airspace issues, 2016212, a CAT aircraft flew into conflict with a light aircraft involved in dropping parachutists at a site in Scotland. The implication for airspace design from this particular Airprox is that that were no standard departure routes in place designed to avoid this parachuting site, and the recommendation that was made was for Dundee ATC to include the site details in their aviation publications for pilots.

From these four examples, it can be seen that the way in which airspace is designed can impact upon air safety, and also that the introduction of change can decrease safety, such as in the Southend and Lossiemouth examples where the reports suggested that the changes were either not introduced well enough or were reversed after the incident. These two examples fit within the supposition that change can increase near-misses. The most relatable points from these examples though, is that it is the way that the introduction of change is managed that is important.

Eleven reports over the two years are coded as having a procedure at fault, implying that regulations may need changing, but that is not germane to this analysis. Similarly, the

node coding for ‘procedures changed because of the Airprox’ (eight) does not apply to the research. The one incidence of ‘human error’ is a cognitive East/West slip by a controller at RAF Brize Norton and on 31 occasions, ‘not following set procedures’ (F2FP) led to an Airprox being reported.

6.6.2 Analysis of drone-related Airprox in 2015, 2016 and 2017

Table 6-8 shows a comparison of the number of Airprox reported, that involved a drone or other object, in the years 2015, 2016 and 2017. In the coding process, judgement is applied to the ‘unknown’ entries, and where it is felt that it is probably a drone the categorisation is amended for the analysis; 13 of the 23 unknowns are changed to drone.

Year	Drone	Model Aircraft	Balloon	Unknown	Total
2015	29	3	3	5	40
2016	71	12	5	6	94
2017	92	1	6	12	111

Table 6-8 showing the breakdown of Airprox numbers with ‘drones and other objects’

For analysis, the reports are coded using NVivo to reflect an altitude band (below 400ft, 400-999ft, 1000-1999ft, 2000-2999ft, and at or above 3000ft), CAT¹¹⁰, Not drone and ‘Drone operating iaw¹¹¹ the Dronocode¹¹²’. This last node represents drones that are being flown below the recommended ceiling 400ft AGL¹¹³, within VLOS¹¹⁴ of the operator and away from airfields and flight paths. In essence the majority of sources for this node are events where the drone operator had filed the Airprox against an unexpected encounter with a helicopter, as most other cases involved a drone interacting with an aircraft flight path or being too close to an airfield. The coding incidences from the analysis is shown in Figure 6-15, which shows what altitude band the drone Airprox were operating within and how many Airprox were with a CAT aircraft.

¹¹⁰ Commercial Air Transport, which effectively should be thought of as an airliner with passengers

¹¹¹ In accordance with

¹¹² Document produced by the CAA to improve awareness of safe practice with drones (CAA, 2017b)

¹¹³ Above Ground Level

¹¹⁴ Visual Line Of Sight

Name	Referen...
1) at or above 3000ft	83
2) 2000-2999ft	33
3) 1000-1999ft	50
5) 400-999ft	23
6) below 400ft	12
CAT	138
Drone operating below 400ft AGL and away from airfield or flight path	8

Figure 6-15 showing coding for Airprox with objects 2015-2017

The Dronecode recommends that drones are not flown higher than 400ft above the ground, whereas aircraft often report their altitude at the time of the encounter¹¹⁵. Without detailing the elevation of the ground in the vicinity of the Airprox (possible to research but of limited value) the altitude band listed may differ slightly from that the encounter occurred in. This will generally not be the case for the higher bands. It can be seen that 138 of the drone-Airprox involved CAT aircraft. Only 12 of the drone-Airprox occurred in the lower band where drones are recommended to be flown, and 83 of them in the band above 3000ft where they cannot possibly be considered to be being operated within VLOS.

As presented in sub-Section 2.2.2, Airprox are given a Risk rating when assessed by the UKAB, where A represents the most serious risk of collision. A synopsis of the regulations pertaining to drones in force at the time of these Airprox is in Section 2.7. The law that is most applicable to these Airprox scenarios is the ANO¹¹⁶, Article 241, which states that a drone must be flown in such a way as to not endanger another person. This is currently the only regulation that pertains to drone flights, all other guidance is a suggestion on how to operate. On 71 occasions, in UK airspace, there was a serious risk of collision between a manned aircraft and a drone (Cat A) during this 3-year period. On a further 65 occasions the safety of the aircraft may have been compromised (Cat B). On none of these occasions was a drone operator prosecuted, despite being in contravention of the ANO, and furthermore in only eight of the Airprox was the drone being operated in accordance with the advisory Dronecode. Drones do not need to be registered, have their height electronically limited, or their operation prevented in the vicinity of an airfield. Their operators do not need to be licenced, except if operating commercially. It is therefore suggested that the data supports the supposition (S₅) that there is not enough regulation on the use of drones, and more is needed urgently.

¹¹⁵ Without being specific on the technical detail of the difference between height and altitude, in this thesis height is used with reference to the ground and altitude in reference to Mean Sea Level

¹¹⁶ Air Navigation Order 2016

This research was included within the DfT¹¹⁷ consultation on drones in 2017, and then, on 30 May 2018, it was announced that the ANO is being amended on 30 July 2018 to include a maximum height of 400ft and the prohibition of flight within 1km of an aerodrome (Department for Transport, 2018). This is a good start but does not resolve many of the problems associated with the potential for mid-air collision, not least of which is that at 1km from an aerodrome in a straight line to the runway a manned aircraft intending to land will likely be below 400ft, especially where there is high ground surrounding an aerodrome. The same can be said for an aircraft taking off, although the height will very much depend on aircraft performance. 12 of the Airprox analysed were operating below 400ft and eight were not in the vicinity of an aerodrome, so these would still have happened under the new regulation. There is a further ANO amendment planned for November 2019, which includes the requirement for registration and training courses. This is excellent progress and it is hoped will educate drone users, who are often not aviation aware, where to expect aircraft to be and the folly of being in close proximity to them. There is no regulation being introduced for electronic conspicuity or geofencing.

6.6.3 Support to the SERA Case Study

In support of the case study analysis at Section 6.9, the Airprox reports from 2nd April 2015 to 2nd July 2015 (three months) are analysed for any implications associated with the introduction of the new SERA regulations. The sequence of reports checked are 2015034 through 2015101, none of which are found to implicate the changes to SERA. In many of them SERA is mentioned in the context of how the rule affected the geometry of the flight paths, but in no case is either the cause or a contributory factor associated with the introduction of SERA.

6.7 Analysis of Airprox data from the 3 years prior to, versus the 3 years after, the introduction of ATSOCS to the UK on 12 March 2009

On the 12 March 2009 there was a major change to the regulations surrounding the provision of Flight Information Services (FIS) within UK airspace, a change program known as ATSOCS, designed to replace all of the existing services and align the way that both military and civilian controllers provide the services (CAA, 2009). One of the reasons given for the change was as a result of safety concerns raised by the UKAB about a perceived confusion surrounding the old services and a lack of standardised provision

¹¹⁷ UK Government Department for Transport

(ASI, 2009). The data for the 3-years prior to, and 3-years after, the introduction of ATSOCAS was obtained from the UKAB, and analysed using Excel. Prior to ATSOCAS the services were termed RAS, RIS and FIS. The new services are called DS, TS and BS, RAS was replaced by DS, RIS by TS and FIS by BS; further explanation of either the abbreviations or what they mean is not relevant to the research.

In the 3-years prior to the introduction of ATSOCAS there were a total of 451 Airprox, in the 3-years after there were 493, representing a 9% increase. When this is broken down, in unregulated airspace (i.e. that covered by the new services – the OCAS bit) the number of Airprox was 267 before and 379 after, a 42% increase. When at least one of the aircraft was under a RAS (before) there were 31 Airprox, when under a DS (after) there were 13; this is the only decrease seen in the data and is a reduction of 58%. When neither of the aircraft were under a RAS/DS the numbers went from 88% of the Airprox before, to 97% after. Figure 6-16 shows this information graphically, where it can be seen that the total number of Airprox increased, especially the number in uncontrolled airspace (OCAS), but except for DS, all of the other service saw an increase in the number of Airprox. These are numbers and must be compared with flying hours to have any meaningful trend analysis conducted.

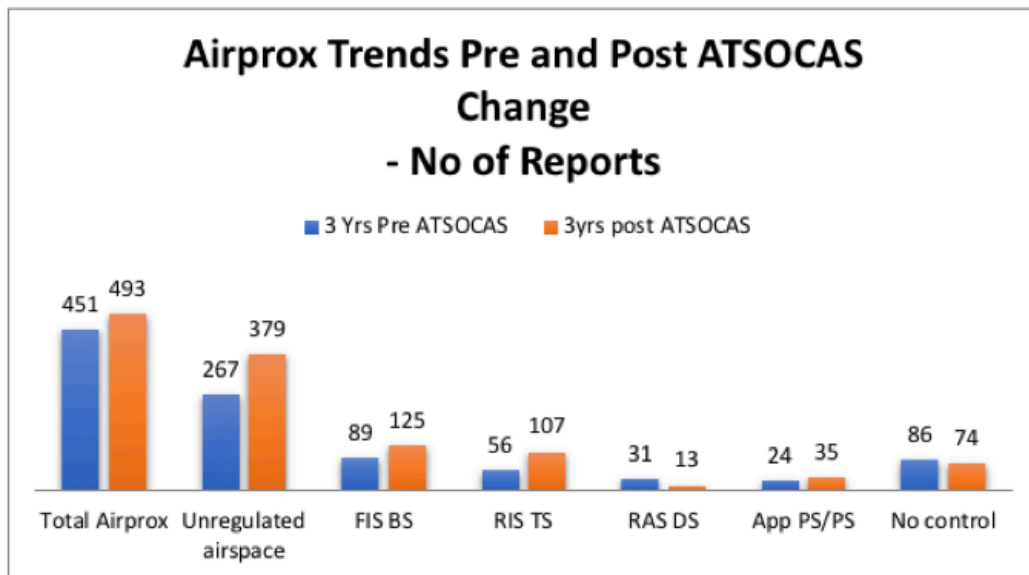


Figure 6-16 showing the breakdown of Airprox before and after ATSOCAS

Flying hours for the years 2006 – 2012 are shown in Table 6-9; there is a discrepancy with the figure for GA in 2011 between successive annual reports, so the figures reported in the Annual Report 2015 (published in 2016) are used because it is the most recent report that includes 2006 data from their 10-year figures (UKAB, 2016a). Flying hours are only presented together as a table from the annual report of 2014 Airprox onwards.

	2006	2007	2008	2009	2010	2011	2012
CAT mfh	1.603	1.620	1.635	1.494	1.416	1.471	1.454
GA mfh	1.305	1.346	1.351	1.312	1.130	1.127	1.098
Mil mfh	0.431	0.434	0.401	0.432	0.318	0.311	0.256
Total mfh	3.339	3.400	3.387	3.237	2.864	2.909	2.808

Table 6-9 showing the flying hours (million) for the years 2006 – 2012, reproduced from UK Airprox Board Annual Report 2015 (UKAB, 2016a)

The ATSOCAS regulation changes were made on 12 March 2009, so the Airprox data from 3-years prior to this commences on 12 March 2006. In order to interpolate the flying hours for the 3-years prior, and the 3-years after, the formula ‘0.8 x current year’ + ‘0.2 x the next year’ is used to represent approximately 20% of the year being prior to 12 March, taking into account that 2008 and 2012 were leap years; the interpolated results are shown in Table 6-10.

	-3	-2	-1	ATSOCAS	+1	+2	+3
CAT mfh	1.606	1.623	1.607		1.478	1.427	1.468
GA mfh	1.313	1.347	1.343		1.276	1.129	1.121
Mil mfh	0.432	0.427	0.407		0.409	0.317	0.300
Total mfh	3.351	3.397	3.357		3.163	2.873	2.889

Table 6-10 showing the interpolated data for the flying hours (million) for 3-years prior to, and 3-years after, the introduction of the ATSOCAS changes

The marked decrease in flying hours which can be seen post-ATSOCAS change is believed to be due to the economic downturn and not in any way associated with the regulation change. The total for ‘3-years prior’ is 10,105,800 flying hours, and ‘3-years after’ is 8,925,000 flying hours. When referenced to the total Airprox recorded in this period, the Airprox rate is calculated as 1 per 22,408 flying hours before ATSOCAS, and 1 per 18,103 flying hours after. The rate of Airprox, therefore, increased by 19%, despite the overall number of Airprox only increasing by 9%. This applies for the Total Airprox data; however, the majority of CAT flying will only ever be conducted in controlled airspace, where ATSOCAS does not apply (OCAS = outside controlled airspace). The data for unregulated airspace (the second pair of columns in Figure 6-16) are, therefore, compared with the flying hours of GA plus Mil, which together are the predominant users of unregulated airspace. In this case, the total flying hours for ‘3-years prior’ is 5,269,600, and ‘3-years after’ is 4,552,000, which gives an Airprox rate of 1 per 19,736 flying hours before ATSOCAS, and 1 per 12,011 flying hours after, representing a 39% increase in the rate of Airprox post ATSOCAS. This is represented in Table 6-11.

	3-years prior	ATSOCAS	3-years after	% change
Total Airprox Rate (all aircraft)	1 Airprox per 22,408 flying hours		1 Airprox per 18,103 flying hours	19% increase
Unregulated Airspace (GA+Mil)	1 Airprox per 19,736 flying hours		1 Airprox per 12,011 flying hours	39% increase

Table 6-11 showing rate of Airprox occurrence for 3-years prior to, and 3-years after, the introduction of the ATSOCAS changes, together with the percentage change

Further analysis could be conducted on the rise of numbers between individual types of service, e.g. RIS/TS rising from 56 to 107, but the numbers are so small that without the data to deduce a rate or likelihood (such as the number of times this type of service had been given) the results appear exaggerated. However, the results in Table 6-11 show that the rate of Airprox increased by 39% after the introduction of ATSOCAS to unregulated airspace in the UK. Whilst this data does not prove that in all cases the introduction of regulatory change causes an increase in the number of Airprox, it does show that in the case of ATSOCAS the number, and rate, of Airprox did increase, which may have been due to the change being introduced.

6.8 Descriptive analysis of the UK public perception of drone regulation

The UK CAA released its ‘Dronecode’ in 2015, which is designed to give information to recreational drone users to help them keep within the law (Collins, 2015). Between 17th - 20th February 2017, *Opinium Research LLP* conducted online surveys of 2019 adults on behalf of the CAA, one aspect of which was to see how wide-reaching the Dronecode had been. This was the second in a series researching drone use of the British public, the previous one carried out between 25nd August – 7th September 2016, where 506 online interviews were conducted with UK adults who own, use or were considering purchasing a drone. In this earlier survey, 51% (259) had heard of the Dronecode, of which 10% recalled that it contained guidance on not to fly near airports/aircraft/flight paths. Of the 247 drone users (or potential users) who had not heard of the Dronecode, 83% (204) were aware that there were rules and regulations relating to drone usage, 17% were not. When these 204 respondents were asked “what rules and regulations are you aware of relating to drone use”, 30% (61) responses of “not near airports/aircraft/flight paths” were received.

In the later survey of 2019 people, only 33 selected “I own or use a drone bigger than the palm of my hand”, but 88% (1931) had heard of drones. Of these 1931, 16% had heard of the Dronecode and 37% of them remembered that it says to stay well away from aircraft, airports and airfields. When the 1931 participants were asked what words they associated

with drones (selecting as many from the list as they liked), 42% selected 'Unregulated', 40% 'Risky', 38% 'Dangerous' and 30% 'Unsafe'. Another question asked respondents how important or unimportant they thought it was that all people who fly drones adhered to all of the rules and guidelines in the Dronecode? 76% felt it was 'Very Important', 14% 'Quite important', 2% 'Not very important', 1% 'Not at all important' and 6% didn't know. This shows that the majority of the sample of the British public surveyed, who had heard of drones, felt that drone users should be bound by the rules that were issued by the CAA and more than 1/3 of them associated drones with being unregulated, risky or dangerous. From the perceptions of this sample, it is believed that the general public support the need for better regulation of drone use.

6.9 Lessons identified in a case study on the feedback from the introduction of SERA on 2 April 2015

Appendix I gives a brief reasoning as to why the regulations surrounding the Rules of the Air were changed, and what the issues surrounding the introduction of the new SERA were. In essence, the new regulations became European Law in December 2012, but Member States were given two years grace to introduce them (CAA, 2014c). In the end, it was 2 April 2015 before SERA was implemented to the UK. The changes are listed in Appendix I, but are not germane to this analysis, suffice to say they were not trivial.

The points raised in the case study surrounded the period of uncertainty and confusion about the implementation date and the multiple delays. Some personnel had been proactive and looked on the internet, but this had created more confusion. The aerodrome operator had taken the initiative to proactively brief the squadrons on the changes, but they were still concerned about the lack of guidance coming from higher authority. Good practice identified in the case study is that aerodrome staff can assist in the management of regulatory change programmes, and how beneficial a proactive education campaign can be. In relation to research objective 1, the case study does not indicate an increase in the prevalence of near-miss events during the introduction of SERA at this aerodrome but does imply potential for distraction of aircrew and confusion associated with its introduction. In sub-Section 6.6.3 this is cross-referenced with the Airprox reports and there is no correlation found between the incidents and the introduction of SERA.

6.10 Analysis summary

This chapter has presented qualitative analysis of the free text answers from the survey, the semi-structured interviews and Airprox reports, together with analysis of the introduction of ATSOCAS and SERA changes and public perceptions of drones from CAA research. In doing so, this chapter has embraced the rich quality of the primary data and pursued analysis using a more constructionist perspective rather than the stance of positivism demanded by quantitative hypothesis testing. However, the analysis has been conducted within the framework of the suppositions that support the research objectives, with the qualitative analysis of the primary data used to reinforce, or otherwise, the answers from the analysis in Chapter 5, providing further depth where possible. The respondents' comments, which can be seen in full in Appendix F, have certainly provided this depth, with many pertinent examples given. Objectives 2, 3 and 4 have been satisfied from the primary data, but objectives 1 and 5 needed the secondary data to resolve. This was planned in accordance with Table 1-1.

Examples were provided in the free text responses to directly support the supposition on the inevitability of error and the need to manage these with barriers, some of which highlighted that an accident had been prevented by either equipment or another person. Many examples were also provided that supported the belief that human endeavour can make situations safer, and it was encouraging to see an example of safety management being applied in a 'Fourth World' organisation. There was significant support to the supposition that humans can be overloaded by regulatory change, with examples given to illustrate times when this has happened. There were some very interesting comments within the sub-Section on rationalization and hindsight bias, with many examples of times when investigations have not been thorough enough to identify the real root cause. There were a number of comments on how Malaysian Airlines Flight 370 could be an example of a 'Black Swan' instead of the rush to rationalize the event and give it some kind of label. There is a perception of hindsight bias prevalent throughout the comments, and the responses have exposed a concerning lack of a Just Culture within organisations globally that support aviation ('Fourth World').

Within the interview reports there were examples given that supported objective 1, highlighting that there are two types of regulatory change, the first showing that the poor implementation of the change reduced safety, and the second implying that the regulation itself was what was unsafe. Analysis of the reports in relation to objective 2 found that one of the interviewees felt that not all attempts at the management of error are successful and

some errors are unmanageable. Despite this, the bulk of the data supported the supposition and the objective is considered to have been met. There was some support from the interviewees about the supposition that eradicating human error can achieve systemic safety, but the overwhelming evidence from quantitative data outweighs this and the supposition is considered to be false. Within the free text and interviews there was significant agreement, together with examples provided, in support of information overload; this is one area where the richness of the data really came across with some excellent examples. From the data as a whole, it is obviously felt that drone regulation as it stands is not acceptable to the respondents, which consequently is also the view of the UK public who took part in the CAA's survey, discussed in Section 6.8.

Analysis of the Airprox data found that the 10-year overall trend is that the likelihood of an Airprox occurring has increased, even without including drone encounters. Drone Airprox numbers have increased dramatically since 2014 and many of these are classified as a Cat A risk as by the time the pilot sees the drone it is too late to react, which relates to the 'five seconds to impact' comments from the literature discussed in Section 2.2. Specifically comparing 2015 and 2016 Airprox reports, each of the aircraft classes show that the number of Airprox have reduced, at a time when flying hours have increased.

Within the analysis, an Airprox rate has been deduced by normalising the data against the reported flying hours for that category of aircraft, giving a rate of Airprox per 10,000 flying hours. Alternative datums which could have been used would have been against the number of flights, the number of take-offs (larger than the number of flights as training flights can often involve multiple approaches), the number of registered aircraft of that category or a time-based normalization. It could be argued that the latter is what is published as a pure number now, in that this is per month and aggregated per year. This is especially the case for drone-related Airprox as these are not normalized against flying hours (unknown), number of flights (unknown), number of launches (unknown) or number of drones (unknown as there is no registration required). Once the new legislation is introduced in November 2019, there will be a requirement in the UK to register drones weighing 250 grams or more with the CAA. This will produce a data set in the future which can facilitate deeper analysis of the rate of Airprox with drones, although at present the rate can still be expressed in terms of number of flying hours of CAT, which is the most concerning aspect; two drones colliding with each other may cause human injury but this is unlikely to be of the magnitude that could be caused by a collision with manned aviation. So, although the number of drones might be estimated to be very large and the number of Airprox with them relatively low in comparison (giving a negligible drone

Airprox rate), it is the aircraft category that the Airprox occurs with that is the more important factor.

The Airprox rate for Cat A incidents decreased, but overall the likelihood of an Airprox was approximately the same. Within the reports there were examples of how the introduction of airspace or procedure changes had contributed, or caused, Airprox but only a small number of times. Comment can be made on the specific events, with lessons to learn, but there is not enough data for a generalisation about regulatory change. With drone-related Airprox the major finding is that the vast majority of encounters between drones and manned aviation occur above the height at which a drone is recommended to be flown. The recommendations are due to become regulation later this year, although it is not known how much this will change the way that drones are flown.

With regards to the analysis surrounding the introduction of the ATSOCAS regulation changes, it was found that for the airspace within which the new Services were provided, the Airprox rate increased by 39% in the 3-years after they were introduced. The evidence that this is directly consequential does not exist, it is acknowledged that the correlation could be entirely circumstantial. However, the evidence suggests that it is conceivable that the introduction of regulatory change can increase the likelihood of an Airprox. There is a correlation between this and changes to aviation regulation, which achieves objective 1.

The findings with regard to the research suppositions after all analysis are presented in Table 6-12, with detailed answers to the research objectives, and how these relate to the literature, discussed in Chapter 7.

Obj		S _n		Findings
1	Determine if there is a correlation between an increase in the likelihood of an Airprox and changes to aviation regulation.	1	The introduction of regulatory change can increase the likelihood of an Airprox.	There is evidence from analysis that the likelihood of an Airprox occurring increased after the introduction of ATSOCAS. It cannot be categorically claimed that it was the change that caused the increase, which after all was designed to make things safer, not worse. The analysis of secondary data suggests that the supposition may be true.
2	Assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation.	2a	Errors occur, but only if left unmanaged do they increase risk.	There is evidence from analysis of primary data to suggest that the supposition is true.
		2b	Humans make safety through their efforts and expertise; this implies that new regulation can be safely introduced through human endeavour and training.	There is evidence from analysis of primary data to suggest that the supposition is true.
3	Analyse whether humans are the weak link in the aviation safety chain.	3a	It is widely considered in the aviation industry that eradicating human error will achieve safety of operations.	There is evidence from analysis of primary data to suggest that the supposition is false.
		3b	Humans can be subject to information overload during regulatory change.	There is evidence from analysis of primary data to suggest that the supposition is true.
4	Assess if there is an active culture of learning from incidents within aviation.	4a	There is a temptation to rationalize every incident with hindsight bias and not acknowledge that some events are 'Black Swans'.	There is evidence from analysis of primary data to suggest that the supposition is true.
		4b	The capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome.	There is evidence from analysis of primary data to suggest that the supposition is true.
5	Determine if changes are required to regulations to integrate drone operations.	5	There is not enough regulation on the use of drones and more is needed urgently.	There is evidence from analysis of primary and secondary data to suggest that the supposition is true.

Table 6-12 showing findings to the suppositions after all data was analysed



Chapter 7 – Conclusions and Recommendations

7.1 Introduction

For many years the aviation industry has been subject to changes to its regulations, and any change has the potential to decrease safety in the air. With Brexit looming and the possibility of severing ties with EASA¹¹⁸, there is concern in the industry as to what the regulatory consequences of this decision will be. IATA¹¹⁹ predicts that the UK may continue to feel the adverse impacts of embarking on its own regulatory programme for up to ten years after Brexit. Major changes in UK airspace can be considered to be regulatory in nature, and an example is given in sub-Section 6.6.1 where two airliners narrowly avoided collision near Southend when they were both cleared to the same level by ATC¹²⁰ just after a change had been introduced. The proliferation of drones, and their potential to be involved in a mid-air collision with manned aviation, has led to a concomitant sharp rise in the number of Airprox. Although these issues are raised as current examples, this study is considered to be strategic with respect to regulatory change in general, and the conclusions herein apply equally to any regulatory change scenario.

7.2 Literature review

In order to answer the overarching Research Question of ‘can new regulation be introduced without decreasing safety’, a review of the literature has been conducted in order to form suppositions that could answer the research objectives, to then be investigated through empirical research. Regulations are often in place to increase safety, but changing them can introduce a decrease in safety, even if only temporary and it is how this change is managed that seems pivotal to the outcome. There is a dichotomy in the literature between the utopia of system safety once the human is removed and humans invariably being the final barrier in preventing an accident. Human error is often the first cited cause of an incident, and yet when investigated deeper this can just be a convenient label, with significantly more lessons to be learnt. Many in the industry recognise this potential, but cite a lack of resources, and specifically time, to be able to go beyond this first level of rationalization. This manifests with time-strapped individuals applying hindsight bias during investigations to satisfy Management’s desire for a quick answer as to the cause, to

¹¹⁸ European Aviation Safety Agency

¹¹⁹ International Air Transport Association

¹²⁰ Air Traffic Control

appease shareholders and be seen to be making good whatever error was found. An evident safety culture and functioning SMS¹²¹ are key to maintaining air safety during change, and organisations need to be willing to learn from mistakes that are identified, especially from others in the industry. These are seen as the bailiwick of senior management, represented by organisational leadership and a demonstrable commitment to safety. At the heart of any system of safety must be a Just Culture, where employees are positively encouraged to report essential safety-related information without fear of inappropriate reprisal. There is a link between leadership, safety management, procedures, culture and safety performance within an organisation's drive for safety (Aryee & Hsuing, 2016).

From the literature that was reviewed, the gaps identified in knowledge are captured in Table 7-1.

The effects of the introduction of large swathes of regulatory change on human performance are not found in the literature.
There is a gap in the literature surrounding how practice deviates from what aviation regulation intended.
Considerations about the perception of MAC likelihood increasing during regulatory change are not found in the literature.
The absence of a clear definition of what constitutes the 'Fourth World', or an equivalent term, and how the linkages of support staff with safety consequence are managed, are gaps in the literature.
The omission of these support staff from any regulation applying the need to manage safety through an SMS is a gap in the professional literature.
There is a gap in the literature about how urgent the industry perceives the need for regulatory change in relation to the operation of drones.

Table 7-1 listing the gaps in the knowledge identified from the literature reviewed in Chapter 2

7.3 Method

Primary data was collected using an online questionnaire survey, with mandatory multiple-choice questions and opportunities for free text answers to provide depth (optional), and by the conduct of semi-structured interviews with experts in their field. The survey reached a global audience and achieved 413 complete responses from across the industry, which is deemed representative of a homogenous aviation safety chain. Verification of the questionnaire was achieved through a prototype study, and then the survey answers

¹²¹ Safety Management System

validated by sequential semi-structured interviews, which were analysed independently to corroborate the results.

It was important to achieve a cross-sectional collection of data in order to achieve representation from each of the 'Four Worlds' of Aircrew, ATM¹²², Engineer and Other Support Staff. It was never the intention for the survey to be distributed globally, and that it did was entirely an accidental bonus. This globalisation of the data provided a much richer data-set for analysis, although the limitations of this are identified in critical reflection within Chapter 8. Secondary data was acquired from the UKAB and the CAA¹²³, to answer the objectives that could not be answered from the primary data.

7.4 Analysis

In support of the overall aim of the research, to 'identify what impact regulatory change has on the barriers to mid-air collision', the primary data was collected by the two methods described above and then analysed in three stages. The data from the multiple-choice survey answers was analysed quantitatively, with the free text answers then analysed using qualitative methods. The interviews were subsequently analysed qualitatively. The results are shown in Chapter 5, which begins with a descriptive analysis before presenting the quantitative analysis, and Chapter 6 which presents the qualitative analysis, together with the analysis of the secondary data.

Answers to the optional free text questions in the survey were given by a large proportion of the respondents (for example 45% in the question asking for an example of witnessing a failed barrier) which provided a significantly rich data-set to conduct qualitative analysis. All of the responses (appropriately redacted) are included at Appendix F, with some pertinent examples included in the analysis. Chapter 6 culminates with Table 6-12 showing the findings from the investigation of the suppositions after all of the data was analysed.

7.5 Discussion

Objective 1 is to determine if there is a correlation between an increase in the likelihood of Airprox and changes to aviation regulation. SERA was not of the same order of magnitude

¹²² Air Traffic Management, which includes Air Traffic Control

¹²³ Civil Aviation Authority

as ATSOCAS or such a fundamental change of operating practice. Whilst the Case Study of the introduction of SERA exposed no evidence of correlation, analysis of the Airprox data 3-years either side of the introduction of ATSOCAS showed that the Airprox rate increased substantially (by 39%) after the change. The evidence to specifically connect this to the change of regulation does not exist, so it cannot be categorically stated that the two are directly related. However, the analysis does suggest that the introduction of regulatory change can increase the likelihood of an Airprox, a perception which is supported by comments made in the interviews. This is despite the intention of changing regulation often being to reduce the likelihood of Airprox, or more importantly MAC. There is a gap in the literature surrounding the perceptions of whether the risk of MAC is likely to increase during regulatory change, and this study shows that the likelihood can increase. ATSOCAS is one example of a major regulation change; it is possible that there could be read across, but a limitation of this research is that this analysis is a snapshot and it would be disingenuous to declare the results as being proof of causality.

The number of Airprox each year is a headline of little value and it is recommended to the UKAB that they adopt the practice of publicising the Airprox rate, in relation to flying hours, as the primary method of dissemination. Regulation change should also be a specific focus during future Airprox investigations. These recommendations, together with the discovery that the Airprox rate increased after the ATSOCAS changes, fill some of the gap in knowledge surrounding the perception of the likelihood of an increase in Airprox, which should be considered during any future significant change programs such as those that may need to be implemented in the aftermath of Brexit.

Objective 2 is to assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation. Analysis of the three elements of primary data showed evidence to support the suppositions, and the majority perception from those surveyed is that the endeavours of key individuals and their management can make a significant difference to air safety, thereby satisfying objective 2. A review of the relevant literature on error is presented in Section 2.4, with the human element expanded upon in sub-Section 2.4.1. Kontogiannis and Malakis (2009) posit that eradicating error from the workplace is impossible and that it is, therefore, an inevitability. This view is also shared by Shorrock (2007) who states that systems must be put in place to assure safe operations, with Woods et al. (2010) saying that humans can make safety by their actions and endeavours. From the analysis in this study, the perception of the aviation industry agrees with the literature, errors are inevitable and the management of them is important to decrease risk. Table 6-2 gives examples of times when individuals have made a difference

and Table 6-3 provides a long list of comments in relation to managing the introduction of regulatory change better. When introducing regulatory change, the perception is that it can be achieved safely, but only with individual endeavour from key management positions.

Objective 3 is to ‘analyse whether humans are the weak link in the aviation safety chain’. There is a debate in the literature, reviewed in Section 2.4, where on one side there is an opinion that the eradication of human error will achieve the utopia of complete safety, as it is human error that causes incidents to occur. On the other side of the argument is the theory that humans are always needed to maintain safety and will often become the final barrier to preventing an accident happening. Marx (2017) goes as far as to say that human error is never the actual reason why an accident happens. In comparison to a machine, humans can be thought of as being inferior and a hazard to the system (Hollnagel, 2014), which stems from whether safety is considered as the prevention or the management of error. This study shows that the majority perception within the aviation industry is that operations are not intrinsically safe until the point a human becomes involved, although this was not the unanimous opinion of the interviewees, with one suggesting that of course it was true that if you remove the human you remove the error. So, humans must always be involved to maintain safety, however, it has already been described how this involves endeavour, which can mean additional workload.

In sub-Section 2.4.2, literature is presented on the overload of Air Traffic Controllers and it is speculated that the same situation can apply across the industry, the supposition being that ‘humans can be subject to information overload during regulatory change’. This study finds this supposition to be true, that from the perceptions of a cross section of the industry, it is believed that the introduction of regulatory change can cause humans to become overloaded. So, the additional workload associated with the endeavours of humans to manage the introduction of regulatory changes can lead to them becoming overloaded with information, which has the potential to decrease safety.

S_{3a} was the only supposition where the evidence went against the theory, and this is reflected upon in Chapter 8, although both sides of the argument from the literature are presented in Chapter 2. Objective 3 is considered satisfied though, as analysis shows that the majority perception is that humans are not the weak link in the safety chain, that despite the propensity for citing human error in an investigation, it is often the case that a human is the final barrier that prevents an accident from occurring.

Objective 4 is to ‘assess if there is an active culture of learning from incidents within aviation’. In order to learn from incidents, so that they do not reoccur, lessons need to be identified. To identify all possible lessons, investigations must not stop at the most obvious cause but delve deeper to understand fully what happened. For an incident to be investigated it must be known about, which requires it to be reported. For staff to feel able to report everything, there must be a Just Culture within the organisation where everyone can report incidents without fear of an unfair reprisal. To have a safety culture an organisation needs a learning culture, which requires a reporting culture that is underpinned by a Just Culture. The literature reviewed in Sections 2.5 and 2.6 cover the leadership and management of safety, SMS and cultures (safety, just and learning). The literature in these areas is extensive, but in sub-Section 2.5.1 Woods et al. (2010) postulate that there is hardly ever a single cause to any event and more often a series of contributory acts that come together, and there must be a failure in every barrier for a MAC to happen. The literature on Black Swans (sub-Section 2.5.3) posits that extreme events should be considered as outliers to the norm and yet it is suggested that, through hindsight bias being applied to investigations, events are rationalized and either the real lessons are not unearthed, or the wrong lessons are identified.

The majority perception of the survey population is that it is important to capture every error in order to learn from it and prevent a potentially worse outcome in the future. However, it is also their perception that hindsight bias plays a significant part in investigations, where a single cause is identified through a desire to rationalize all incidents, especially when resources are stretched, and time is short. This study finds that the perceptions of the respondents supports the objective and there is an active culture of learning from incidents, but with the nuance that actually there is an overwhelming sense that hindsight bias is prevalent in investigations throughout the global aviation industry. This is a major finding from this study, which would benefit from further research in itself. It is also worthy of highlight, that another finding of this research is that whilst an appropriate Just Culture was reported by Aircrew, ATC and Engineers, there was a significant proportion of responses from members of the ‘Fourth World’ (other support staff) within the UK, reporting that this is not the case for them.

A gap in knowledge was identified about the effects of the introduction of large swathes of regulatory change on human performance. Objectives 2, 3 and 4 have generated knowledge in respect to this perceived gap. Objective 4 has also generated knowledge to fill the gap surrounding how practice deviates from what regulation intended, with empirical evidence highlighting that investigations can be rushed, and over-simplified, in

an attempt to rationalize them into a single cause as quickly as possible; Appendix F lists all of the free text comments. Several respondents gave examples that support the view in the literature on safety bureaucratization (Dekker, 2014a; Provan et al., 2017) and in doing so provide the evidence that is described as missing.

Furthermore, in an effort to ensure the inclusion of all elements of the ‘aviation safety chain’ (see sub-Section 2.3.1) within this study, knowledge has been generated to fill the identified gap in understanding what jobs and roles fall into the category of ‘Fourth World’ by the data garnered from the survey, which is presented in Table 5-3. The observation surrounding the lack of a Just Culture amongst the ‘Fourth World’ respondents in the UK also supports the gap in professional literature, where it is highlighted that the majority of support staff are omitted from the requirement to establish and maintain an SMS to manage air safety. It is opined that if a functioning SMS was in place, and properly managed and assured, then it would include the cultures of reporting, just and learning.

Objective 5 is to ‘determine if changes are required to regulations to integrate drone operations’. The literature reviewed in Section 2.7 suggested that there is a need, which is heeded by the UK government and EASA, and the head of ICAO¹²⁴ has been lobbied to encourage more regulation to make things safer. Analysis of the primary data shows that only 1% of respondents feel that the current regulations are fit-for-purpose, with the vast majority voting for changes to make things safer; 53% believe that more regulation is needed urgently. Analysis of the secondary data on the rapid increase in near-miss reports between drones and manned-aviation adds justification to this opinion. The objective is met, it has been determined that changes are required to regulations to integrate drones safely and the gap in the literature on how urgent the industry perceives the need for change is filled. This outcome is timely and acknowledged by the DfT¹²⁵ who, on 30th May 2018, announced that UK law would be amended on 30th July to make it illegal to fly a drone above 400ft or within 1km of an aerodrome. The interim results of this study were submitted to the UK Government consultation in 2017 and had impact upon the Government policy to introduce this change to regulation¹²⁶. Further changes are planned for November 2019 when mandatory registration and training for drone operators will come into force. This is all a good start and will go some way to mitigating the risk of collision with manned aviation but does not go far enough. However, a drone flown within the new regulations can still conflict with a manned aircraft if the drone is in the approach

¹²⁴ International Civil Aviation Organisation

¹²⁵ UK Department for Transport

¹²⁶ See Appendix D

path, or climbout, of a runway, because at 1km away from the aerodrome the aircraft could also be below 400ft.

7.6 Concluding comments

The aim of the research was ‘to identify what impact regulatory change has on the barriers to mid-air collision’. The Research Question posed was ‘Can new regulation be introduced without decreasing safety?’ Five research objectives were established to support this.

The study has shown that, the likelihood of a near-miss can increase when regulatory change is introduced, which means that barriers are challenged in order to prevent a collision. If all of the barriers fail, ‘the holes in the cheese line up’ and a MAC could occur. Any errors that are induced by the changes to regulation need to be managed in order to ensure that a barrier does not fail. Humans are necessary to manage the barriers, and they work hard to do so as their endeavours are a mitigation to make things safer and must, therefore, remain as an intrinsic part of the system. However, humans can be overloaded with the extra work necessary to implement, understand and manage the changes, which must be acknowledged during the process and mitigated by such things as supervision, training and design of the implementation. Part of this proactive safety management is also ensuring that the same errors are not made that were identified previously. Identifying lessons to learn requires a culture where incidents are reported, and comprehensive investigations conducted to establish why they happened, not just using the label ‘human error’. An SMS is essential for this to happen, and must be functioning efficaciously and justly, with the whole organisation able to report errors in the knowledge that they will be investigated properly, and any lessons identified disseminated and acted on appropriately. Furthermore, it has been highlighted that the consequence of not introducing changes when they are required, in itself leads to a decrease in safety, which is apparent in the case of the proliferation of drones and the slow process by which the authorities are updating their regulatory position. This will be exacerbated with the decision by EASA to slow down the rate of regulatory change in the next few years, at a stage when ICAO are being lobbied by flight safety experts to encourage global change in drone regulation as soon as possible. The UK are ahead of many countries in this and begin implementing their enhanced regulations in July 2018. This research has found that new regulation can be introduced safely but can also induce error, despite often trying to prevent it.

7.7 Recommendations

Over and above the support that this research gives to the increased regulation of drones, with both primary and secondary data showing a clear need, two areas of concern are highlighted in this thesis which give rise to recommendations. Firstly, it is very surprising how many survey respondents felt that hindsight bias plays a significant part in safety investigations within their organisations. Secondly, analysis has discovered that whilst an appropriate Just Culture is reported by Aircrew, ATC and Engineers, there are a significant number of reports from members of the ‘Fourth World’ (other support staff) showing that this is not the case for them. The recommendations are summarised in Table 7-2.

1.	All personnel within the aviation industry should take a critical look at their safety investigations with a view to removing hindsight bias.
2.	Further research should be conducted to investigate hindsight bias in aviation safety investigations.
3.	Organisations, such as airlines and airport operators, should consider the wider safety culture of the support staff that they interact with, as the safety management processes in these ‘Fourth World’ organisations in the UK fall outside of extant regulation and may not be equivalent.
4.	The UKAB should publicise the Airprox rate, in relation to flying hours, as the primary method of dissemination rather than a headline number.

Table 7-2 listing the recommendations of this research



Chapter 8 – Reflections, Limitations and Contribution

8.1 Critical reflective account

Fulton, Kuit, Sanders and Smith (2013) recommend that constant reflection is integral to any research study but particularly important to a professional doctorate thesis. Maintaining a reflective journal has been a key part of the learning process and has often shaped the next steps during the research, especially when the way ahead was not clear. “*Conducting research across disciplinary borders also highlights how important it is for researchers to reflect on their own standpoint within the research process*” (Hesse-Biber & Burke Johnson, 2015, p. xliii). Kolb extols learning through experience as being the most powerful form of education, and reflection is an intrinsic part of his learning cycle, which is described as being “*the process whereby knowledge is created through the transformation of experience*” (2015, p. 49). In the context of this thesis, this is interpreted as being a cycle from the collection of data, through continuous reflection, to analysis of the data by each research objective and then understanding the results and how they impact upon the whole process, which continues around again for the next objective.

This research study has been a personal learning journey. As well as the obvious gaining of knowledge through researching literature, and insight from representative opinion, there are many other noticeable gains in academic and personal developments. Writing style is one of these, which became most apparent when writing up this thesis and revisiting one of the very first drafts of a chapter that was started in the second year of the study and finding the style of writing to be particularly poor and unsuitable. This revelation is seen as being evidence of the developments made during the course of this study. If it is appropriate to say so, much enjoyment has been gained from the breadth of reading that has been conducted over the period, and most surprising that so much of it has not made it in to the reference list but only served to broaden understanding.

An aspect that is peculiar to a professional doctorate is that the researcher is also embedded within the research itself, which can create its own challenges in terms of being a manager within the work environment, whilst simultaneously being a student (Fulton et al., 2013). This was specifically addressed in terms of the collection of primary data, where the researcher’s military rank and position within the military regulator was considered when drafting the questionnaire and what affect this might have on the reader. This was acknowledged in the survey introduction and countered with reassurance that the

beneficiary was the researcher as an individual, followed by the community as a whole. This was also considered when selecting the military interviewee, and an individual was chosen at the same rank to avoid any issue of bias or reticence to speak freely. It was important throughout this study that any potential bias that the researcher might have had themselves was considered and reflected upon. It is acknowledged that there could have been an element of 'groupthink' during the study, in that it is possible that the survey respondents and interviewees were 'like-minded' to the researcher. This was countered in the analysis stage by corroboration from a third-party independent researcher and is not the case in the survey because of the demographic spread across the experience levels of respondents; for example, those with less than six years' service in the industry could not be considered contemporaneous with the researcher who has been in it for over 20.

Stephen and Labib (2018) reflect upon the model that they propose in their paper as being too dependent on individual subjectivity and the bias that this has on an investigation, but mitigate this by suggesting that the opinions of a group can eliminate the bias. It is the potential for "dependency on personal judgement" that they suggest can bring inconsistencies and bias to an investigation, but they do also extol the use of a "collective judgement" that a disparate group of people can provide, especially when the opportunity for influence over that group does not exist (Stephen & Labib, 2018, p. 221). This supports the thought that the added benefit of the accidental globalisation of the research (covered in Section 8.2), is that the respondents' attitudes to air safety would have been across a much wider spectrum than just either European, Western or British. With such a wide recruitment base of respondents across many countries, and the random nature of the distribution through the Curt Lewis (2017) newsletters, the opportunities for sampling bias are negated. Had this globalisation not occurred then further consideration of sampling bias may have been necessary, not just from the researcher's perspective but also by the reliance on a small number of 'gatekeepers' into their organisations. Having such a diverse distribution network in the end has helped to neutralise this possibility as far as is reasonably practicable. This aspect of globalisation also overcame one of the significant early challenges when the support of several large UK operators could not be gained, despite the desire to help from individuals. With this corporate support a better UK picture would have been formed, whereas the globalisation diluted this UK element. On the other hand, it exposed the research to a wider audience, which led to unsolicited contact from a major Asian airline to write an article for their safety magazine.

The process has inculcated a desire to influence the aviation industry of the future, and specifically the management of air safety within it. It was an honour to be approached to

write an article for Pakistan International Airlines' safety magazine, and to be invited to present the research at the Aerodrome Operators Association safety conference. Both of these were enjoyable experiences and whet the appetite for further involvement in the future. The feedback from the airline was extremely positive, with an open invite to write for them again, and the presentation was well received, with engaging questions afterwards and many expressions of interest in the research. The website setup for this study¹²⁷ will have a synopsis of the results of the research, once finalised, so that those that were interested can see the end-product. An abstract of a paper on this research study has been submitted to the International Air Safety Summit being held in the USA in November 2018 for consideration.

It is also the intention to continue writing articles for both academic and professional journals/magazines, and the feedback received from both attempts at academic publication has been most useful in further developing writing style. The article submitted to Safety Science on safety culture and climate is included at Appendix L, which although not accepted for publication, is included as an appendix because the content supports the thesis in a wider context but did not warrant inclusion in the main body. It is also intended to review the content of this article, reflecting the peer-feedback, and attempt submission to other journals, such as 'Disaster Prevention and Management', 'Advances in Transportation Studies' and the 'International Journal of Aviation, Aeronautics and Aerospace'. The researcher has received two offers from esteemed academics to co-author journal articles and both opportunities will be pursued, perhaps taking up this study's recommendation to conduct further research into hindsight bias in investigations.

Another success during the study was to be awarded the status of Chartered Fellow of the CMI¹²⁸, and with it the recognition of the contribution the researcher has made to professional management. This is not directly attributable to the research but is indicative of holistic personal development during the period of study, in which academia has played a large part.

The study itself evolved over the four-year period, with the focus changing from its original investigation of an EU-led change that did not come to fruition, to the emergent issues of Brexit and drones. The review of the literature found that several authors commented on the removal of humans being the panacea of achieving air safety and even

¹²⁷ www.ifgairsafety.co.uk

¹²⁸ Chartered Management Institute – CMgr FCMI

going as far to say that systems need protection from humans (Woods et al., 2010). However, this is the one supposition, of the eight set, that was found to be false from the analysis of survey responses. Both sides of the argument were presented in the review of the literature, and whilst the perceptions of the survey respondents did not agree with the supposition set, it did agree with the other side of the argument exposed in Chapter 2. This supposition was specifically formed as the opposite to the researcher's personal opinion, in order to challenge it and to explore the perception of others in the industry, without adding any bias. It is of little surprise that the supposition was not supported and aligns with personal perceptions, but an open mind was maintained to explore the opportunity for rich data. The outcome of the research broadly aligns with what was anticipated, although the strength (or weakness) of some of the ratios of answers are different to what was envisaged. This said, three discoveries were startling, the amount of hindsight bias being applied in investigations, the lack of a Just Culture in organisations associated with aviation, and the magnitude of the increase in Airprox rate after the introduction of ATSOCAS¹²⁹.

It is acknowledged that this thesis has on occasion displayed positivist tendencies whilst attempting to explore the nuances of the rich data, by focusing on suppositions as a framework. Acknowledging this has made the researcher revisit those areas of the thesis and review the comments through a constructionist lens to expand the analysis accordingly.

8.2 Limitations of the work

One must also comprehend that there may be an impact upon any facet of an organization's culture, including a Safety Culture, by the local culture of the Nation. (Schneider, Ehrhart, & Macey, 2013)

It was thought that the accidental globalisation of the survey had opened up new possibilities with what analysis could achieve and the comparisons between the attitudes and opinions of diverse regions, especially in such areas as safety culture. Even with the realisation that small numbers of respondents from each country did not allow representative comparison, it was thought that grouping the respondents by firstly sub-continent, and then by continent, might allow for some analysis of regional variations. This was not the case as the small numbers prevailed and, therefore, the data could not be considered representative other than as an overall global picture. This is a disappointment,

¹²⁹ Air Traffic Services Outside Controlled Airspace

but it must be remembered that it is not an objective of the research plan, merely an added bonus, but could be an avenue for future research.

Engineers were under-represented in the survey respondents, although enough gave their thoughts to make meaningful observations from the analysis. It was suggested by one of the interviewees that this could be due to contracting out of the engineering task within a company, and the survey not reaching the contracted staff. This in itself is slightly worrying, as that would imply a barrier to communication between company safety managers and their engineering staff. It is more likely that the distribution of the survey just didn't reach far enough into the engineering community and should research of this nature be done again this is an element that would have to be addressed. This all said, it is not felt that the low representation of engineers skewed the results at all, and the survey sample is considered to be representative of the 'aviation safety chain' as a whole. The literature suggested that 383 respondents would be acceptable, and whilst this figure was not reached for the UK-alone, with 413 respondents across the world it can be said that suitable representation was achieved, as long as the respondents are considered a single homogenous group. This puts a limitation on the sample, in that it cannot be broken down and analysed in its constituent parts but has to be considered as a whole to remain representative. Some risk was taken in the analysis by comparing elements, such as the two biggest respondent countries of US and GB, but the conclusions from the research are based on the overall responses. The identification of an issue with the Just Culture amongst support staff in the UK is still believed to be a valid observation due to the number of negative responses affirming as such, despite the total number of 'Fourth World' respondents not being considered a truly representative sample. However, it would be difficult to estimate the total size of the 'Fourth World' anyway, when its identity is not defined.

The use of mixed methods can be argued to “...dilute the research effort in any area, since resources would need to be spread” and it is always necessary to properly design and prepare for a study of this nature (Bryman & Bell, 2007, p. 658). It is felt that this research study has been conducted in a way that meets the criteria for a valid mixed methods approach, however, it could be argued that a purely quantitative analysis might have yielded more specific answers and been less generalised. This is not seen as a limitation of this study though, and it is posited that the mixing of methods in this study has enhanced the findings and in “filling in the gaps” was absolutely required as no one method in isolation would have achieved a complete answer and sated the research aim (Bryman & Bell, 2007, p. 649).

Whilst the finding of S_{3a} to be false has been reflected upon in Section 8.1, objective 1 and its associated supposition should be addressed as a limitation of the work. The supposition that ‘the introduction of regulatory change increases the likelihood of an Airprox’ could have been better phrased. The objective is achieved, an example was found that showed an increase in the Airprox rate after regulatory changes were introduced, despite their aim being to make things safer. However, there is no proof that this increase was because of this change and not through any other factor, including chance. The research objectives were declared in Chapter 1 as being SMART¹³⁰; but, on reflection objective 1 is not. If this research is repeated, it can be improved by the setting of a more specific, easily measurable, more achievable and realistic objective. The evidence just does not exist to prove that the likelihood of an Airprox increases (or not) with regulatory change.

8.3 Contribution

The most tangible impact of this study is the amended UK regulations on the operation of drones, which come into force on 30th July 2018. The DfT¹³¹ ran a public consultation between December 2016 and March 2017¹³². By 11th March, the survey for this research had been open for two months and had received 275 responses, 99 of which were from GB. Interim results of pertinent areas of this research were submitted to the consultation, where 83% of all survey respondents perceived that the current regulations on the operation of drones needed enhancing, half of those stating that this needed to be done urgently. The DfT consultation received input from 503 individuals, but only 36 of these were from members of the public who were not pilots or drone users. The researcher was one of these 36 and, by providing the interim results of the survey, has made an impact on Government policy. Participation in the DfT consultation is verified by the email confirmation in Appendix D.

UK military aviation has six Operating Duty Holders (ODH), who are individually held legally accountable for the safe operation of aircraft within their bailiwick, in which they have a clear definition as to what their responsibilities are in relation to Air Safety risk (MAA, 2017). Each of these ODH’s has the possibility of a Mid-Air Collision listed on their Risk Register in their top five, which they are constantly seeking to manage and

¹³⁰ Specific, Measurable, Achievable, Realistic and Time-bound

¹³¹ UK Government Department for Transport

¹³² EASA (European Aviation Safety Agency) also ran a consultation on drones May - August 2017, and updated results of the survey were submitted

mitigate against. The findings of this study will be available to the ODH's Safety Managers in order to highlight the impact that regulatory change can have on the barriers to mid-air collision. It will also be made available to the MAA Analysis and Regulation divisions. The specific contribution that this research makes is to highlight the impact that regulatory change can have on the barriers to mid-air collision, so that those responsible for maintaining these barriers can take the necessary precautions to prevent them being eroded.

The largest ANSP in the UK is NATS¹³³ and, together with each of the UK-based airlines, irrespective of whether support was given to the study or not, the findings will be available for them to draw upon. A summary will be published on the research website, with a link sent to those that facilitated the distribution of the survey. Articles will also be written for practitioner magazines to disseminate the results to other organisations.

The most immediate contribution of the research will be to put the findings of this research into practice in Brunei Darussalam, where the researcher is currently based. The Regulatory Division of Brunei's Department of Civil Aviation (DCA) has a policy of *"Complying with ICAO standards and appropriate recommended Practices as a minimum but adopting EASA-based rules or any other suitable rules where there is a definite benefit to Brunei operators, industry or personnel or where there [is] no ICAO standard"* (DCA, 2018). Their latest published regulations date from 2006 and they have been working to replace these; it is anticipated that significant changes will be implemented in the near future. Working with several Government organisations in Brunei, the findings of the research will be available to assist in the transition process and can be used to establish mitigation strategies for both military and civilian aviation. Specifically, drone flying is banned in all of Brunei's airspace, without a permit from DCA; illegal drone flying does take place, probably by people who do not understand the rules. Bruneians accept that this total ban will not stand the test of time and that they will have to develop regulation that allows drone operations to take place, which this research can help to establish.

During the study the researcher was involved with the National ATM¹³⁴ Advisory Committee (NATMAC), the UK Flight Safety Committee (UKFSC), the UK Airprox Board (UKAB), the Airspace Infringement Working Group (AIWG), the UK Confidential Human-factors Incident Reporting Programme (CHIRP), MAA Mid-Air Collision

¹³³ Formerly National Air Traffic Services, now referred to just as NATS - the main Air Navigation Service Provider (i.e. provider of ATC) in the UK

¹³⁴ Air Traffic Management

Conference, the Small Unmanned Aircraft¹³⁵ Working Group (SUAWG), Eurocontrol Runway Incursion Safety Forum and the CAA Mid-Air Collision Challenge Group (MAC-CG) amongst others. In all of these groups the thoughts and concepts discovered in this study were conveyed.

On return to the UK in 2019, the researcher expects to be assigned to the CAA, where the findings of this research can be put into practice in supporting the management of aviation operations. The role in the CAA will involve future airspace changes and the implementation of regulatory changes, be they European or specific UK ones if that is the post-Brexit decision.

This research study has created knowledge, which fills the gaps that were exposed in the review of the academic and professional literature, and provides global insight into the perceptions of aviation professionals.

¹³⁵ drones

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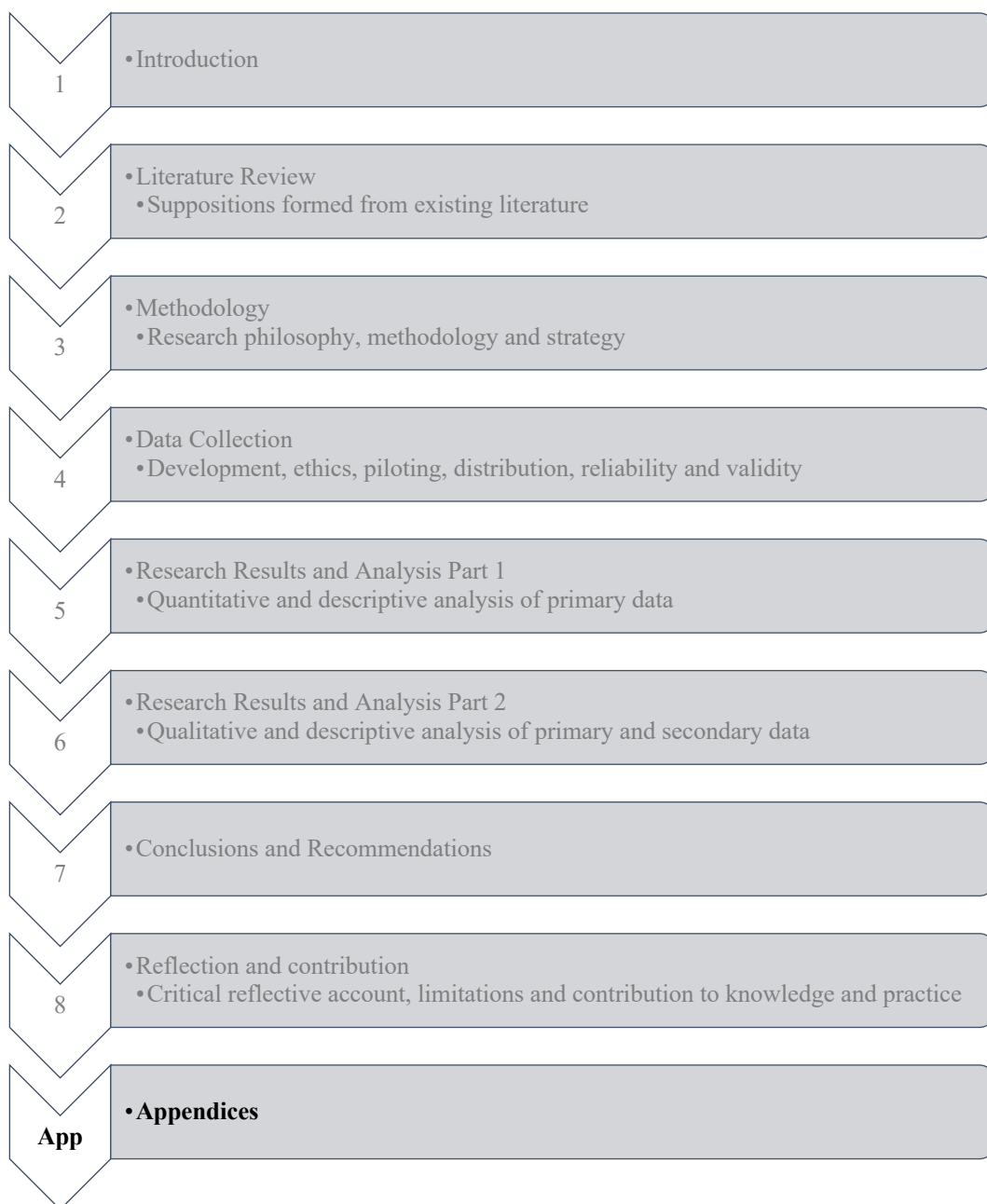
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Appendix A – Survey Questions

Introduction page and consent



University of
Portsmouth

Towards a better management framework of aviation risk during regulatory change

[Exit Survey >](#)

Thank you for reading this. I would like to invite you to take part in my doctoral academic research study by completing this survey. It is entirely up to you whether you participate but your responses would be valued. You have been identified as a potential respondent because you work in the aviation industry and you have either received an email from your safety management team or followed a link from my LinkedIn profile or website.

The aim of my research is to assess the impact of regulatory change on aviation risk management, with a specific objective to understand how best to manage it without inducing error. I hope that around 500 people across the industry will complete these questions about their experiences; it should take less than 10 minutes of your time, and consists mostly of questions on aviation and the final 2 about you. Your participation in this study is completely voluntary, and I neither need your name or any identifying details; all reasonable steps will be taken to ensure confidentiality. At no point will anyone be able to identify you from your responses to the multiple choice questions. If you feel uncomfortable answering any of the questions, you can withdraw from the survey at any point up until final completion and the data will not be saved. However, it is very important for me to learn your opinions so I do hope you will feel able to complete the questions fully. Your survey responses will be coded and remain strictly confidential, with data from this research reported only in the aggregate. Upon successful award of my doctorate all original data will be destroyed. If you have questions at any time about the survey, please contact me at my university email address of ian.fyfe-green@myport.ac.uk.


I do work within the Military Aviation Authority, but this survey is in no way connected with my employment; it is purely for my personal academic study with the University of Portsmouth, which is conducted in my own time. Whilst the finished thesis will be available to all in the industry, it is not intended that the specific results of this survey will be reported to either the military or civilian regulators.

Thank you very much for your time and support. Please proceed to the questions by ticking the box to say that you are happy to undertake the survey and then click the 'Next' button below.

I consent to participate in the survey

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Academic Supervisor: Professor Ashraf Labib

Question 1a



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13%

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*** In his 2007 book called Black Swans, Nassim Taleb stated an opinion that all major catastrophic occurrences are just random events and as such have no rational answer as to why they occurred. The implication being that although there is a temptation to rationalise every incident with hindsight bias, attempts to identify the cause of a past event are a waste of time and we should just acknowledge their randomness.**


How much do you agree that this is applicable to the aviation industry?

- Very
- Somewhat
- Neutral
- Not very
- Not at all

Can you provide an example where an event has been over simplified and the cause is much deeper than widely concluded?

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Question 1b



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21%

[← Back](#)Questions marked with a * are required[Exit Survey →](#)

*** Woods, Dekker, Cook, Johannesen and Sarter (2010) state that humans actually make safety through their efforts and expertise. This implies that new regulation can be safely introduced through human endeavour and training.**

Do you agree that safety can be 'made' through your endeavours within your organisation?

Yes


No

Please give an example of a time when you have personally made things safer:

[Next](#)

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Question 2a



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30%

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*** Errors occur all of the time, it is only when they are left unmanaged that there is an increase in risk.**

Do you think that errors are an inevitable part of day-to-day business in the aviation industry?

Yes

No

*** It is how errors are managed and dealt with that determines whether or not an error becomes an incident.**

How much do you agree with this statement?

Not at all


Somewhat

Completely

[Next](#)

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Question 2b



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43%

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*** Do you believe that aviation operations are intrinsically safe until the point a human becomes involved?**

Yes

No

*** In your opinion, is it possible to completely remove human error from the workplace?**

Yes


No

Please provide an example of a company initiative that was aimed at the total eradication of human error:

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Question 2c



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52%

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*** In normal circumstances there are multiple barriers in place to ensure safe operations. Have you witnessed a time when one of these barriers was breached, but the incident was prevented from developing by the presence of another barrier?**

Yes


No

Please give an example of this:

[Next](#)

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Question 2d



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60%

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Opinion: Personnel in the aviation industry frequently deal with information overload; new regulations can exacerbate this.


	Yes	No	N/A
* Have you ever felt overloaded by the amount of change being introduced at once?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* If Yes, was this in relation to changes in Regulations?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* In your opinion could these changes have been managed better?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please explain how you would have managed the change differently:

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Question 3a



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65%


[Back](#)Questions marked with a * are required[Exit Survey](#)

The capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome.

	Always	Most of the time	Some of the time	Rarely	Never
* How much do you think that it is important to ensure that all errors are identified, no matter how trivial, in order to prevent future incidents?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* In your experience, does a well-run Safety Management System capture all errors and analyse them appropriately?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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Question 3b



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69%


← BackQuestions marked with a * are requiredExit Survey →

Opinion: There is a fundamental desire that all negative events are labelled with a cause. There is a possibility that this can lead to a biased answer through the application of hindsight.

	Yes	No	Sometimes
* Is it necessary for every event to have a single cause identified?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* In your experience does hindsight bias impact on safety investigations?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* In your organisation, is it normal to apportion blame to an occurrence?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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Question 3c



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78%

[< Back](#)Questions marked with a * are required[Exit Survey >](#)

*** Do you believe that the Management within your organisation perceive the possibility of risk to be the same as you, higher than you or less than you?**

The same

Higher than me

Less than me

*** Do you feel that you have a 'Just Culture' for reporting within your organisation's Safety Management System?**


Yes

No

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Question 4



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86%

[Back](#)[Exit Survey](#)


If aviation were described as having a fly-crash-fly principle at the core of its safety management (ie an incident happens, cause identified, problem fixed, carry on flying), is there any other industry that you have experience of that can be described similarly?

If you know one, please give an example of how a non-aviation related industry deals with, or anticipates, an increase in risk:

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Question x



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91%

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*** With the numbers of unmanned aircraft (drones, SUAs, UAVs, UASs, RPAS, models etc) increasing, how do you feel about the current level of regulation?**

- Not enough regulation, more needed urgently
- Current regulations are generally OK, but could do with some development
- The current level of regulation is absolutely fine and covers everything that is required
- Current regulations are confusing and need to be simplified
- There are far too many regulations on this already

[Next](#)

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Classifiers



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100%

[Back](#)Questions marked with a * are required[Exit Survey](#)

*** This last question will help me to put your answers in to context.**

In which of the following areas of aviation do you work:

- Aircrew
- Engineering
- Air Traffic Management
- Other Support Staff (please specify)

For how many years...

	<1	1-5	6-10	11-15	>16
* ...have you been in your current post?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* ...have you been employed in the aviation industry?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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Academic Supervisor: Professor Ashraf Labib

Thank you page and references

Thank you so much for taking the time to fill in my survey, it really is very much appreciated.



Once complete, my research will be available on my website: www.ifgairsafety.co.uk

References:

Taleb, N. N. (2007). *The Black Swan*. London: Penguin Books.

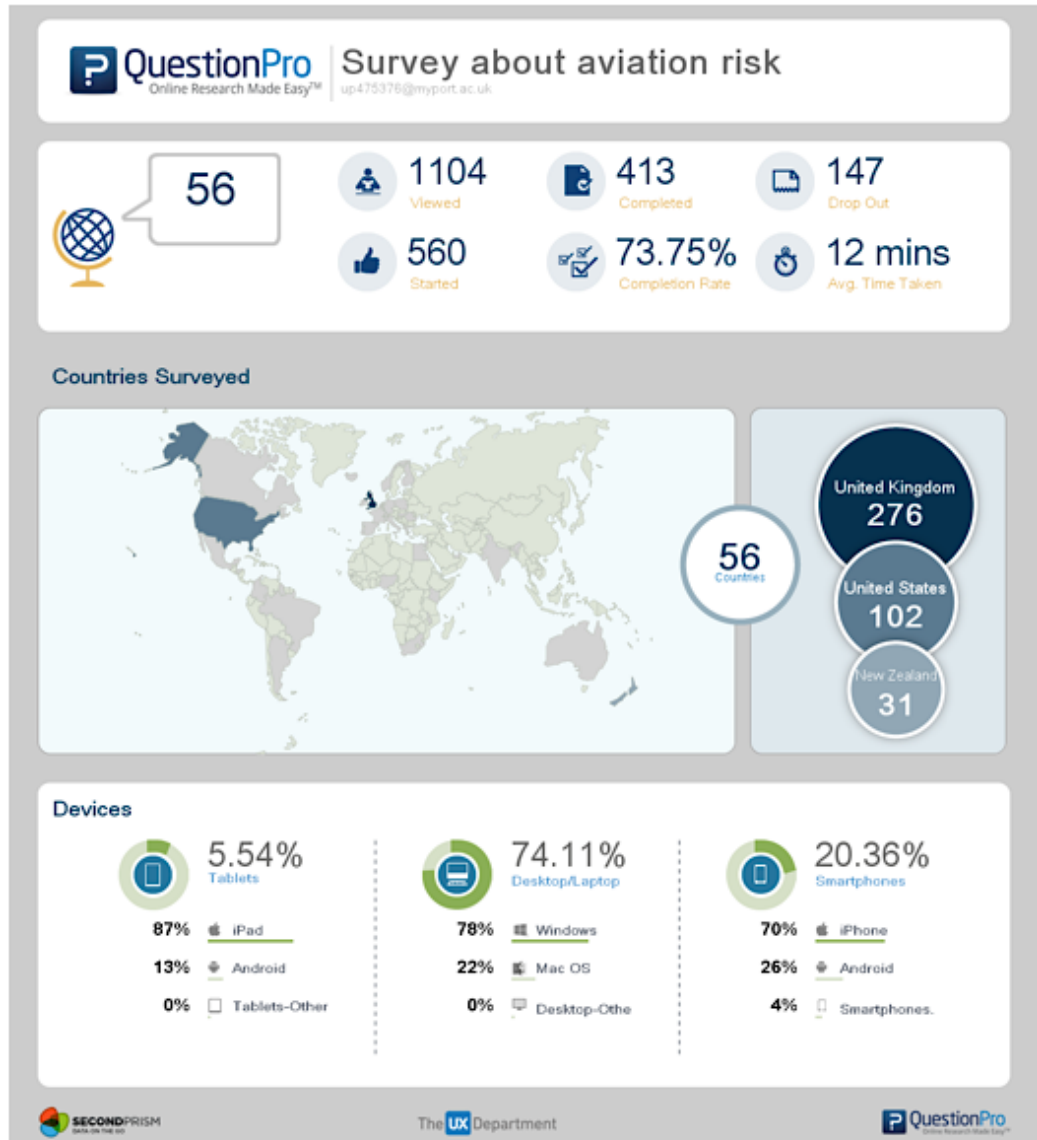
Woods, D. D., Dekker, S., Cook, R., Johannesen, L., & Sarter, N. (2010). *Behind Human Error* (2nd ed.). Farnham: Ashgate Publishing Limited.

[Thank you for completing this survey.](#)

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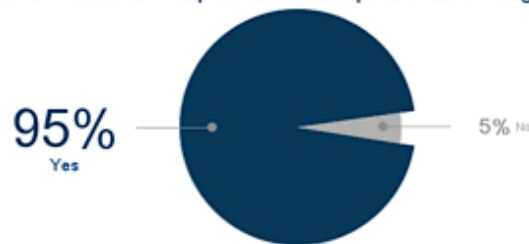
Appendix B– Survey Infographic



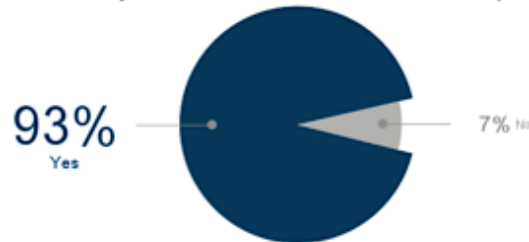
In his 2007 book called *Black Swans*, Nassim Taleb stated an opinion that all major catastrophic occurrences are just random events and as such have no rational answer as ...



Woods, Dekker, Cook, Johannesen and Sarter (2010) state that humans actually make safety through their efforts and expertise. This implies that new regulation can be safely in...



Errors occur all of the time, it is only when they are left unmanaged that there is an increase in risk. Do you think that errors are an inevitable part of day-to-day business...

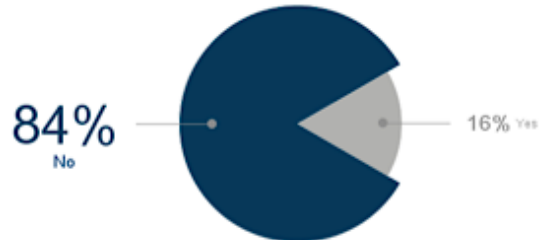


It is how errors are managed and dealt with that determines whether or not an error becomes an incident. How much do you agree with this statement?

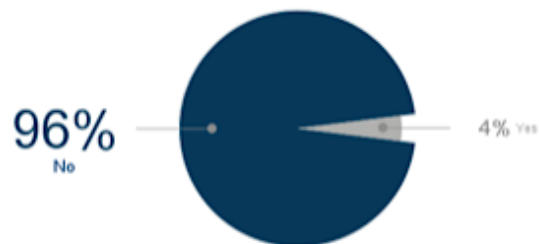




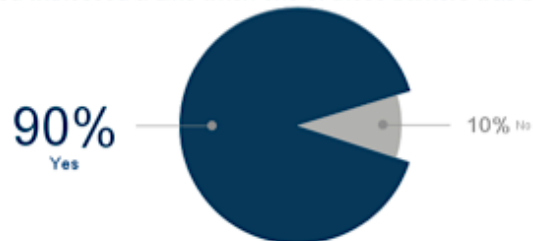
Do you believe that aviation operations are intrinsically safe until the point a human becomes involved?



In your opinion, is it possible to completely remove human error from the workplace?

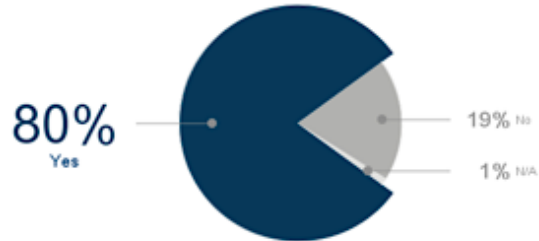


In normal circumstances there are multiple barriers in place to ensure safe operations. Have you witnessed a time when one of these barriers was breached, but the incident was...





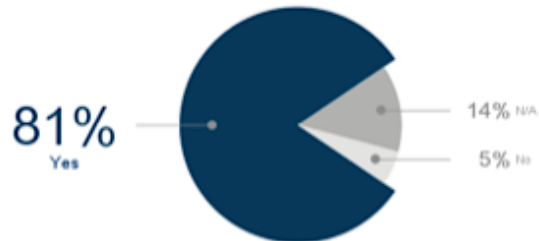
Have you ever felt overloaded by the amount of change being introduced at once?



If Yes, was this in relation to changes in Regulations?

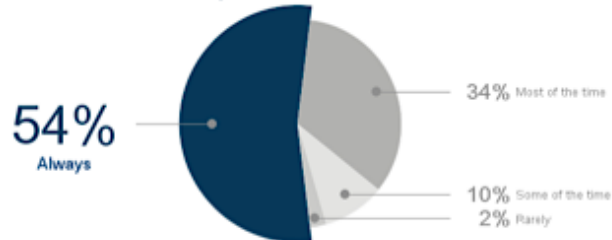


In your opinion could these changes have been managed better?

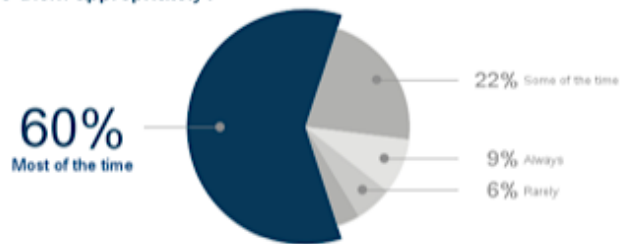




How much do you think that it is important to ensure that all errors are identified, no matter how trivial, in order to prevent future incidents?



In your experience, does a well-run Safety Management System capture all errors and analyse them appropriately?

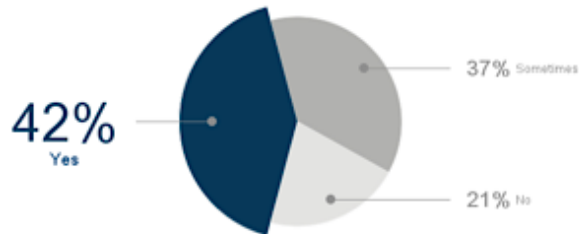


Is it necessary for every event to have a single cause identified?

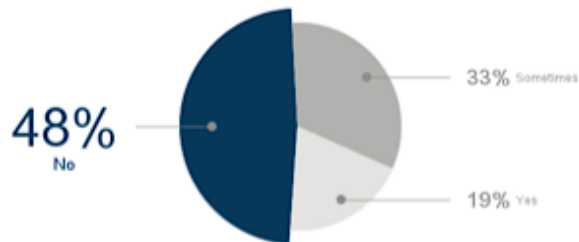




In your experience does hindsight bias impact on safety investigations?



In your organisation, is it normal to apportion blame to an occurrence?



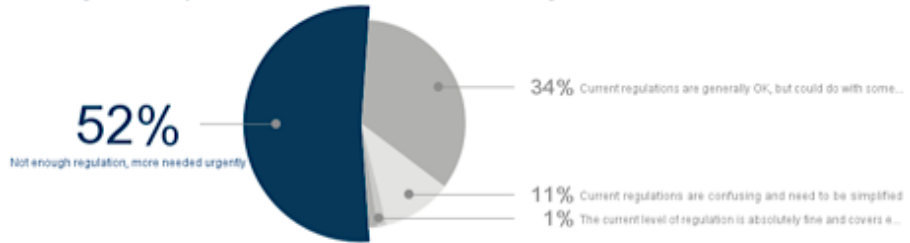
Do you believe that the Management within your organisation perceive the possibility of risk to be the same as you, higher than you or less than you?



Do you feel that you have a 'Just Culture' for reporting within your organisation's Safety Management System?



With the numbers of unmanned aircraft (drones, SUAs, UAVs, UASs, RPAS, models etc) increasing, how do you feel about the current level of regulation?



This last question will help me to put your answers in to context. In which of the following areas of aviation do you work:



...have you been in your current post?



...have you been employed in the aviation industry?



Appendix C - Extract of interview responses

Extract of interview responses

The aims for the interviews were two-fold, firstly to gain independent insight in to the quantitative results of the survey, thereby validating them, and secondly to explore further in-depth answers to the Research Objectives that were not addressed or achieved by the survey. Additionally, the interviewees opinion was sought on how regulation is currently introduced and how they see the future developing in regard to new aviation regulation.

The following are extracts from the reports written after each interview, grouped against the pages of the survey report in Appendix B, which each interviewee had sight of beforehand and was referred to throughout the interview itself. The interviewees have been assigned a letter (A-E) to replace their name. All interviewees were sent a copy of their extract for approval to publish.

Note: Page likelihoods relate to Infographic of survey responses (Appendix B)

Introductory comments

The focus of the interview was to validate the survey responses, garner Interviewee A's opinions on regulatory changes, how they are managed and introduced, seek examples of good or bad practice and ascertain how he sees future development (especially in the UAV sector). In order to validate the survey responses, I ran through each page of the infographic with A, asking if he personally agreed with the populous and felt that the answers were representative of those within the industry he knows. The answer was yes.

When interviewing D, my opening question was "can new regulation be introduced without a decrease in safety?". This led to an open discussion about regulatory change in general and D's response centred around the management of any change programme. This was the first interview in the series and I started with the general discussion topics of current regulation and then future changes before moving on to the validation of the survey. I realised afterwards that it would be better to structure the interview around the survey first, which will likely cover off the other two questions as we go along.

I asked Interviewee D if he had seen any trends in Airprox relating to regulation changes? He used an example of the change from APATC-1 to PANS-ATM and the changes this brought in to Approach criteria, drawing from his experience as a pilot, saying that he felt that this was poorly introduced and could have caused an accident. This then led to a discussion about the study that happened three years after the introduction of the ATSOCAS changes. D kindly provided a copy of the data that had been used to compare the 3-years pre ATSOCAS with the 3-years post introduction (open source). He also mentioned the recurring debate between the military use of QFE versus QNH. He recalled that in the late 80s early 90s there was a push to stop using QFE and adopt civilian QNH approaches. The change was made but then rescinded and the military converted back after a couple of years. In late 2016, the question has been asked again and a study was conducted as to whether it should be implemented again because no-one recorded why the experiment was deemed to have failed. I asked D what his thoughts were on induced error and whether regulators could be better at introducing change, or is it entirely the burden of management? He felt that there probably was more that the regulators could do, but actually they do a good job as it is and at the end of the

day it is down to the local management how changes are managed dynamically and through leadership.

I also asked D about perception of change, and he stated that the normal response was always “not more change!” and then talked about change fatigue. He answered that he had witnessed this aspect many times in his flying career and there were distinct periods where it had greater impact than others; he felt that we had been through a tough time over the last few years with regards to regulatory change, but the worst was yet to come with the potential upheaval from Brexit, the changes for drones and general European airspace changes (SES/SESAR).

I explained to Interviewee B that the focus of the interview was in 3 parts, firstly to validate the survey responses so far, secondly to ask B’s opinion on how regulation is currently introduced and thirdly how B saw the future developing, especially with his UAS experience.

Interviewee E was content with the format of the interview, which was structured around the survey results in order to validate them, and also to seek his opinions on introduction of regulations and how the future will develop, especially in regards to UTM.

Page B-1

The title page of the Infographic shows graphically the global coverage and likelihoods of respondents. I explained the nature of my research and how I had reached such a wide audience; Interviewee A was impressed with the global take up of the survey.

Survey results: In going through the survey results with Interviewee D, he felt that the questions were well phrased and to the point. He was impressed with the global reach shown on the title page.

Page B-2

Page 2 covers the first 4 questions to which Interviewee A agreed the answers provided.

Page 2 of the survey results did not highlight any discrepancies in Interviewee D’s thoughts.

Interviewee B was familiar with the term Black Swan and agreed that “not at all” fits with the aviation industry, saying that the quest for determining cause was part of the “cultural makeup of aviation” and that there was an “attitude to safe operations”. He agreed that Yes, an individual could make safety within their organization but stated that this also needed to be at management level to be fully successful as without leadership the individual’s efforts would likely fail in the long run. He agreed that errors are inevitable and said that “by nature humans are inconsistent biological machines”. He completely agreed that error management is what is important and commented that there must be a severity aspect.

In relation to Black Swans, Interviewee E agreed the majority viewpoint that they were not at all appropriate to aviation and stated that there is always a benefit from investigating an incident fully. He was not totally convinced with the majority opinion that safety can be made and said that he fell halfway in that “subsets of effort” were required and that it was a function of “guidance, leadership and time to

imbed change management”. For it to work and actually make safety required “right person, right place, right background” and therefore not everyone would be able to make things safer.

Interviewee E felt that errors were always an inevitability but again took a halfway viewpoint on the management of them saying that he was “sometimes to completely” and that the “system couldn’t cope with speed of development”. If it had been a 5 level Likert (instead of the 3 options given) he would have been at level 4. His point was that “something can happen too quickly for an SMS to stop the outcome, measured in a matter of seconds or years!”. His point here relates to events like the recent issues with an aircraft type, where the organisation only just prevented a potential accident, despite the system to do so being in place for many years.

Interviewee C agreed with the majority view and was not at all surprised by the percentage splits.

Page B-3

Page 3 provided an interesting discussion point, with the first question relating to whether or not aviation operations were seen as being intrinsically safe, up until the point a human gets involved. This is rather simplistic, but the point Interviewee A made was that he was very surprised that the YES vote hadn’t been higher and would have expected a more 50/50 result. His point was that the technology associated with modern aviation operations is very well advanced and is backed up with other equally advanced systems, therefore the overall ‘System’ is intrinsically safe and it is only when you introduce humans do you get human errors taking place. He said, “computers don’t have a bad day”. The follow-on question about removing human error from the workplace he felt was an easy one to answer – remove the human! He was surprised at the somewhat “defeatist” ‘No’ answer. With regards barriers, he spoke of Swiss cheese models and how there are always several layers of defence.

Discussion on Page 3 centred around how Interviewee D thought that analysis might show how mature a country’s SMS is in relation to the breaching of barriers and geographically where those who have not witnessed an event were located.

Again, as in previous interviews, the next question created much discussion. Do you believe that aviation operations are intrinsically safe until the point a human becomes involved? Despite Interviewee B’s involvement with UAS and UTM, against my expectation he was emphatically No. B focussed on the word ‘operations’ in forming his argument saying that “this word bounds the question by a condition of use”. He gave an example to support his argument, and asked me to consider a parked aircraft, which is generally considered safe; it does not become potentially unsafe until the human climbs in. When I asked about drones and mentioned a previous interviewee feeling that the answer was Yes because of UTM etc, he said that perhaps both sides were true, all operations are only “safe to a point” but as drones are “not yet assured to a high level” that point is currently lower. When asked if it is possible to completely remove human error from the workplace his answer was No, only achievable if you completely remove humans, albeit somewhat contradicting the previous question, although I believe his point in both is that there will always be a human involved somewhere in the chain. He said, “Humans design the workspace” and therefore define what is (or is not) addressed by the design, and that “software is a series of instructions written by humans” or via tools written by humans, hence there is opportunity for mistakes

and errors that will be revealed during operation. The main point being what is unknown or mis-understood cannot be addressed properly in design and may lead to errors or unexpected situations and hence unsafe conditions. [NB, when asked to review the extract he made the following additional comment in retrospect: “there is question of what level of safety is appropriate as nothing is totally (intrinsically) safe – but the focus was about the human element and when this may compromise safety – and my view is that this is not only during operation – but decisions and actions taken before this, e.g. design, maintenance, can pre-set a situation”.]

With regards to multiple barriers, Interviewee B had of course seen plenty of occasions when one barrier had failed but others had prevented escalation. He gave the example of the BA A320 cowl issues and the time that they were despatched with them unlocked and then opened in flight. There had been previous events with the A320, thought by some to be a design issue. In the BA case, the supervisor tasked to check the locks went to the wrong aircraft on the line, the correct one not being checked at all. A whole raft of barriers totally failed. This was therefore an example of when things don't get prevented!

The question on intrinsically safe created significant debate, with the word intrinsic leading Interviewee E to be absolute about the No answer, but he said that if the question had been replaced by ‘mostly safe’, he would have said Yes. An example he gave was a catastrophic birdstrike at low level, the result is the same whether there is a human in the aircraft or not, there is nothing that can be done to save the air system. He went with the majority view that it is not possible to remove human error from the workplace and agreed that he had seen plenty of occasions when one barrier was breached but others saved the day. This led us to discuss reporting (lots of people have witnessed an event where a barrier failed, but how many reported it?), and E opined that there “is often too much emotion” in a report and that “often people jump to defensive and blame emotions”. He also said that he has seen occasions where the way in which a report is handled within the leadership of a squadron, can set the whole safety culture back by 5 years!

In relation to the question about being intrinsically safe, Interviewee C's response was that “the failing in the system is always the human” and that “we are all individuals and react differently”. We also discussed HF. When asked about the possibility of removing human error from the workplace, C stated that “there will always be a human in the chain somewhere”. The discussion about multiple barriers centred around reporting cultures and C described how his organisation handles a report and how the multiple barriers were considered as a ‘big thing’, especially with the organisation's move to BowTie.

Page B-4

Page 4 covers the possible overloading by regulatory change. Interviewee A was unsurprised at the high percentage having felt overloaded but did cite an interesting example in relation to managing changes better: When air traffic operations were moved to a new centre, there was a significant technological leap between the two centres and for the military controllers there was the added complexity of now having to use electronic flight progress strips (FPS) instead of paper. The civilians retained paper FPS for many years afterwards and have only relatively recently switched away from paper. A recalls that the change from using paper FPS to having to type the details in to the computer whilst talking to the aircraft and assimilating the situation was very challenging and the way that people coped was to call for assistance from a Planner earlier than would be perhaps necessary. When a new system was introduced c2013 there was a substantial training

programme beforehand and flow was reduced in the early days of implementation. However, it was quickly found that controllers had significant spare capacity and there had perhaps not been the need to reduce the flow, although this demonstrates the intrinsic safety focussed approach the aviation industry takes. Indeed, the new planning tool opened up extra capacity in sectors. In hindsight, A thought that there may have been too much training and unnecessary restrictions in place but said, “when does cost balance against safety” and commented that it had to be proven that the introduction of the new technology did not adversely affect safety. He used an example of a 100% safe sky being one with only a single aircraft in it; i.e., no risk of collision. Totally unpalatable to commerce, but an example of perfect safety.

Page 4 elicited another example of change introduction from Interviewee D, in that he mentioned the AIRAC cycle as being problematic when changes are slaved to it and may be introduced too rapidly in order to meet the AIRAC cycle deadline. He also mentioned the new Skyway code and how this would be a rolling live document online, but an out of date one in print.

In respect to overload, Interviewee B had faced situations where he had felt overloaded in his work and it had on occasion been down to Regulations. A debate ensued about Regulation versus regulation, i.e. R vs r, in that was I talking about formal Regulation (including EASA, ICAO, CAA etc) or did the low-level stuff like local orders, aircraft manuals and operating procedures count? Interesting debate. When asked about the introduction of Regulations he felt that the CAA were “very good at engaging with industry” and working with them in partnership.

When looking at change, Interviewee E agreed that he had felt overloaded, which had been due to regulatory change but not always. He described it as just being part of the system. He did comment that the problem is the “constant drip feed of minor changes”, using the phrase “trivial water-boarding”. He suggested that important changes can often be missed in amongst the trivial and suggested that the community suffers from “change fatigue” and that often the changes are nugatory. He has had influence in a change within the MAA so that from Sep 17 onwards the MRP goes to a drumbeat of twice a year changes, rather than the current change whenever needed. Major safety issues will be notified to the Regulated Community by a Regulatory Instruction (RI) and then the regulation changed at the next cycle. E thought that the CAA system is much better because the cycle is slower.

Interviewee C agreed with the majority opinion that ‘Yes’, he had suffered from overload at points during his career, and that Yes it was from regulatory change, although he also pointed out that this could both be in relation to Regulation with a capital R (from higher authority) but also regulation with a small r at a more local level. He stated that there were many times when he had been subject to nugatory changes to local orders which exacerbated a situation rather than resolving it. The main point C made in relation to managing changes better was the lack of reflection that was often missed after a change has been introduced, saying “its all about moving on to the next change rather than taking time to reflect on what has happened”.

Page B-5

In coming on to the identification of errors on page 5, Interviewee A was surprised that the ‘always’ percentage was not higher; why would you not try to identify every error in order to learn from it? He was dismayed at the 2% who said ‘Rarely’

and wondered which of the Four Worlds those respondents were from, and if there were any trends across their answers in respect of region perhaps. He was unsurprised by the percentages in respect to SMS, except again for the 6% Rarely; what job and which country? With regards a single cause, A agrees with the majority that one cause is not always the right answer and cited the Nimrod crash report as being an example of a large likelihood of causes being found.

Interviewee D made a very interesting point in relation to the question on how important it is to ensure that all errors are identified – I had not considered before the power of the phrase “no matter how trivial” in this question. D thinks that this may have swayed some respondents away from the ‘always’ response because really some errors are incredibly trivial and do not warrant reporting or explanation. A debate ensued as to where the line is drawn though and how subjective this is. Comments made included the concept of having too much data to analyse because of the inclusion of the trivial, but this needs to be balanced against the desire to capture evidence of near-misses that can be learnt from and trend analysis. The comment on analysing SMS responses by country came up again in relation to the 6% of respondents in whose experience an SMS did not capture and analyse errors appropriately. He also commented that the distribution across the Four Worlds would be an interesting analysis on this question too.

The question about how important it was to ensure all errors identified produced a very animated response. Interviewee B focussed on the word ALL and commented that it was a matter of “scaling; lose ability to see the important stuff in the noise”. He also said that “too much data and you’ll drown” and “capacity of understanding”. The next question on SMS caused the same debate about ALL; B’s answer was “No – and it shouldn’t!”. “You will spend most time capturing data and no capacity for analysis”, which I felt was a really important point. He finished by saying that the “best run SMS knows key risks and collects appropriate data”. He agreed that No, it was not necessary to identify single causes, commenting that “sufficient understanding to deduct or induce the important” and that “too many chase root cause at disproportionate effort”. Without infinite resources and time there is a need to prioritise.

In relation to the question on the importance of identifying all errors, Interviewee E focussed on both ‘all errors’ and on ‘trivial’. “Where is the line, and how do you know when you reach all errors” he asked? He went on to state that it was a law of diminishing returns and the potential for disproportionate effort to be expended for little return. He said that there was potential for “flogging a dead horse” and he felt that strong leadership should say “enough, we can’t keep investigating with finite resources available”. His answer was therefore “Most of the Time”. On SMS, his opening statement was that “it would be naïve of anyone to answer Always”, especially as there will no doubt be human error within an SMS, and if the SMS is actually only one individual then this would also be exacerbated. His answer was therefore “Most of the Time”. Causation – No, not single cause, we should look for Root Causes.

Interviewee C was surprised at how low the majority figure was for ‘always’, the expectation would have been higher. He did notice though that taken as the ‘top 2’ including ‘most of the time’ this was 88% and is more like the order of magnitude that he would have expected for wanting to identify errors. The question about an SMS capturing all errors sparked a debate as to the realistic utility of capturing all of the trivia and he opined that perhaps things had gone a little too far, giving the example that “a 100% increase in the reporting rate has made a disproportionate draw on existing limited resources” and saying that there is “a need to balance

headcount with workflow”. When questioned about a single cause being identified, C commented that “an SMS can’t accept when someone just {makes a mistake}” and he therefore understood why the majority viewpoint was ‘No’. C went on to describe some aspects of his organisation’s SMS and how Flight Data Monitoring is used a lot and has proven useful, albeit that reporting has increased because of it, especially amongst the engineers. He finished this section with a comment that “when people are reporting that the Pringles were in the wrong drawer, you know that you are getting all the information”.

Page B-6

On page 6 we covered hindsight bias, with an emphatic YES from Interviewee A in both opinion and experience. We discussed the substitution test as being the fairest foil to his example of when he has investigated in the past and the ‘hierarchy’ put hindsight bias on to scenarios and then blame the controller. His other example was that of the Hudson River landing, whereby he had been told that the pilot was initially lambasted for not turning the aircraft around and landing back on the runway because every pilot who had faced the same circumstances in the simulator had managed to land ok. It was apparently the Hudson pilot himself who pointed out that the simulator pilots were already aware that they were about to hit the birds and knew what actions to take, in the real scenario he had had to assimilate the events as they unfolded before making the decision as to where to land the plane. When a delay (not sure of length but say 30s or 1 minute) was introduced before simulator pilots were allowed to react, they crashed every time. The next answer also elicited a strong response from A. He said that of course it is normal to apportion blame because we live in such a “blame culture society” inherited from the USA, with the desire to sue people at every opportunity. {with this in mind it would be interesting to see the analysis of the results by country}. PMN – Watched the DVD ‘Sully’ and researched the Hudson River event.

Page 6 brought this country split back to the fore in relation to blame. Interviewee D said it was disappointing that so many had a blame culture and he asked, “how mature is their SMS”. He felt that the previous question on hindsight bias was “realistic, as this is human nature” and with the desire to “rationalize, this figure could have been higher”. D stated that his own answer to the question of management’s perception of risk would be to agree with the middle figure ‘less than me’ but was pleased that the majority view was ‘the same’.

Hindsight bias – Yes. Interviewee B commented that “some of the best investigators recognise and balance against hindsight bias, but training could be better”. No, it is not normal to apportion blame in his organisation and it was down to “culture and attitude”. Aviation management share the same perception of risk in general and look to “identify which risks are important”. There is not always the clarity though across all levels of the organisation, and management could do better at describing the risks cohesively to different audiences/groups/layers.

Interviewee E thought that ‘Sometimes’ hindsight bias impacted investigation, especially unconsciously. He highlighted the Hudson River example as well, whereby the substitution test in the simulator had the aircraft turned back and landed safely every time, until hindsight bias removed, then it always crashed. E thought that it is not normal to apportion blame within military aviation, as aircrew acknowledge human error and engineers have systems for consistent and ingrained processes. He opined that the Yes contingent might be commercial aircrew who faced far more competitive agendas than military. Management perception was

answered The Same, and Just Culture was agreed. He did express surprise at the relatively high response from those saying No!

In this section, Interviewee C was emphatic that he did work within a Just Culture and he felt that the statistics reported in the survey results were realistic.

The next result surprised me. Interviewee A believed strongly that management's perception of risk is higher than the shop floor because of the relatively recent era of accountability. He agreed with the 10% of respondents and the example he gave was of a current and experienced controller doing his job routinely, with all of the risks inherent with it suitably thought through and a course of action chosen, whereas a snap-shot look at a situation by management would have them wary of the risks being taken because they were perhaps not as current on console as the workers. So, Accountability was his key point in this answer. In Just Culture we wondered how this 16% NO would break down by country and if there would be any correlations.

Page B-7/B-8

UAVs are Interviewee A's specialist area and we came on to the question of regulation at this point, which then took a sizable portion of the interview time. A stated that more regulation is needed urgently. The regulators believe that we need to gain evidence to develop regulation, the manufacturers want regulation now so as not to waste money later. "Need for standards to be established for manufacturers to build UAVs to. Either that or manufacturers should develop a set of universal protocols to inform the regulators." He made a very valid point about Brand Protection and used Amazon as an example. He opined that one mistake from Amazon and they will be hit hard (bad press), and in general the UAV markets are non-aviation with big brands unwilling to risk reputations and bad press. Therefore, developmental progress is slower than it could be. The EASA proposals of introducing categories was seen as a good thing as manufacturers can then focus on deciding what product to aim at individual markets within a category to fit with appropriate regulation. They need guidance, which has not been forthcoming. GUTMA group of manufacturers and operators trying to lead the regulators by developing these protocols. ICAO are focussing on interoperability.

With regards to drone regulation, Interviewee D feels that current regulation is confusing but needs development rather than having too much regulation. He said "it is barking that you can fly drones in CAS at any height, this is endangerment. Regulation should be more explicit." D was somewhat 'hot/cold' in regard to the benefit of registration because we "haven't caught a single person in relation to an Airprox with a drone". If registration is introduced, then he suggested that it might be in the form of a SIM card. What does D think about UTM? He thought it was the right development line and that the key would be the integration of UTM with ATM, which must come. It would not be possible, or right, to prevent drone development, but it must be done safely and with the safety of manned aviation at the forefront. "At the moment this is lagging well behind the advances of drone technology and proliferation".

On the subject of drone regulation, Interviewee B felt that the current regulations are mostly fit-for-purpose but need some tweaks. "Regulatory aspects are fairly well understood", the difficult part is in the implementation and an "international interoperability challenge". He agreed that electronic conspicuity (EC) and registration are the way ahead, and necessary, but said that EC must include GA

and that registration will be of maximum use if there is cross-border accessibility and interoperability – people will take their drones on holiday.

Interviewee B commented that the balance of responses was ATM heavy, about right for aircrew and low for engineer, but said that this could be due to not accessing the design engineering aspects of aviation. With regards to drones, design engineers are entrepreneurial non-aviation and would probably not have seen this survey. He was not surprised about the proportions of respondents who had been in the industry a long time, but commented that it would be worth my while to look at the opinions of the respondents in their 1st few years – the newbies.

Regulation on drones – Interviewee E commented that this issue was far wider than drones and needed to be addressed across GA and gliders too. “The entire regulation set needs boosting” was his comment in support of the statement that drone regulations were generally ok just need a tweak.

Interviewee E thought that the survey was well balanced and had far reach across the community but felt that engineering representation “was a bit light”. This he opined might be due to the use of contracted engineering which my survey might not have reached into.

In regard to the proliferation of drones and the current level of regulation, Interviewee C felt that the current regulations needed some bolstering but were in general fit-for-purpose.

General

In discussions about good practice, Interviewee A suggested that the space industry could be seen as an example, they haven’t had a disaster for some time and all things space-related are thoroughly regulated. The final point made was on change fatigue; A stated that ATCOs face this all the time and it was a genuine concern with the continual change to operating procedures. In relation to the Research Question, A said he thought that new regulation could be introduced safely, as he wasn’t aware of any evidence of crashes because of it.

What did Interviewee D think about the EASA NPA? D had not at this point read the whole document (c500 pages released that week) but we were able to talk about some of the concepts introduced in it. He liked the concept of airspace zones and felt that this was a quick win for future products but would not resolve the here and now.

On the subject of Brexit, Interviewee D was very concerned about the possibility of the UK diverging from EASA but suggested that if we do so then the key will be a direct link with ICAO. When asked if this would open the door to the UK adoption of ICAO ATS instead of UK FIS he felt that this would be “a backward step as we have come a long way on the journey with ATSO/CAS/UK FIS and it would be a shame to introduce a new set of services that could be seen to be less safe”. That said, he acknowledged that there was potential that this would be the case anyway if we did remain tied with EASA, in that the ATM IR stipulates this change and the UK may not be able to achieve a derivation.

When asked about his thoughts on the way that MAA regulations are introduced, Interviewee E said he has personally witnessed a significant improvement in the way that the MAA does its business over the last 18 months. An example of this is the fuller collaboration with the CAA in such areas as display flying. On a

negative point, he said that “we are changing regulations for the wrong reason” such as blindly exchanging the word Aircraft for Air System. He finished by saying that “the aspiration to give people a period of stability is never achieved due to external pressures from bodies such as EASA etc”.

After validating the survey results, questions were asked about regulatory change in general and examples of how it might be done better. C thought that the way that the Transition Altitude change programme had been running was particularly poorly handled, and relieved that it had been put on hold for now. He stated that his organisation has daily dealings with the CAA, but it was “not always clear what they expected of us”. He suggested that the CAA gives too much consideration time ahead of proposed changes, although he was frustrated at the time it has taken to rollout ECCAIRS. On a positive note, C commented that their “CAA Flight Inspector is excellent, understands their issues and is pragmatic with day-to-day contact, and coaches them through new regulations”.

Appendix D – Support to the UK Government’s consultation on future regulatory policy for drones 21 Dec 2016 to 15 Mar 2017

● dronesconsultation 

22 July 2017 at 16:51

D

Publication of the drones consultation response

To: dronesconsultation

Dear consultation respondent,

Many thanks for your response to our consultation entitled ‘Unlocking the UK’s high-tech economy: consultation on the safe use of drones in the UK’.

We are pleased to tell you that we have today published the Government’s response to this consultation, which summarises the responses received and sets out what measures the Government will take going forward. You can find the press release for this announcement [here](#).

The Government’s response to the consultation can be found [here](#), it details information on responses including the:

- number of responses
- types of bodies and person responding
- overall results

It also gives the next steps to be taken by Government to:

- implement a registration scheme and mandatory competency tests for all users of drones weighing 250 grams and above
- bring forward work to create an authoritative source of UK airspace data, which will facilitate the implementation of geo-fencing and build greater awareness of airspace restrictions amongst drone users
- explore further measures such as increasing penalties, creating new offences and reviewing the powers available to law enforcement agencies to enforce relevant law

You may also be interested in the outcomes of the Government’s safety research being published today, as it influenced the outcomes of this consultation. The safety research was sponsored by the Department for Transport, the Military Aviation Authority and BALPA, the pilots’ union. It examined the impact of a drone hitting helicopter and airliner windscreens. It showed that drones of 400g could critically damage helicopter windscreens. For airliners a drone of 2kg or more could critically damage the windscreen when the plane is flying at a high speed, not commonly flown for take-off or landing. A summary of the results can be found [here](#).

Many thanks again for participating in our consultation!

The Drone Policy team



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Figure D-1 showing email acknowledgement of the researcher’s input to the consultation

Appendix E – Ethics approval and letter to interviewees

Ministry of Defence (MOD) policy for research involving human participants is specified in JSP 536, Annex C to which is replicated below at Figure E-1. The regulation requires that the checklist in Table C-1 (to JSP 536) is considered, which is at Figure E-2, to ascertain if MOD ethics approval was required or not. It can be seen from Figure E-2, in conjunction with common sense, that specific MOD approval was not required.

University of Portsmouth ethics review was required for this study and the letter of approval, with reference E417, was issued on 8 December 2016 and is included at Enclosure 1 to this Appendix. Enclosure 2 is a copy of the letter that was sent to all participants ahead of their interview, and understanding checked before the interview commenced.

Ministry of Defence Policy for Research Involving Human Participants	Annex C to JSP 536 Dated 16 May 14
ANNEX C - DOES MY RESEARCH PROTOCOL NEED TO BE SUBMITTED TO MODREC?	
<p>Not all human research needs ethics review. For example, there would be no need for ethics approval of an anonymous questionnaire seeking opinion about canteen food. In the case of testing a new rifle, there would probably be no need for ethics approval unless the research involved studying the effect of the rifle on the individual, for example to assess the effect of the noise on hearing. On the other hand, assessment of a new protective suit in a hot environment would need ethics approval because of the risk of the participants becoming dangerously overheated. Research involving life support equipment whose failure could cause death also requires ethics approval.</p>	
<p>In all cases the guidance given in JSP 536: <i>Policy for Research Involving Human Participants</i> must be followed. If you think that your protocol does not need ethics scrutiny it may be helpful to answer the following questions. If any of your answers fall into column A in the table below, it is likely that ethics approval of your protocol is required from MODREC. Further advice can be obtained from MODREC via the MODREC Secretariat.</p>	
<p>This checklist of questions is aimed at helping you decide if ethics scrutiny is needed. It cannot be totally comprehensive, so even if all your answers are in Column B, if you are in any doubt as to whether ethics approval is necessary please contact MODREC via the MODREC Secretariat for advice.</p>	
<p>It is the responsibility of you and your MOD Line Manager to ensure that no research requiring ethics approval is started before MODREC approval has been obtained, this includes the commencement of the recruitment of volunteers.</p>	

Figure E-1 showing the MOD criteria for requiring specific ethics approval

Table C-1: Investigator's Decision Aid for Ethics Review Requirement.

	A	B
1. Are the risks to the research participants in any way greater than those to which they are exposed in the course of their normal peacetime duties?	YES	NO
2. Is there any psychological intrusion, for example personality questionnaires, psychometric tests, or recording of sensitive personal information?	YES	NO
3. Is there any physical intrusion, for example body fluid sampling or medical examination?	YES	NO
4. Will the psychological endurance of the research participants be tested beyond the limits inherent in their normal peacetime duties?	YES	NO
5. Will the physical endurance of the research participants be tested beyond the limits inherent in their normal peacetime duties?	YES	NO
6. Will any physiological monitoring be used, for example of body temperature, heart rate, ECG, breathing rates e.t.c, spirometry?	YES	NO
7. Will any drugs or other substances be administered?	YES	NO
8. If applicable, have all the unmanned tests and safety assessments been completed satisfactorily, to appropriate standards and throughout the ranges of environmental and physiological conditions in which human exposures are planned?	NO	YES
9. Will the research participants be paid extra for taking part in the study?	YES	NO
10. Will the research participants be drawn from a group which stands to benefit from the new equipment or technique?	NO	YES
11. If applicable, are Standard Operating Procedures available for the equipment or system?	NO	YES
12. Can the information collected be linked to individual participants?	YES	NO

Figure E-2 showing that specific MOD ethics approval is not required

Enclosures:

1. UoP Ethics Committee Letter of Favourable Opinion dated 8 Dec 16
2. Letter of introduction to Interviewees (written 4 Jun 17)



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8 December 2016

Ian Fyfe-Green
DBA Student
Portsmouth Business School

Dear Ian

Study Title:	Towards a better management framework of aviation risk during regulatory change
Ethics Committee reference:	E417

Thank you for submitting your documents for ethical review. The Ethics Committee was content to grant a favourable ethical opinion of the above research on the basis described in the application form, protocol and supporting documentation, revised in the light of any conditions set, subject to the general conditions set out in the attached document, and with the following stipulation: The favourable opinion of the EC does not grant permission or approval to undertake the research. Management permission or approval must be obtained from any host organisation, including University of Portsmouth, prior to the start of the study.

Summary of any ethical considerations:

-

Documents reviewed

The documents reviewed by Dr Peter Scott [LCM] + PBS Ethics Committee

<i>Document</i>	<i>Version</i>	<i>Date</i>
Ethical Review application	1	26 Oct 16
Question Survey	1	08 Nov 16
Question Invitation	1	08 Nov 16
Survey about aviation risk	1	08 Nov 16
Ethics Review application	2	22 Nov 16
Response to feedback	2	22 Nov 16
Amended survey	2	22 Nov 16

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements set out by the University of Portsmouth.

After ethical review

Reporting and other requirements

The attached document acts as a reminder that research should be conducted with integrity and gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
-
- Notification of serious breaches of the protocol
-
- Progress reports
-
- Notifying the end of the study

Feedback

You are invited to give your view of the service that you have received from the Faculty Ethics Committee. If you wish to make your views known please contact the administrator, Christopher Martin.

Please quote this likelihood on all correspondence: E417

Yours sincerely and wishing you every success in your research



Chair



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Please excuse the generic nature of this letter, it is incumbent upon me to produce a standard format that all participants see, in order to satisfy policy on ethical research.

The aim of my research is to assess the impact of regulatory change on aviation risk management, with a specific objective to understand how best to manage it without inducing error.

My research questions are as follows:

1. Can new regulation be introduced without decreasing safety? Does the likelihood of near-miss reports (Airprox) increase when new regulation is introduced? Is there evidence of direct correlation?
2. Is there any evidence of induced error due to regulatory change?
3. Is an impact on safety anticipated by the regulators when making changes? Does perception of regulatory change play a part in inducing error?
4. What 'good practice' can be learnt from other industries for managing safety during changes in regulation?

I have asked you for your time in order to help me to answer these research questions, firstly by validating (or not) the responses received from the global online survey of aviation industry personnel and secondly to discuss the elements of my questions specific to your area of expertise that were not answered by the survey. The latest results of the survey are included with this introduction ahead of the interview.

Your participation in this study is completely voluntary, and I will not include your name in any of my published material. However, I would like to refer to you as being a representative of your organization if that is ok? Please tell me at the beginning of our meeting if this is not acceptable. Equally, if at any time, you wish to change your mind then please let me know and none of what you have said will be used in my thesis. I may wish to record our discussion so that I can refer to it when writing up at a later point but will not do so without your specific agreement at the time. I would like to take notes, whether the meeting is recorded or not. Written and recorded data will be stored in an appropriately secure location and destroyed once my thesis has been accepted by the University.

As you are aware, I work within the Military Aviation Authority, but this research is not funded by the MAA, is in no way connected with my employment and is purely for my personal academic study with the University of Portsmouth. Whilst the finished thesis will be available to all in the industry, it is not intended that the specific results of this survey will be reported to either the military or civilian regulators.

Thank you very much for your time and support, I look forward to our meeting.

Appendix F – Free text survey responses

These answers to the free text questions in the survey are presented exactly as written by the original author, except where companies or organisations were named, in which case the identifying details have been redacted if it was felt necessary to protect anonymity. All of the free text questions were optional, only the respondents that chose to answer the question are shown. The answers should be read in conjunction with the survey questions, which were presented in Appendix A.

Q1a - 2. Can you provide an example where an event has been over simplified and the cause is much deeper than widely concluded?

<p>Although not aviation related and more general but still relevant; road traffic accident investigators are I believe constrained to provide a single route cause of an accident, rather than the more contemporary analyses and derivation of accident causation chains. The result is that the investigator may be forced to pick, in their subjective view, one of several route causes. This subjective opinion will clearly vary and thus cast doubt on the robustness of road accident statistics and our ability to provide effective mitigations.</p>
<p>Aircraft entering closed worksite on taxiway - simplified as lack of markings but much wider implications regarding operational processes, training and safety culture. However the event was of little consequence which led to a relatively quick investigation focusing on main causes.</p>
<p>Not a specific event, however I have taken part i many investigations over the years, and more often than not the real root causes are not fully identified. Many investigations begin with a perceived outcome, this, in many cases compromises the investigation process, and ultimately outcome.</p>
<p>Most aviation accident investigations until the 1980's were overly simplified. From the 80's onwards (post the Canadian Dryden accident) started to take on human factors elements to learn more why the event occurred. Still cases today with shallow investigations/causal factor identification but much better generally.</p>
<p>a vehicle hits a plane on ground and the unreported damage has consequences on the plane structure.</p>
<p>AF447</p>
<p>I tend to favour the "Swiss Cheese" interpretation of accidents. There is rarely a single cause but usually several contributing factors that line up.</p>
<p>TWA 800 is a good example of where it could easily have been defined as a Black Swan event, or put down to terrorism, however deeper analysis showed that the location of the airconditioning unit and its capability of overheating caused a spark to ignite fuel vapours etc etc... Learning post this incident has led to various initiatives and regulations on inerting which would have been missed if the initial Black Swan account had been accepted. There are Black Swan events, but many are not, it is just not possible to measure what we have prevented by the very nature of its non-occurrence!</p>
<p>I consider that the effect of the so-called 'startle effect' in the Air France crash off Brazil is massively overstated. It is too simplistic and ignores the much more likely scenario that sleep inertia prevent the captain from responding in the appropriate manner when roused from his bunk and called to the flight deck.</p>
<p>ORG Course example of a Tornado DASOR - under pressure to achieve hours prior to deployment two junior aircrew kept waiting all day due to serviceability and ended up launching at night from HAZ - incorrectly marshalled by first time marshaller = incident. Fault laid at hands of crewe and marshaller. Deep cause - lack of supervision by auth (both v experienced and current) who should have put juniors first.</p>
<p>The recent RAF Voyager incident where a personal camera was lodged between armrest and sidestick. The root cause may be a systemic acceptance of PEDs used by crews on the flight deck.</p>
<p>Air Traffic Control-controller gives confusing instructions to low-time pilot and pilot gets confused-at same time controller focuses on regional jet arriving runway 36. Controller lost track of confused low time pilot and the low time pilot lands runway 18 at the same time as jet on 36. Initial reaction was to blame pilot confusion. Clearly there were cultural issues that allowed the controller to drift into poor communications skills and no respect for timing of clearances relative to pilot workload. More clearly defined and reinforced communications timing and phraseology would have greatly reduced potential for confusion and increased the chance the controller would have detected pilot error</p>

Kegworth 737
02 September 2006 - RAF Nimrod crash - On board fire following aerial refuelling.
Not necessarily in aviation, but in working life generally.
There is always a rational explanation behind any major catastrophic event.
Shoreham accident
Many accident reports prior to 2000 looked for a single cause and often this was pilot error. Often, the organisational and regulatory factors were more important. A good example being the Viscount crash at LHR in 1965.
Multiple examples exist within the record of deliberations of the UK Airprox Board where the cause of the incident has been over simplified, or insufficient analysis has been conducted to support the cause. One example is airprox 2016/209 where the Board concluded that the A109 pilot overtook the tug/glider combination too close; however, utilising an Ishikawa diagram to facilitate analysis would have prompted the Board and the Secretariat to probe further as to 'why' the pilot flew too close to the tug/glider combination. As such, this would have permitted the identification of root cause.
Anything written in the Daily Mail!!! I'd argue that in the UK. safety events are generally investigated to a thorough conclusion of causal factors. A good recent example is the Shoreham air display disaster. Historically, the Herald of Free Enterprise has generally been regarded as the fault of the human in the unfortunate place at the time when the holes in the swiss cheese decided to line up; OK, he was asleep too, but why? The real factors were only dealt with in the Lawsuite that followed - and failed to hold the Directors personally to account. Otherwise, what about events like Flooding? The EA is not as honest or thorough in its review and investigations.
Yes - snow clearing with extremely old equipment causing airlines to complain about delays but unwilling to pay to enable new equipment
Not specifically addressing this question, but the opinion "all major catastrophic occurrences are just random events" would be valid if there was only one with no commonality. Where there are more than one or similar trends occur they should be investigated.
I investigated an incident where an employee severely cut his finger on an aircraft pallet. the initial investigation concluded the finger was cut because the employee did not wear his protective gloves. where in reality The pallet had been damaged leaving tears in the pallet which made the pallet dangerous to use. PPE is not issued to allow damaged and dangerous equipment to be used
RAF Chinook accident Mull of Kyntyre assessed as being due to pilot error
Air Accident Formal Reports will clearly show Major Aircraft Incidents generally with follow a chain of events either involving human failure or systems failure where warning signs were displayed and not picked up on - With no malice by any individual.
An aircraft overrun incident at a UK airport which was piloted by two captains, one a training captain. The aircraft didn't touch down until in the final third of the runway and a go-around should have been executed much earlier. Nobody was injured and the aircraft was recovered, but the closed runway put pressure on a busy London airspace. Although not revealed in the final investigation report it was thought, by some close to the incident, some elements of the auto-pilot were not disengaged, neither captain took control to make the necessary decision to abort the landing.
The midair collision between the glider and Air Cadet Grob near Abingdon
Probably MH370 - without going into the various conspiracy theories in depth, I believe some people particularly military authorities in SE Asia no more than they are letting on - probably to protect their ability (or lack of) of their surveillance radar systems.
The Colgate Q400 crash, in the USA. Many tendrils of reducing safety without analysis or reason. In the Colgan case, much speculation was provided as fact without basis.
Infringements by aircraft on taxi across threshold of grass runway (to depart from the main sealed runway) at Christchurch are mostly incurred by "Sunday flyers" and visiting pilots. There is usually a sequence of small errors by different parties and/or lack of clarity on a written procedure that results in an incident.
Examples abound of organisational/cultural factors in aircraft accidents, where the underlying cause is much deeper than initially thought. e.g. cross-cockpit authority gradient inducing incorrect/late/non-existent action from the subordinate crew member due to cultural norms of behaviours to authority.

Most aviation accidents have a root cause
Uberlangen mid air collision!
German Wings CFIT - focus on pilot psych profile - rather than supply & demand of cheap travel for the masses as a root cause.
Nimrod explosion over Afghanistan - Haddon-Cave Report tried to establish cause and allocate blame but did not dig deep enough into the politics of degeneration of the Safety Systems in place. For example when i served in the RAF we had a Chief Engineer at 2 star level - an independent arbiter - this was degraded to GpCapt level and got subsumed inside another department - insanity. They then in hindsight formed the MAA and restore the independent Chief Engineer role. Organisational malignancy.
It is all too easy to associate a single cause to an incident without delving in to the back story and finding all of the contributory factors.
Most major accident investigation reports: these reports rely on factual deduction methodologies and not root cause analysis or analysis using applied causal methodologies leading to a conclusion. Also, accident reports generally remove any contentious content based on the Annex 13 system where all parties have effective veto rights on content. This masks the content from revealing underlying sources and the deeper systemic origins of an accident
Initially the F15 crash at Ben Macdui. Controller blamed for descending below TSL however on investigation clear HF with controllers personal circumstances combined with aircrew terminology and altimetry played a huge part.
1994 RAF Chinook crash (Mull of Kintyre)
Bell 212 'heavy landing' / crash in Kenya in 2014.
I cannot give a specific answer without it being debated ad infinitum, however after 'stepping out' of Mil Avn (318/550 era) and returning (MAA era), there is far more emphasis on the blind compliance of regulations to the detriment of safe flying. It is unrealistic to think that any of the 4 worlds in Mil Avn can safely, and more importantly, legally fully comply with them due to the proliferation of RAs and the ever expanding 'library' they are contained within.
snow cause of runway delays at UK airfields. conclusion need more snow equipment but also need personnel trained, able to get to work in conditions of snow. Extrapolation is an interesting exercise.
Although I cannot give you a specific incidence, I feel that there is often a desire to assign the most obvious cause to minor occurrences and move on. The willingness and time required to look for more fundamental issues is often lacking due to business/financial pressures. A case in point is that I feel there is often a default of assigning as human/pilot error, mistakes in selection of automation on the flightdeck, when perhaps some of these may more correctly be assigned to system and interface design being at fault. Forcing the human in the system to overcome the inadequacies of the technology is back to front, improving the technology to mitigate human frailty would be more sensible.
Not in the aviation industry and in the transportation industry in general for that matter as passenger lives have always been at stake. This generates a level of accountability and before Just Culture a requirement to apportion blame. Events may have been over-simplified in times of conflict (notably the First World war) but with a Government perception of acceptability. Even in the Middle East, where God's will is key with the indigenous population, over-simplification of a transportation event involving loss of life is not possible and they are investigated to identify root cause, corrective actions and preventative measures.
Unfortunately in aviation history safety has been a reactive response. The entire basis of the ICAOs push for more reactive measures (IE the implementation of SMS) was due to the latency of airport and airline operators in regards to proactive safety measures.
Singapore Airlines SQ006 accident 31/10/2000.
Teneriffe collision of 2 aircraft on the runway ; simplification : the ATCO was watching TV instead of doing his job ..20 years later the KLM captain is recognised as the main part of the collision, as his brain was acting as a Simulator instructor.
Air New Zealand Erebus disaster in the Antarctic
A simple compass fault where engineers have replaced the unit with no excuse for the fault.
Vauxhall helicopter crash. Whilst there are random events the causal factors were identified and could have been mitigated against.

Chinook ZD576 Mull of Kintyre 1994 crash
Most that stop at error without understanding the circumstances
German Wings
Any accident simply attributed to "Pilot Error". From a process development perspective, by definition, a root cause is a factor that, when removed from the sequence or chain of events, would prevent or greatly reduce the likelihood of a negative outcome. To error is human (Alexander Pope, b. 1688), and therefore human error could never be full removed from a process, and could therefore never be considered a root cause. However, in reference to Black Swans, because humans can never be fully removed from any process, there will be some element of randomness to catastrophic occurrences due in part to human error that wasn't or couldn't be anticipated by system or process designers.
Catastrophic occurrence is broad, but aircraft accident investigation proves otherwise in almost every case.
The sinking of RMS Titanic
In third world countries accident investigation is not done until root cause analysis and eventually similar events keep on happening
I believe Aviation events are generally analysed in detail
Many - just attributed to "pilot error" as the cause. This isn't the cause, it should be the start of the investigation....
Germanwings 9525 primary factor for CFIT was co-pilot depression. Immediate changes were made by Lufthansa to flight deck door access procedures and flight deck occupation policy to allow at least 2 crew members on flight deck at any time. Privacy rules with regards Pilot doctor's confidentiality were also questioned. The CFIT on March 24th had a primary causal factor but there were so many options that could have halted this tragedy.
United Airlines 173 crash. Pilot error but it caused a revolution in training as the psychological aspects were adressed.
As a mathematician and person wise in the ways of analytics, my argument would be that it only appears to be random. "Acts of God" aside, all accidents and incidents are predictable and preventable if we have the analytical tools to identify true root cause. It is complicated and complex and perhaps we haven't yet discovered the tools required; however, a comprehensive data analytics systems (Flights Data Monitoring (FDM) or Military Flight Operations Quality Assurance (MFOQA)) is the currently missing weapon. It has recently (finally) been regulated via the change to the Air System Safety Case Regulatory Article (RA1205) which now effectively requires the Accountable Manager to have considered FDM. Most events are a culimination of a Factors. The one area which is often misunderstood is Cognitive Attention/Distracton and Fatigue (Tiredness). One recent Puma accident very clearly had a root cause of cognitive error due to tiredness, but this was only touched upon in the SI.
Cultural beliefs, corporate egos, and national reputations can obfuscate and impede scientific investigation into accidents. EgyptAir Flight 990 - http://www.independent.co.uk/news/world/us-officials-blame-jet-crash-on-pilot-suicide-1126988.html "Egypt's position is being forcefully represented by the country's ambassador in Washington, who is trying to fend off a probe that Egypt fears would cast its national flag-carrier and the country in a negative light."
The bow doors of the herald of free enterprise.... systemic failings not an isolated event
Many events such as runway incursions are categorized in terms of risk, e.g. avoiding action to prevent a collision etc. There is also a tendency to summarise a causal factor as pilot error, ATC error or driver error without considering the many other potential causal factors such as the individual's personal circumstances, specific operational aspects of the incident, the effect of complacency or unfamiliarity in the incident etc.
Specifically, not off-hand but the standards of investigation vary around the world and there are "non-useful" influences in play too often. The current Egypt / France investigation arguments relating to the Egyptair A320 crash in the Med demonstrate all too apparently.
MH 370
The myriad of instances where pilot/controller error is indicated and the slip/lapse that led to an incident where the multitude of human factors that may have been impacting the performance on the aviation professional are not well considered.

coordination failure between bordering states and it is perceived that it is language barrier
Asiana 777 at SFO - much deeper than just pilot error
Pilot fired for being safe and following regs.
Egypt air accident, in which the NTSB investigation related the cause to deliberate action by the pilot, based on him saying "I rely on God", problems with the elevator, and repeated resetting of the Auto pilot during previous flights, were down played during the investigation, and no testing was done to evaluate history of stresses on the broken elevator.
The loss of a RAF C130 in Jan 2005 was caused by an Armour Piercing Incendiary round hitting a fuel tank. However, the tactics being employed, A2 feed, lack of fuel tank inerting equipment and on-board threat sensing equipment all played a significant part in the loss.
ATC typically relied on a specialist's memory when things such as runways were closed. This often led to events because the person forgot. Now it is required to utilize "memory joggers" as aids to prevent these types of events.
For most occurrences there is no single root cause. There are always multiple factors and causes leading to an occurrence. Life is not simple, but we need to find opportunities for improvement and eliminate preventable occurrences.
WATCHKEEPER SIs 031 (published 12 Aug 16) and 006 (published 15 Dec 16). Outcome of both incidents was a Cat 5 loss of airframe but no fatalities or injuries to 1st, 2nd or 3rd parties. The cause and implications of both these occurrences are the subject of much speculation, rumour and supposition: much of the detail within the SI report is difficult to follow and highly technical. The incidents have, however, been used as "proof of risk" by those with a pre-disposed mistrust of unmanned aviation capabilities but with little try understanding of the root causes or the implications and corrective actions they demonstrate.
The crash of Colgan flight 3407 is extremely over-simplified. There is little doubt human factors were central to the reasons behind the crash. However, the resulting changes to the rules were training requirements of student pilots and fatigue rules. However, the reason the plane crashed was because there was lack of familiarity about and recognition of severe icing conditions by both the Captain and First Officer. Fatigue and training deficiencies resulted in breakdowns in communication, but the resulting regulations were more a response to popular voice of the public and they do not fully address the reasons for the crash.
D. Wiegmann ANd S. Shappell developed Human Factors analysis Classification System (HFACS) Which has been field tested and verified in over 1000 aviation accidents. The HFACS does serve to place blame, instead it looks for underlying preconditions leading to the unsafe act. Much like Dr. Reasons Swiss Cheese approach it requires several factors to line up in order for an unsafe act to take place. But in HFACS these are not random factors instead they are underlying assumption and decision that lead to the unsafe act. By discovering these factors we are able to change the culture of leading up to the unsafe act and reduce the possibility of it happening again.
Most aviation accidents have revealed multiple safety issues throughout thorough and unbiased investigations. The current safety record of the 121 operators illustrates the changes that can be made to improve safety resulting from these investigations. These investigations reveal that it is often much deeper than just pilot error.
I believe Southwest Airlines' runway overruns and unstable approaches stem from their company culture of rushing to make it on-time, instead of the normally accepted view that the individual pilots broke SOP.
Use of incorrect tooling as a norm, in lieu of torque adaptor. No issues ever resulted from not following procedure but unknown issues of stresses from over torquing not identified.
A simple hard landing in the training world is considered the cost of doing business. When fully investigated, that type of accident led to changes in procedures, methods of teaching various maneuvers as well as changes in the training and hiring of instructors. The end result was a dramatic lowering of this type of accident. If all accident are random, how does one explain the results?
Loss of separation incidents where failure by the controller to use and record flight progress strip information was not considered as a primary or contributory cause.
9 / 11
In aviation incidents, news media tend to try to establish cause even prior to NTSB preliminary findings. In most cases the actual cause is not clear until a full NTSB investigation (normally 6 months) is complete.

<p>Aircraft runs out of runway or flat spots the tyres due to heavy braking after high landing speed. Deemed pilot error for landing too fast. This does not show up the underlying reason why the pilot was landing too fast. Flight training covers stalls and stall recovery is practiced, but the pilot becomes inherently frightened of stalling so "adds" some speed to all manoeuvres including landing. Better stall training and dangers of overspeed discussed during training would have prevented the incident.</p>
<p>Events may happen due to randomness but one has to measure the probability of such randomness. For such decimilistic possibilities the current stand should not be discounted.</p>
<p>At my current location, we have a large problem of Runway Incursions by the pilots. While this has been going on for a while, it seems the core issue is proper communication and training. The culture is that "this is expected due to the fact that we are a pilot training base and we simply need to be on the lookout".</p>
<p>An example I recall was an accident involving a DC-9 aircraft in the late 80s. The aircraft landed hard and the fusilage broke just aft of the wing. There were no injuries. The authorities determined that the accident was due to pilot error in failing to correct for a high rate of descent just prior to touchdown. It was later determined that the pilot had been flying with an undiagnosed case of Parkinson's Disease, the nature of which we believed contributed to the lack of quick reactions from the pilot to arrest the descent. A submission was made to the authorities prepared by a noted authority on movement disorders which indicated that the symptoms of Parkinson's did in fact, play a role in the accident. The Authorities however discounted the report and retained the simplistic probable cause of "failure to arrest the rate of descent."</p>
<p>Any event attributed to "pilot error". Unless having suicidal tendencies, no pilot sets out on a flight with the intention of crashing. "Pilot error" may be the immediate accident cause, but what led the pilot to make the error? All kinds of latent conditions could have contributed - poor training, poor procedures, fatigue etc.</p>
<p>To understand and to learn from past events, albeit accidents, is a necessary but non sufficient condition, for progress and improvement.</p>
<p>It is usually said "a human factor", and the deeper cause e.g., can be the working load of personnel or working conditions.</p>
<p>The Colgan Air crash in Buffalo. An unprofessional captain with past poor performance, yet blame was placed on lack of training instead of the fact that the captain should not have been employed as a pilot.</p>
<p>Refuelling vehicle driven away from aircraft still connected. Integrity failure of fuel hydrant system</p>
<p>I can't think of any specific aviation crash but, in the majority of all accidents there are three factors that influence these accidents they are: 1. Human factor 2. Aircraft design 3. Weather</p>
<p>Whilst I am not providing a specific example, I feel that one of the major safety issues in air traffic control is airspace infringements. There are hundreds of infringements per annum in the London TMA alone and it's an issue, which despite numerous attempts at reducing the number, continues to remain fairly constant. These incidents are usually put down to pilot error but my opinion is that it is a lack of pilot education and poor awareness of the consequences of their actions. This could be due to the fact that a lot of flying instructors are low hours and relatively inexperienced, usually waiting for a job with the airlines to come along. I feel that this is a contributing factor but I also think it's is poor education both during and post training. As a PPL myself I know that since qualifying I have never had an assessment of my navigation ability, airspace knowledge or RT standard. It is my opinion that these occurrences are not just random pilot error but a fundamental flaw in pilot training from PPL level upwards.</p>
<p>I am not at liberty to discuss events involving the provision of ANS</p>
<p>Soanair accident at LEMD of MD88 acft.</p>
<p>Every investigation that I've read contains causal factors that could have been prevented or mitigated prior to the accident, and hence the accident itself could have been prevented or mitigated. I believe that the key to separating Nassim's postulation and my observation is the extent to which the subject of scrutiny is understood: with a lack of understanding of the subject of analysis Nassim's postulation is valid, with an understanding (of any amount) of the subject of analysis results in the ability to control to a commensurate amount, the likelihood and / or severity of potential outcomes. Hence it is only random if you don't take preventative actions, based on knowledge of the subject of analysis. The aviation industry is (thankfully) a deeply understood industry, and whilst there are always areas where our understanding can be improved (and hence our predictions about hazards and risks cannot be considered perfect), the outcomes of accidents should not be considered to be completely random. At a practical level, the trick to this is understanding that the world will never be entirely predictable but we should strive to make it less random.</p>
<p>TWA Flight 800</p>

<p>MI-24 attack helicopter engine's compressor blades were damaged, because of something. Several times was detected (specially winter time) that, the engines compressor blades are damaged, but the reason why was not investigated as deep as needed, therefore the occurrence repeated. Finally one of the engineer was more persistent, than the others, and find the cause which was the ice which was generated in the dust selector of the air intake of the engines, than after starting the engines this ice as the engines started to be warm this ice detached from the dust selector just into the engine's compressor and damaged the blades. When it was checked and removed before start the engines, there was not happened again</p>
<p>Yes - Seaking disembarking from RFA ran out of fuel with an underslung load. Pilot failed to jettison load or enter autorotation. All but one crew killed. I served on the same squadron as the pilot and there were a number of underlying behaviours that are likely to have shaped behaviours. It was a tragic and avoidable accident but not quite as simple as the findings.</p>
<p>Chinook FADECS</p>
<p>370 recently</p>
<p>An individual incident within the air traffic management area whereby the investigation identifies the human element of the event but does not delve deeper to asses the systemic factors that may have contributed.</p>
<p>Incorrect application of a procedure regarding a military aircraft resulted in confusion as to the intentions of the aircraft which may have had an affect on safety of flight, this was exacerbated by problems establishing who (if anyone) was in contact with the aircraft. The report was incorrectly filed and the eventual conclusion was dismissive of there being any underlying issue, despite taking this up with the safety team, nothing was changed.</p>
<p>introduction of SMSs</p>
<p>Just about any investigation into commercial aviation accidents. Often due to public pressure, investigators are prompted to provide an answer without having explored every plausible, or sometimes implausible, explanation of the accident. As in the case of US Air 427 where 'turbulence' from adjacent mountains was originally cited as the cause of the crash.</p>
<p>Retention of qualified engineers in DE&S</p>
<p>ATC error-2 aircraft get too close-ATC determines it was due to either "distractions" or "failed to comprehend the display". Case closed. That labeling causes the critical questions to stop instead of proceeding to the root.</p>
<p>the majority of catastrophic accidents</p>
<p>Loss of C130K XV304 at RAF Brize Norton following wheels up landing. SI President identified a number of salient factors that contributed to that accident which were ignored by the SI Convening and Reviewing Authority who couldn't accept the captain was not at fault for not putting the gear down.</p>
<p>Hillsborough football tragedy, until recently perhaps.</p>
<p>Can't provide a specific example but, until recently it was common for HF incidents to be dismissed as such. As organisations have matured and embraced HF and a Just Culture it is clear that almost all HF incidents have provenance in poor practice/supervision down the line.</p>
<p>I think there are lots of examples across the world where a simple diagnosis of 'human error' has obscured an underlying systemic failure in process, culture, investment, management, and or leadership etc.</p>
<p>There was a crash in Afghanistan involving British soldiers being transported in a Canadian military helicopter. The crew was comprised of a new aircraft captain and a new first officer. The accident (involved the death of a British soldier) was assessed as being pilot error with no reference to the leadership that allowed the two inexperienced pilots to be paired to fly together in such a high-pressure and safety-critical mission.</p>
<p>Vast majority of aviation accidents, once investigated, are explained. The aviation world benefits from such investigations to reduce or eliminate future accidents.</p>
<p>Generally, events in which the conclusion is that it was caused by pilot error is an over simplification of the cause.</p>
<p>asiana SFO, air france 447</p>
<p>NUMBER OF MISSED OPPORTUNITIES IN AIRBUS</p>

<p>Alaska Airlines flight 261- Catastrophic crash of an MD 83 in 2003. Crash originally blamed on a failed jack screw leading to the stabiliser getting torn off in flight. What the later investigation uncovered was a culture of poor discipline, cutting corners, inadequate supervision, FAA oversight, design and cert issues and unauthorised maintenance procedures that all led to the crash.</p>
<p>General aviation accidents that occur every year and simply state "pilot error" as the cause, without examining any internal or external human factors influences.</p>
<p>I cannot think of any particular examples where an accident has been under investigated, however, I could imagine that in previous years going back to the 50's to 80's this would have been the case. There is a big focus around SMS which involves risk management processes (as I'm sure you are aware) and stresses the importance of determining true root causes. Investigations are very detailed around determining far beyond active failures and look to seek deep latent conditions that may have played part to this.</p>
<p>I my experience most 'human factor' incidents do not ask enough 'whys' to establish the real route cause.</p>
<p>The Nimrod Crash the led to the Haddon-Cave report.</p>
<p>I'm thinking about an incident where a local pilot wrecked his Ercoupe. Pundits called it "pilot error", which was a contributory cause. But digging in, he had maintenance issues on the aircraft (that he should have caught with a competent run-up and preflight), and his flight instructors felt he was a marginal pilot at best. So examining the incident based on the events of that day only yielded an incomplete picture. There were systemic issues that directly contributed to the chain of events. I'm a believer in SMS.</p>
<p>Cause is usually very very complex and will contain many elements. It is much more productive to identify and evaluate the risks with a vies to reducing or eliminating those risks. I spent 20 years directing aircraft accident/incident investigations.</p>
<p>Fuel starvation events can be caused by carburetor issues and not readily identified especially if hidden by inaccurately calibrated fuel gauges. Fuel starvation is easy to blame on PIC but sometimes there are other causes that are not identified.</p>
<p>No but I can provide examples of incidents where the simplified event was overlooked and the much deeper event was selected as the actual cause. We seem to examine incorrect clearances for spurious underlying causes and select that instead of just accepting that people make mistakes. A colleague passed an incorrect landing clearance and then tried to cover it up by claiming all manner of random reasons. As these spurious reasons were examined and found to be false flags the original mistake was lost and eventually forgotten about.</p>
<p>Many occurrences within ATM where the controller has been blamed rather than any form of root cause analysis taking place. This happened to me personally where the cause could have been put down to supervision and manning but this was only from my own investigation and not that of the unit.</p>
<p>Not off the top of my head, most events seem to be thoroughly investigated these days not necessarily to apportion blame but to identify causes and learn lessons to prevent similar events from happening again.</p>
<p>After a pilot ended up hitting forest after takeoff, management blamed the winds from a nearby thunderstorm. The investigation revealed that the pilot mismanaged the use of flaps and acceleration input causing the aircraft to "mush" into the trees.</p>
<p>Swearingen Metroliner crash at Cork. Unstabilised third approach and poor execution of go-around procedure. In reality, poor oversight of safety, non-existent safety management culture, 'virtual' airline, contract pilots, airline known to be in economic difficulties. PLUS PLUS PLUS pilots under pressure to operate owing to obscenely stupid Regulation 261.2004 which provides very costly for pilots to accept operations in known difficult conditions or oblige the company to pay enormous compensation to passengers. In determining the interpretation of this Regulation, the European Court of Justice took no cognisance whatsoever of the adverse safety implications that would be the inevitable consequences of its uninformed but legally binding opinions. The ECj is itself a very dangerous body which ignores any thoughts of risk assessment. It is thus unfit for purpose.</p>
<p>See FAA rule change after Buffalo accident requiring new hires to have at least 1500 hours and an ATP before they can serves as FO in airline operation</p>
<p>The habitual damage and non-compliance reports that we get on a daily basis. We receive irregularity reports daily. many of these non-compliance events include gross errors in weight and balance and gross errors in not following the standards loading guidelines. This non compliance is mostly attributed to an Agent failing to follow proper procedures. However, in reality, it should also include a look at Ramp and Station leadership and what they do or fail to do to improve performance.</p>

No but I can give you the opposite example: The Challenger accident. Read the book Truth, Lies and O Rings.

Examine U.S. aviation accident reports from the 1950s and 1960s, and you will find the investigators did not do a detailed investigation and conclude the cause of the accident to be "pilot error".

Root cause analysis (if researched deep enough) has always led to multiple causal factors. These factors fall into the categories of managerial and operational as well as individual and systemic. These are for inhouse of our flight department filed incidences and close calls but never an accident.

Most events are over simplified and involve many barriers being by-passed or broken.

Events are a mixture of the low frequency random events which do comply with this opinion and others which actually are predicted and do occur. Examples of the former are those such the BA777 that landed short at heathrow and was attributed to Fuel Icing, as opposed to the communications failure in Los Angeles over a decade ago which was as a result of a procedure not being followed to prevent memory overflow. The predicted result of the procedure not being followed was that the system crashed and it did.

Take your pick. although we are getting much better at identifying root causes there is still a tendency to focus on technical explanations whilst ignoring the human performance of the event and leading indicators prior to the event

Q1b - 2. Please give an example of a time when you have personally made things safer:

Changing a design to reduce risk
As a traffic management coordinator I have personally stopped/rerouted departures and arrivals into Chicago when in my judgement weather conditions no longer allowed continued use of the routes.
For context it is a combination of human efforts and expertise with effective rule based regulation that I feel provides safety, stating one or the other is too simplistic and idealistic. In order to announce that a Windshear Go Around rather than a standard Go Around was to be performed, I used to brief that I would call "Windshear Go Around" if a Go Around in Windshear was required. This would be to prevent the monitoring pilot from altering the aircraft configuration as would normally be done, sometimes from muscle memory, on a standard Go Around. One day when encountering low level Windshear I did actually have to make this call and the manoeuvre was performed as required. It is now SOP to make the call "Windshear Go" for a Windshear Go Around as this was seen as an extra safety requirement so that the correct actions were taken in good time.
Changing operators behaviour to reporting has led to improvements as a result of investigations which in turn have prevented future unsafe events
By identifying weaknesses in performance in risk critical areas (firefighting) and subsequently providing additional skills training as well as incident commander training and assessment.
Every hazard report or suggestion/opportunity for improvement is a human attempting to make the system safer.
under the safety network we built with operators and other stakeholders
Identifying changes in ATm and AOC procedures which are compromising the margins currently available to operate flexibly. The subject area being CAT fuel policy.
I agree to an extent. I have personally made things safer through improving ATC procedures as an operational ATCO, analysing risks and suggesting safety improvement outcomes. As a regulator it is the core of what I do, constantly striving to improve how we manage our risk from a strategic perspective.
I have been extensively involved in SMS implementation for both operational and maintenance organisations and consider that this has been a significant step forward.
By refusing to fly when fatigued. This set an example for others and forced the Command to appreciate views from all.
Fire Escape ladder from building slippery when wet. I had the ladder painted in non slip paint. Realised no procedure for Flight Calibration of the ILS. Introduced a procedure to ensure all parties involved knew what was expected of each other. Introduced Maintenance programme for facilities to ensure equipment maintained in a timely manner
Very slowly, by encouraging development of a just safety culture in a society where a blame culture is normal.
As an ATC manager I changed requirements/Standard procedures many times to increase safety. The best ones were when I did sufficient research to truly understand the root of the human factors-then educated a small team in what I had found-and empowered them to develop a solution after they understood the root cause.
I raised the lack of standardisation concerning Instructors and Operators using Crew Served Weapons operating from JHC aircraft. The Army Air Corps and Royal Marines Instructors are awarded Skill at Arms qualifications and Field Firing Range qualifications by the Small Arms School Corps as the Tri-Service Defence sponsor in accordance with the Defence Systems Approach to Training (DSAT). The RAF personnel had apparently opted out of this system a number of years ago and were conducting non DSAT compliant 'in-house' training; there were a number of safety issues associated with the 'in-house' training. The JSP 403 Vol III was re-written to reflect best practice and ensure a Safe System of Training was implemented.
Organised lectures explaining the cause and effect of accidents on life, business and morale at the working place.
Safety can be implemented and danger can be mitigated.

Not going flying in contaminated runway situation, even when others were
Making the stabilisation criteria simpler and easier to understand. We were in a situation where less than half the pilots in our company could accurately state the criteria. This led to unnecessary go-arounds (not without risk themselves) and continued unstable approaches. The change reduced both go-arounds and unstable approaches. This is a good example of where over-prescriptive SOPs actually reduce safety.
daily
Over a period of incident investigation and trend monitoring, I identified that ATCOs were providing traffic information that was potentially misleading to pilots. The cause of this was inadequate training over a sustained period which had led to the development of a significant misunderstanding of how to provide accurate traffic information throughout the controller cadre, including the oversight teams and inadequate regulatory material; in this case CAP 413. A safety recommendation was made to the Regulatory authorities to improve the content of CAP 413 and educational materials were distributed throughout the Regulated community.
It starts with experienced leadership, this puts a hand on safety by generating the appropriate culture for it to thrive. Have a look at the various definitions and implementation of "Just Culture". It's about people, not processes or procedures.
This is all about culture. Where personnel who work with or for you believe that whatever is said will be taken 'justly' and not held against them then personnel become much more honest in their view points such that I have been able to change procedures to improve safety. The problem comes when someone, often higher in an organisation or through a legal requirement, insists that information is shared and used for non-safety related purposes. At this point personnel tend not to be open or share their thoughts and beliefs.
Improving team working and practically enabling a just culture.
Filing occurrence reports
Carried out a full review and re wrote the Airside Drivers Training policy at this airport. Many of the things that were implemented then, are now standard practice through the issue of CAP 790.
Safety Management System developed and rolled out across the business successfully. Full Change Management process followed to ensure everyone was aligned to the new process. SMS is an ongoing and constantly evolving process that requires regular oversight.
A simple example would be to introduce an extra safeguard into a procedure. For example in radio comms we introduced the term 'enter' a runway rather than proceed to emphasise the difference between transiting a taxiway and runway in a vehicle.
By ensuring staff are trained to undertake the tasks they encounter on a daily basis. However, there will be some random events which you cannot prepare them!
By proactively involving staff at all levels within your organisation and striving for an open culture where we recognise failures and support open discussion and reporting of concerns or failures of individuals without pushing a blame culture.
For many years in a role for the airside areas of a UK airport, by continually assessing the new regulation, new processes, procedures and theories for improving safety I was keen to introduce new methods to enhance what we do today for a better tomorrow. Using regression analysis it is easier to assess that just ten years ago what we were doing seems very outdated. Introducing new training methods, identifying with issues such as Human Factors, puts some sense behind staid attitudes and ideas that "this is how we have always done it". Changing peoples attitudes and the ethos towards safety improvement however can take years. Such as the UK "just culture".
Increasing awareness of other forms of aviation within Class G users
Taking new technology and procedures and fully integrating them into the current structure.
By 'forcing' colleagues to follow the specific procedure to manage safe outcomes for pilots/ATC rather than reacting to requests and creating much potential for consequential safety events when things go wrong.
Reducing the number of instructions contained in a single transmission to pilots to 5 for experienced local down to 1-2 for a student pilot or English second language pilot.
To a degree. May be more accurate to say that humans make the environment where safety is effective - or not.

gave parachute training to RJAF F-16 pilots
Knocking down icicles hanging down over from an overhang by the doorway
Adaptions of new self made roster during night shifts in agreement with my colleagues
Assisting a civil GA pilot to file an airprox against a mil ac, despite me being accused of 'fowling my own doorstep'. He did, it was Cat A max 150 ft co-alt. I wanted the mil pilot to learn and live rather than cover it up.
By holding management responsible and accountable for "proper" training and not just paying lip service to "process revision" at tool box talks - that is not training. As Chief Engineer for large multinational I insisted that training was formal, measured and included skills, knowledge, competence and currency and consumed at least 5% effort in contracts.
Through experience I requested that further safety work be completed as more failure modes than originally detailed, existed. This was based on experience and training. If the further safety work had not been completed a potentially unsafe design could have been implemented.
Implementing regular Air Safety Meetings in order to share experiences and review occurrence reports.
All the time with my involvement in the SMS
Through my participation in the SMS
by skillfully avoiding the trap of consensus in decision making and applying the required corrective actions regardless of consequence.
Camp bastion despite Afghan Hind crew reporting visual with instrument C5 traffic I took the decision to build in separation to avoid the Hind conflicting on short final with the heavy fixed wing also negated the need for wake turb considerations.
Introduction of a more robust and thorough authorisation process within the unit.
Duty Authoriser process. As DA i have, on occasion, been required to veto or amend sortie timelines/plans IOT achieve (in my opinion) a less risky sortie. This process was not as robust when i first started flying and therefore i have witnessed a procedural (and cultural!) shift in my organisation towards a safer operating environment.
I do not think the statement above implies new regulation can be safely introduced, I think that people will try to find 'work arounds' to the new regulations to make it work for them, that is the endeavour and then passing that on becomes the training. Upon arrival at my previous unit, I looked at the way in which training and tasking was being conducted. The SOPs at the time were unsafe, however the crews operating them were of the belief that they were operating within the rules as published, but this was to the detriment of safety and safe management of fatigue. It took personnel experienced in role to produce new duty rotas and tasking to minimise/mitigate the risks present at that time.
Liaison between Army/Navy air forces by close liaison of sharing information to all aircrew or groundcrew.
the wrong oil was put into a helicopter main bearbox. The investigation revealed that all cans of engine, gear and hydraulic oil were stored in bulk together, whereas the in-use items were safely segregated. no-one had identified this as a potential risk of mixing up the identically coloured and shaped cans. The types were segregated in the bulk store although we have been unable, as yet, to change the colour of the cans to improve identification.
Having arrived in post, I noted that Trails Approaches were being conducted without any set trg (at Unit or JATCC) and with no reference to the procedure in BM documentation (inc BM Force Orders or BM Regs). I ceased provision of the service with the intent to safely reintroduce the procedure with an appropriate trg package, once the procedure had been formally recognised in BM documentation.
Informed a wider audience of a potential sfatey issue, which has raised awareness and reduced the risk of the event happening. Probably.
Especially working with military traffics requires experience.seperating civil a.craft from the military one
carried more fuel than prescribed by the company in challenging weather
However I disagree with the term 'made' - I feel safety can be enhanced or improved. An individual's idea of safety is a function of their perception of risk. The commonly held concept of improving safety within

<p>aviation through standardisation and procedure only works as far as the participants share a similar attitude to risk. A participant more amenable to a higher level of risk will surely be more likely to deviate from prescribed procedures than another member of the group with more conservative attitudes. The introduction and use of checklists has been beneficial to aviation, however I see within my company the deluge of new proscribed procedures for every possibility has resulted in a workforce more likely to disregard them, as they becoming seen as nannying and demeaning</p>
<p>Introducing parallels mandatory routes instead of free tracks in the upper airspace in French Guyana (Cayenne) with no radar coverage over the Atlantic Ocean</p>
<p>Warning pilots of risk of similar callsign confusion</p>
<p>Working at crew planning, on a planning stage we need to validate the best crew pairings possible to reduce costs but keeping the minimum level of crew fatigue</p>
<p>Full engagement with the Air Navigation Services Regulator to develop and strengthen working relationships through information sharing. Activity led to improvement of safety governance, safety documentation (SMS) and safety education at a major International Airport.</p>
<p>proposal and implementation of changes to infrastructure and procedures/documentation</p>
<p>Any time you actively remove a hazard or reduce risk in an aviation area, you're making things safer. Yesterday I picked up a tin can that could have been sucked into an engine. I regularly check badges on the airfield. Consistently monitoring risk is the best we can do to "make" safety happen.</p>
<p>I can provide detailed work instructions to my coworkers in any subject I find tricky and/or troublesome. After research and confirmation by my supervisors of course.</p>
<p>I am a safety regulator and auditor in aviation. My role me identifying deficiencies at airports and promoting safety. We require airports to identify their top risks so that discussions about how best to mitigate them ensue. Whilst procedures can offer scope for safe working, it the humans that undertake those procedures and training/experience are important. So are Human Factors, i.e. the appreciation that the human is fallible.</p>
<p>The ideas come bottom up. The mandate top down. Most aviation efforts have a conscientious focus on safety and every incremental improvement closes another door on compromise. My life has been spent making aviation a safer place.</p>
<p>Standardised checklists and a SOP for go arounds being introduced.</p>
<p>Repetitive teaching of procedures and an inmate teaching of when things are not right. This can be reinforced through diligent and professional instruction.</p>
<p>Introduction of Safety Management System including just culture and safety cultural change</p>
<p>Very little is safe until mitigation is put in place to reduce risk and make the activity safer.</p>
<p>encouraging peer to peer oversight, responsibility for safety. When employees, co-workers, crewmembers are willing to engage peers to contradict negative behavior, a safer environment exists.</p>
<p>Handling hazardous materials.</p>
<p>Safety is a status, not an event. As such, a condition may be made safer or conversely less safe through human endeavour or training (or lack of!). New systems and processes can have a positive (or negative) effect on safety. After an investigation into a 'near miss', I made several recommendations including changes to policy and the adoption of processes and the purchase of communications equipment. The end result was that the event that triggered the investigation was markedly less likely to occur.</p>
<p>Regulations have always been in place, once a DGR 6.2 was unknowingly about to be sent through air shipment without proper container, I came to know and intervened. The problem was with the understanding by the cargo handlers.</p>
<p>Challenging why an event has occurred, to ensure we learn lessons</p>
<p>Carrying out audits which have found issues/failings about which the management were not aware.</p>
<p>Safety can't be made. Things can be made safer but safety can't be guaranteed. I completed an investigation into a runway incident involving ice and 2 landing ac. Recommendations made from the report changed the recovery procedure for formation ac in icy conditions.</p>

Teaching habit patterns for paperwork and final numbers to pilots new to the fleet, thus preventing departures with incorrect data input.
Difficult to argue with Woods, Dekker, Cook, Johannesen and Sarter! By introducing in-flight rest regimes on countless flights. I bring two self-inflating mattresses which supplement the non-existence bunk on the C17. This allows personnel to get improved sleep during the cruise. Sleep is the only true mitigation to tiredness and we are going to be buying replacement bunks in line with the recommendation from [name redacted] Fatigue Thesis 2012.
Before, on the job trainees wanting to obtain a facility rating have to work a minimum of 6 hours, be it day, evening or midnight shift. With this work load, they were prone to errors because of tiredness or lack of sleep. Now, when the work hours were reduced to 4 hours minimum, they were more focused and less prone to commit error in control work and had less or zero operational hazard reports
Passed along good techniques to other pilots at my airline.
I have written a full SMS/FS program for my aviation employer in attempts to introduce a safety culture in our organization. Despite the owner's resistance to change ("we have done things this way for 15 years, so I don't want to spend time on training for these guys when they didn't need it in the past..."), I see a significant change (dispatchers, baggage loaders, pilots) towards adherence to basic safety principles that were previously ignored due to cultural ignorance and / or resistance to change (via introduction from an out-group (i.e. western culture).
After observing aircraft maintenance being conducted without any fall protection, I connected the a/c maintenance supervisor with a facilities manager who was in charge of cherry pickers, fork lifts, etc. that were being stored out in the rain. The result was a cost-free mutually beneficial relationship btwn the two departments...one for safe maintenance aloft and one for indoor storage in the hangar.
As a leader highlight my own failings/human error in driving on the airfield and being distracted
Apart from the day job which involves writing safety standards and is difficult to quantify in terms of safety improvement, during day to day operations at the airport I have often spoken to people about unsafe acts such as not wearing correct PPE reversing without banks person, children riding on passenger baggage trolleys. These small examples prove to me that individuals can make safety even though it is not possible to know what incidents have been avoided as a result.
Safety cannot be "made" in my opinion. It can, however, be positively influenced or improved. I just don't accept the term "made".
Where a group of controllers felt comfortable with a particular procedure, due to unit culture and 'group think', and I have highlighted the heightened risk without a commensurate efficiency or other gain.
highlighting a safety issue with traffic converging over a particular VOR therefore I establish an arc approach and redirect flight to a holding pattern
Controller safety net - selected level - correcting pilot error before separation is lost
The consistent use of checklists
By actively issuing a track to fly to an aircraft that was directly heading towards controlled airspace, even though that aircraft should have been on its own navigation.
I refused to be rushed to taxi for takeoff, or depart when bad weather was enroute when a short delay would avoid it. I always did one last quick final walk around after loading my cargo. I saw other pilots taxi with the tail stand still on, leave cargo doors open, takeoff with a ladder still attached to the aircraft, and start an aircraft with the prop strap still on...etc.
Take preflight more seriously - perform inspection looking for a reason not to fly, if none found, then go. When planning a cross-country flight, pre-plan alternate routes and landing points to accommodate weather changes.
Listening to experience of the employees with system experience, in their own particular fields, can be more effective in eliminating accidents and provide safe aviation, especially in new airplanes with extensive application of digital technology. Cause of accidents related to digital technology will not be obvious, and will vary across a broad range of possibilities, and most of the time cause of accidents will be more driven by politics. Also, the trend of using production programmers, without understanding the technical details of the whole system in writing software, may diffuse liability, ownership, and reverse the trend of safe aviation.
Introduction of an improved Air Safety incident reporting tool.

<p>Through training, mentoring and discussion. The important of discussion cannot be underestimated as we may all read the same document but interpret in different ways.</p>
<p>Equipment in the Tower Cab was partially obstructing the view parts of one of the runways. Requested management have the technicians move this equipment to another area in the Tower.</p>
<p>Safety training - raising awareness and insight to operations personnel</p>
<p>Following the specified rules and regulations</p>
<p>Introducing a more communicative medium of risk presentation, achieving wider engagement and understanding at both risk holding and risk facing levels.</p>
<p>Thinking about safety and practicing safety are not only about regulations, but also about mindset and culture. As a flight instructor it is important to instill a positive safety culture in a student. Making go/no-go decisions when weather is marginal can be difficult when there are completion deadlines, but making the no-go decision and then examining why that decision is the best one to be made can prepare others to feel comfortable to make similar decisions in the future.</p>
<p>Safety is a cultural phenomena. It must start from the top and work its way down. A manager who preaches safety but does not practice what they preach instills a belief that safety is just a mouth piece to reduce insurance cost. As a result employees are more willing to take "short cuts" to get a job done, increasing their possibility of injury. I would not condone these short cuts. A safety policy is a policy that must be followed. When the policy effects the out put i would talk it over with my personnel asking for input on methods to modify the safety policy to help maintain productivity while also reducing the risk that the policy was designed to alleviate. I would then take these suggestions to the primary safety council notifying them of the hardship caused by the policy to see if any of the suggestion would work while still elevating productivity and safety. When your employees see you taking an active part in safety and they are proved the opportunity to develop safety procedures they take ownership in these procedures and try that much harder to ensure they are followed and are successful.</p>
<p>Identifying weaknesses within an operation and making changes,</p>
<p>Pilots develop personal techniques to remind themselves to do something. While running an abnormal procedure, I put a sticky note on a switch that is not supposed to be touched in this particular case.</p>
<p>In general as my role of Assistant Flight safety Officer enforcing standards.</p>
<p>leak in hangar roof during heavy rain. aircraft working bay relocated and work stopped if leak became heavy/persistent</p>
<p>Only after a clear understanding of the root cause and corrective action developed and implemented that deals with the root cause. The example given in the previous question is a good example of that.</p>
<p>I developed a new airway that greatly simplified a clearance regularly issued to aircraft.</p>
<p>Holding ground when faced with peer resistance.</p>
<p>Audit of preventative measures from past incidents, with gap findings, analysis and elimination.</p>
<p>During my career as an air traffic controller and traffic management specialist, I have developed routes and procedures that keep aircraft clear of know weather hazards.</p>
<p>Introduction of an Airfield static database and procedures for its management, supervision, security and verification.</p>
<p>Changes to Squadron Orders to ensure personnel returning from operations and leave receive refresher training before commencing flying at 'home' base, and mandating limitations on self-authorisation of flights by those individuals whilst refamiliarising with the UK environment.</p>
<p>Implementation of new handing over procedures between controllers to ensure ALL aspects of situational awareness are covered. We created an enforceable checklist.</p>
<p>... by making changes to the pilot training programs based on feed back; among other from individual reports (QR), FDM trends, FFS gradings etc</p>
<p>Any organization is an amalgamation of people, equipment and procedures; these three are inter-related and compliment each other. Any Gap therein can be a potential recipe for an event. Human action can merely reduce the possibilities of such occurrences.</p>
<p>On one occasion, tightening of some plating on stairs reduced the chance of a slip or trip.</p>

We added an airspace diagram at each control position in our Rapcon
There are numerous safety initiatives that have come about as a result human efforts. One of my contributions was to work with our local authorities to develop a method of using the vertical navigation function of the newer flight management systems that compute a vertical navigation (VNAV) path when conducting non-precision approaches. This was first introduced in the United States in late 1998.
I have been an auditor at various times in my career. identifying non-compliance and poor practice and then influencing the subject organisation to take corrective actions to eliminate the root cause always improves safety.
As I was only Joe Employee I was on the receiving end of changes made to make things safer, these usually resulted in slowing traffic down and increasing space/time intervals.
Preventing Rwy incursions using non standard icao phraseology on a tricky holding point
I agree partially. Regulations are necessary, but non sufficient, and only install a "compliance" oriented safact management? What we need to add to regulations is a "performance" driven safety management
When you are absolutely focused on your job you have a lot of times the opportunity to safe things and situations. I did it myself at least two times in my professional life taking the control (microphone) from others in order to fix dramatic situations.
Changing procedures on an airfield where the RW ac did not have to call taxying back from a specific point that required them to cross a link road. It relied on controllers lookout to remember to put the lights to red to stop any traffic.
Implementing ISBAO SMS program within our flight department.
Implementation of a higher stringent Helicopter separation standard from fixed wing commercial air carriers to reduce TCAS RA events leading to pilot correction in a highly congested airspace.
Developed industry-based training to help educate personnel so they understand the rules, regulations and their contribution
Totally agree
This is not an example but to clarify my answer, yes I think safety can be made due to individual or team effort and this happens daily in ATC. I would caution that if safety comes at a cost to an organisation then it may not be made as safe as it could be, or as the individuals may want.
Flight crew licencing regulations and Part 142 exposition training.
Reporting on air traffic incidents where I believe safety could have been compromised further than actually was.
It is often very difficult to categorically link cause and effect due to the number and complexity of causal factors (i.e. establish whether individual changes to a system have been the only cause of improvement to safety performance). However during my career there have been many examples where new hazards and new controls have been identified, and the measured safety performance (and proxy indicators) have then shown positive improvements.
There have been times where a simple change in procedures have created a safer environment. We have been tasked with doing Activity Hazard Analysis Reports for our everyday functions, one which is typical office work. An example is minor task of prolonged sitting. You risk thrombosis and fatigue without giving it a second thought. Risk mitigation includes periodic breaks, stretching, and maintaining proper posture while seated.
As am member of the [name redacted] Systems Safety and [name redacted] Assurance Team, made considerable safety improvements after the [name redacted] accident.
I, as safety manager of a helicopter company developed checklists, do not forget important things, during different aviation operations
Assisted in the development of trend monitoring to identify potential failure of gas turbine stator module on a military aircraft, while the oem developed a permanent solution through a re-design of the module
Endorsement of system safety cases (safety assurance).
nothing special personally helped disabled woman once or twice

In a tactical sense when controlling aircraft in times of weather deviation and adapting to the situation and ensuring safety despite the route structure barriers being eroded.
By highlighting an issue that had been noticed with a radar feed and proposing an increased separation requirement to remove the risk associated with it. This was introduced by management before any significant issues occurred.
created a risk register
Introduction of a formal endorsement, examination and assurance process for air traffic controllers in the Middle East
Implementation of an SMS at 2 organisations.
By stamping out unsafe practices on the shop floor. "We've always done things this way" doesn't was with me, I simply refuse to let people work in an unsafe manner.
Following a ground handling incident with a Tornado F3, I intervened and stopped the team trying to recover the aircraft with the same haste that had led to the event in the first place.
When a new requirement for an ATC controller to actively respond to an alert message instead of passively
During operational training, I expressed the opinion that a specific weapon's check procedure was error prone. The procedure was ultimately changed, thus averting the possibility of a serious ground personnel injury in case of an electrical malfunction during weapons checks.
Ensuring the continuous oversight of the SMS and have process put in place
procedural and standards development,introduction of the concepts and then enforcement.
Facilitating operating review for experimental unmanned air system prior to deployment to theatre which resulted in a change to SOPs to make 'loss of control' on take-off a safer outcome.
A change of attitude of management - possibly through a change of personalities. I've seen 'old and bold' management who would be quick to judge and punish without investigating issues. This will then prevent further reporting of instances.
Introduction of policy to better understand the impact of fatigue and to better manage the risk.
In the regulatory context, I have worked very closely with the regulated community in the interpretation and application of brand new regulations (Class I(b) RPAS). By ensuring a potentially belligerent community of operators understand why and how we are trying to regulate their activity to make it safer, they are more likely to be fully engaged and become advocates of safe practice in an area which is very difficult to regulate/police both from a military and civilian perspective.
Introducing a regulation that allows 2nd and 3rd party organisations to assure aerodormes: RA 1026
Through have identified potential system configurations which, if allowed to 'Safety' is a relative term. Without the safety professional, the socio-technical system will be less safe than with the human present. Humans represent the most effective and Omni-present error trap.
I always fill in claims to management when an unregulated/unusual event appears. In this way we can disseminate information through the company/industry. Sometimes this claims are transformed into safety notifications or regulation for everyone concerned.
Introduced steps to alter inherently unsafe procedures in air traffic e.g. Conflicting SIDs
My involvement in the implementation of PBN has, I believe, contributed to a safer airspace in New Zealand as it has created a more predictable, regulated set of procedures that simplify ATC.
I wrote the world's first Safety Case for aviation.
Refusing to put a passenger on a flight when mechanical safety of an aircraft may be compromised. Same also in decision- making to recommend flight or withhold authorization to fly whenever circumstances beyond our control are affected by adverse weather conditions.
any time an individual files an ASAP report
I was part of the team that introduced MAA certification regulations

TO A DEGREE - SAFETY CULTURE CAN TAKE YEARS TO CHANGE
I pioneered the introduction of Safety Management Systems for aviation for Australia's Civil Aviation Safety Authority.
Provided better working routines and safeguards to limit the possibility of fatigue leading to errors.
Introduction of a new procedure to avoid 'accepted work-arounds'
Introducing a new Sqn and new capability to deliver MEDEVAC in [name redacted]. We took over the role from a different Sqn and type (independent unit) and found their supervisory chain, risk assessment processes, fuel management, shift patterns, stores accounting and flight procedures woeful. In country and in contact the Sqn turned the capability around in short order redesigning process, re writing flying orders, ensuring log and fuel issues were JSP and HSE compliant etc. Then invited 1 PA and 2PA teams from [name redacted] to inspect the capability to ensure it was safe and met the required regs.
Through audit and the follow up of post-audit corrective actions to a successful conclusion.
Spear headed the project to put fall protection in the hangar.
Detailed pilot briefings, preflight, in-flight, and post-flight.
Introduced new SOP's in the [name redacted] company I was flying for in 2012.
There is a problem with this in that introducing safety initiatives when a potential problem has been identified but no incident has occurred is subject to push back from those holding the purse strings. Without legislation or regulation driving safety initiatives forward is an up hill task.
Leading my team through a change process that created new working practices and associated instructions that removed unsafe behaviours.
You've only offered a binary yes/no choice. :(I think human activity can make things safer, but not eliminate all risks. I make things safer every time I fly by carefully checking the taxiway near my hangar for foreign object debris (FOD) that could damage my tires or propeller.
Reduced emphasis on assigning cause and gave emphasis to identifying and analysing risks - associated with design, manufacture, operation with sub components such as training and weather.
A change of ATC procedures at my unit.
A decision to not conduct a flight. A decision to not return an aircraft to service with a known fault. A decision to eliminate a system thought to help prevent engine failures, that was actually leading to accidents of other types.
After the mid-air crash at Oberlingen, a colleague and I successfully lobbied the European Parliament to have an EASA Regulations changed that would compel pilots to act on TCAS warnings rather than await ATC input.
Operational experience helped my numerous times in risk assessment and risk management
Process redesign - for example the replacement of bumpers on the belt loaders with the new d Bumper
I say no because the authors you quote say that the "operators" improvise to make the system safe. It is the procedures and the culture that affects decisions that make the system safe. Safety must be the result of the organization. all accidents are failures of the organizations said Jerome Lederer.
I work within the Flight Operations Quality Assurance team. I review all flights our 121 carrier performs and I send out problem flights to be contacted. Through reviewing what has been done wrong I aide our training department in creating scenarios to prevent those unsafe acts for being done again.
As a flight instructor by instilling a sense of safety culture within the students I taught to fly.
To a degree but not absolute safety. Humans are limited in there ability to arrive to work ready and focused stay focused. Technology, automation and regulation have achieved as much or more than human disciplines such as CRM & SMS.
I'm a firm believer that 'People create Safety'. Having everyone across the organization understand how they play a part in the safety of the operation and in everything we do is hugely inspiring, engaging and helps to reduce or even close down many barriers.
Reporting safety issues beyond those issues required by regulation

By regularly carrying out hazard analysis against new & existing procedures and introducing new or additional mitigations against identified risks

Q2b - 3. Please provide an example of a company initiative that was aimed at the total eradication of human error:

FAA use of time based metering is an initial attempt to take the human out of ATC
Many initiatives have been introduced throughout my career, however none of these have aimed, nor achieved total eradication of human error. I think this is a futile aim, we can aim to reduce errors to a low or even acceptable degree, however I feel total eradication is not possible.
Safety is incremental. The operational environment is dynamic and constantly changing so I believe the question is slightly flawed in the concept of a single action suddenly or totally making the activity 'safer'. Every action introduced should make the aviation activity safer and it must also consider any unintended consequences (correctly applied change management process within a SMS). Getting safer is a constant awareness of the environment and adapting to the threats around you.
Of course the system should do all it can to reduce the incidence of human error, but (unfortunately) some errors will still be made.
unmanned flights
using more automation to reduce human intervention but the system totally not understanding average situations
Introduction of FDM
Identification of latent risks within the national ANSP - trying to look beyond what may have been reported through MOR, to include external factors which may impact upon human behaviour and therefore risk.
a controller as human beings make error every day
No idea - has there ever been one?
I know of no such initiative as humans are normally always involved. Even a company initiative to eradicate human error involves humans.
Gross generalization - but the ever increasing levels of automation on Airbus aircraft, including unnecessary automation of military equipment. E.g. The 'automated flying boom'.
In the U.S., in the 80's-00's, the ATC mental model was "the system is perfect-we have perfect airplanes with minimum equipment lists, we have perfect procedures and phraseology, we have perfect training and operational checklists, we have perfect automation. Wait-you messed up? You are the broken piece of the system. Here-take this training to remind you of how it's supposed to work. Done? Great-now that we have fixed you-the system has been returned to perfection". Problem 1) employee already knew the requirement and did not need to be reminded 2) the employee's buddy might make the same mistake tomorrow-they don't see the potential in the system for error and still believe everything, including themselves, is perfect. 3) it develops a blame culture "that guy sucks-I'm sure glad I don't have to worry about that. That approach essentially means the only improvement happens as employees experience their own errors first-hand and no one designs an "error trap" or fixes the weak process.
Loose items such as pens/pen lids were being left in the aircraft - all personnel are now to check before & after each flight that all pens & pen lids are accounted for.
Impossible to realise, you can never underestimate the MK 1 human being, doing something instinctively or a knee-jerk reaction to a situation in the belief they were 'doing the right thing'.
But we can minimise it.
TCAS RA SOPs
Humans are involved with every aspect of aviation - even a computer has to be programmed by a human. You can't remove human error.
In around 2003/2004, [name redacted] introduced their [name redacted] programme where they stated that within 10 years, [name redacted] controllers would not be involved as a causal factor in any accident or incident with a severity rating of 1 or 2 ([name redacted] internal scoring system at the time). The programme was not well received by the work force as it was considered unrealistic. Whilst this objective was quietly dropped, I don't believe that, in terms of what was delivered, it actually worked to eradicate

human error. [name redacted] simply worked to introduce safety nets to mitigate the effects of human error and reduced the scope of their operations to constrain the types of activities that were prone to error.
There hasn't been one. Even automation relies on a human to programme it and install hardware etc. Remember what happened when Airbus first introduced computerised flight law into the A320 and pilots were left to wonder what the aircraft automatics were doing? It probably helped to avoid avoidable accidents such as the alpha floor system, but it has also likely resulted in new types of accident as a by-product of the technology (and human understanding of it) becoming mature.
As we recognise that with a human in the chain, errors cannot be eradicated, I cannot give you such an example. We have to recognise that humans make errors but at the same time strive for continuous improvement. Whilst aviation operations without humans could be safer, once equipment fails then we need to human to resolve the situation.
None - reduction but not total eradication
The introduction of electronic surveillance for security purposes
I cannot think of one specifically aimed at removing human error. Arguably every procedure/process, if followed to the letter, should be successful (Provided that all parameters have been considered).
The introduction of Instrumented Runway Visual Range (IRVR) - before then Human Observer Runway Visual Range (HRVR) was used to calculate the runway visual range at our airport.
Automation of emergency alerting system to ensure all parties receive an identical / consistent message rather than numerous radio or telephone calls placing stress onto an individual.
Safety in aviation is delivered through people, processes and technology, either of these could become a weak link in safety system (for many reasons). It is possible to insert a number of protective barriers where the human is the last barrier for many aviation activities, but not to eliminate the human. Even an automated air traffic management system, which is wholly automated needs human interaction, even to make a software update, and this does not always occur smoothly without some technical problem.
Solent Buffer Zone to stop Solent CAS infringements
[name redacted] has a target of NO loss of separation incidents. A pipe dream.
[name redacted], standard phraseology program. Resulted in a huge reduction in safety related events. ATCs were encouraged to challenge incorrect radio responses.
Aviation Security vehicles are no longer permitted to cross a runway, they have to take the airfield perimeter road and only enter taxiways when absolutely necessary ie; escort of NORDO aircraft under tow.
Any Airbus flight control software.
Alarms on a radar scope that alert when aircraft are within a certain range but have not yet busted IFR separation
None. Au contraire! My company is the source of errors now!
ETote 2-man check for barometric pressures - foolproof, until the met man got it wrong!
Impossible crusade - resilient design allows for human error and ensures systems fail "gracefully" and not catastrophically.
Automation
You will never fully eradicate human error - we are human after all and we learn by our and others mistakes.
"total"?? The introduction of the MAA and DAEMS are clearly paradigm shifts in how the Def Avn community works but I believe we have correctly recognised that you cannot totally removed human error as long as you have humans in the operational framework
Skynet! Risk Management which translates to being Risk Averse - 'If I don't do anything, then I can't do anything wrong'. I have witnessed this mentality in my previous employment (civil aviation) and more so in the military since the advent of the MAA.
Health and Safety 3 points of contact rule for lorry drivers.

<p>Conversly, I can give you an exampe of things going the other way. My compnay is currently changing operating procededures and philosophy towards the manufacturers default. This has opened up areas for errors that had previously been identified and mitigated against. Although this has been raised by many in the workforce, the company line is simply that this is being done for standardisation, get on with it. Although not aversed to change I feel decades of development is being disreagrdded for the convenience of corporate ideals.</p>
<p>Electronic Level Revision</p>
<p>Total - no such beast. The brain is the most intelligent organ in the human body - said the brain.</p>
<p>[name redacted] 'Zero Harm' initiative.</p>
<p>The drive for automation is to gain efficiencies, cost savings and to remove human error. Modern airliners flight management systems have a high degree of automation. Regarding: Do you believe that aviation operations are intrinsically safe until the point a human becomes involved? - This question does not make sense, because I do not know of any aviation operation that doesn't have a human in the loop.</p>
<p>From the first question above, do you think that there is at least one aviation operation which do not request human involvement ? Those operation are defined and set up by and for humans..all the time</p>
<p>Safety Audits were introduced to benchmark aviation safety and try and eliminate the possibility of human error through standardisation. Human Error got in the way.</p>
<p>Introduction of SMS does not attempt to eradicate human error - but recognises it and works to limit undesirable outcomes</p>
<p>Grounding aircraft fleet after an incident</p>
<p>No such thing as total eradication of human error, short of full and pure artificial intelligence (AI), which is hypothetical at this point. Even a system that appears to be completely autonomous was most likely designed, coded by a human. Even, in all current cases, an AI system.</p>
<p>Fitting of Instrumetn Landing systems and Auto Lnad systems to fixed wing aircraft.</p>
<p>This is too lofty an aim - I have never heard of any initiative with such an aim.</p>
<p>Aviation relies on human machine interface so there is no oppportunity within my company to totally eradicate human error. Human error is accepted and culture encouraged to question and report issues to better combat human error within workplace.</p>
<p>My company doesn't believe error can ever be eradicated, thus we must manage, check and cross check to eleminate that which inevitably slips in.</p>
<p>Any aim to eradicate Human Error is flawed.</p>
<p>Every SMS program is aimed at identifying risk areas and putting in place practices designed to mitigate these risks to a point where they are acceptable (a subjective distinction, mind you - how many incidents or accidents are acceptable before a company loses its AOC?). Aviation is necessarily dependent upon human interaction, therefore, we shall always have a degree of risk as humans are not perfect. Until machines become self aware and can produce aircraft and fly them without any human interaction, there will always be a degree of human error. Aviation is an industry where profits drive production and efficiency - it is purely reactionary. Only when there are incidents or accidents that cause loss of profits will regulations be implemented to force companies to improve their safety practices. This is the double-edged sword of the industry. Push the safety limits until someone dies, and only then, under the risk of litigation or loss of consumer confidence (i.e. profit loss), will things change towards a more robust safety culture. The values of human lives, sadly, always comes second to profit.</p>
<p>A misplaced training program that focused on human error as opposed to fixing the deficiency in the system.</p>
<p>The introduction of computerised baggage systems has removed much of the human interaction and therefore human error in those parts. There are several initiatives at the moment which include autonomous vehicles, on tracks and otherwise, these will clearly remove the effects of human error if there is no human driver.</p>
<p>You cannot erradicate error. No system is perfect. After all, something as fundamental as walking is really only a series of corrected tiny errors</p>
<p>automation with the use of AIDC</p>

Replacing transposition error by directly displaying data
Driverless automobiles
We carry out day to day observations on unit. This highlights the good and defensive controlling that controllers carry out rather than focusing on mistakes.
Crew resource management
Driverless cars
The only way to reduce human error from the work place is through having the right people working in the right place that matches their skills, knowledge, and experience. Relying on training and automation, will eventually lead to big-bang hazards, that can be too late to fix.
Utilization of "memory joggers".
The only way you can remove human error is to remove the human. Automation within the industry is not at a stage for that to happen yet
Unmanned aviation is, at a basic level, a move towards transferring some of the risks involved in aviation away from the 1st party / pilot / operator. However, I believe that there is always an aspect of human error in every system: design, manufacture, programming, management, direct operation etc. As such, whilst the "point of error" may move across the system with changes in technology, it can never be eradicated entirely.
I am not sure there is a single initiative that will totally eliminate human error. I believe there is always an expectation of some error, but initiatives may implement a system of checks and re-checks to catch errors timely and appropriately. Artificial Intelligence may be the closest thing to an initiative that is aimed at the total eradication of human error, but there is a long way to go before human pilots are completely removed from the aircraft and AI makes decisions.
Using robots in the workplace; yet, this still has the possibility of producing error through human contact in the design, programming and manufacturing of the robot itself.
allowing computers replace controllers
The development of detailed guidance was developed and used by all personnel to lower the rate of HF issues. The focus however was changing the working and operational conditions to lower the scenarios that can lead to human error.
Having all controllers require pilots to squawk ident on initial contact.
dual signature and quality control for all maintenance processes, regardless of the routine or simple nature of them.
FAA Safety Management System
Operations manuals and operational orders are all designed to eradicate human error. Likewise periodical refresher training for staff. These preventative measures are designed to reduce risk to an acceptable level, but it is impossible to totally eradicate all risk and errors.
EHUs - a computer system to manage maintenance of aircraft in place of paper documentation - it did not work because of errors in component lifing data for components that had previously been used, ie data integrity.
Classic case of accident at Dubai airport due to Autopilot. Air Crash at Zagreb due to ACAS.
Using computer equipment in lieu of manual coordination, ex: FAAO JO 7110.65 para 2-2-6
I'm sure that efforts have been made through training and procedure development, but I think it's an oversimplification to address this as the "total eradication of human error." I think it's more appropriate to state this as the aim being to minimize as much as possible the eradication of human error.
As we were a smaller facility the Manager elected to remove "line up and wait" procedures which help traffic flow at times. this kept us humans out of the process to expedite traffic flow.
The introduction of driverless trains on the Docklands Light Railway in London, UK.
Installing sensors at holding point to warn about Rwy inc.

Human error avoidance can be "optimized" through appropriate strategies, like : 1) make the system as "resistant" as possible to error (i.e. make it impossible to commit this particular error) ; 2) make the system as "tolerant" as possible to error (i.e. although the error might be committed, it is not likely going to result into harm) ; 3° Make the system "conspicuous" to errors (i.e allow errors to become as much as possible "visible", by promoting the reporting and the ongoing monitoring in a blameless "just culture" environment that must be properly installed and maintained by management in it's corporat safety culture and policy.
Seminars and documents.
Punitive action in response to errors.
Seriously.. We removed a particular ATCO from having the ability to train students.
There has not been one
There is a current drive toward removal of the human in ATC worldwide. Advances in RNAV type procedures for arrival and departure, tools which predict en-route conflicts well in advance and suggest resolutions. All of these things are aimed at eradication no human error. Unfortunately computers crash from time to time and to date there is not a computer that could make the moral decisions a human would take in an emergency situation.
Everything that I know (and apply) about human error is based on the premise that the human is fallible. I believe that human error can be reduced but never eradicated. On a practical level, I have investigated incidents where human error was a causal factor and I have found that a common area is poor Human Factors assessments at the design stage (allowing poor HMI design to be implemented).
Car manufacturers implementing the use of robotic technology to do the jobs that were once done by manual labor.
Nasa initiated a "paperless" launch procedure system using "Windchill" for the Ares 1-X launch on the Constellation program.
In my point of view, the "total eradication of human error" is not possible presently, but to reduce it, it is possible with training, with more attention to humans, with procedures, with technology, with clear and acceptable regulations e.t.c. We try to use all of the above mentioned mitigation procedure.
RN Flight Safety
Not possible to eradicate human error (even if remove human a human designed the system)
watch sickness of employees - mental or otherwise
We have not done this to completely eradicate human error, however, we have carried out Team Resource Management in an attempt to increase awareness of human error and improve threat and error management and thereby reducing the likelihood of introducing human error.
auto METARs
[name redacted] - Target Zero
As stated, it's just not possible to totally eradicate errors but by applying the kinds of 'continuous improvement' programs found in manufacturing to the analysis of errors, their frequency can be significantly reduced.
I cannot think of one. Any process, however automated has a human being in the design process somewhere. No system can be 100% safe
Issuing of prescriptive orders/regulations/directives across all aspects of business.
Cannot provide one, given HF receives such priority within aviation it would suggest there is an acknowledgement that HF will always have an impact on ops
Weather conditions are out of the human factor field of management. There are some procedures but finally there is part chance, part skill.
The introduction of Electronic Flight Strips (EFS) was certainly aimed at removing human input/error by generating EFS automatically from Flight Plans.
The company will abide by all recommendations from pilots/maintenance control regarding safety of flight with a specific aircraft. This also affects our company mission regarding absolute safety of our passengers.

A drug and alcohol policy (program) is a good first start; however, if it is not policed and regularly employed (demonstrated to be effective) than it is useless.
Introduction of a Safety Management System.
Not in aviation, but in other industries, the use of bar codes have been introduced to remove mistyping errors. This however may inadvertently highlight other types of human errors.
[name redacted] elimination of unstable approaches without go-around
NUMBER OF DAYS SAFE ON CONSTRUCTION SITES
It is impossible to remove human error from the workplace without removing humans. Even when using robots to conduct work they are programmed by humans. There will always be a human influence at some stage, even if removed from the "front line".
Skynet - Terminator
No company I can think of strives to totally eradicate human error. Most provide some form of HF/SMS training to increase employee awareness, CRM for flight crew is a typically good example. Also through the risk management process involved with companies SMS, new initiatives will be implemented to capture as many of these errors as possible, such as new SOP's, FRMS, training, company communication's etc.
Total eradication of human error is probably unrealistic however my Company undertook regular CRM training and a programme of human factors training focused on the 'Dirty Dozen' in the hopes of educating and informing.
The introduction of the Quality Management System
Implementation of a checklist for operations. But a checklist can miss items, be unclear, be misinterpreted, or otherwise have issues which means that in no way does implementing a checklist eradicate all sources of error.
It cannot be done. It can be reduced and managed.
Because of several CFIT accidents, in 1985 a letter went to all staff requiring the reporting of intentional unapproved IMC. For more than 30 years, there have not been any CFIT accidents. BUT, for several years following, several loss of control or other fatal accidents occurred.
The daft statement made by the USA administration a few year ago, namely, words to the effect that 'we have a zero accident' policy. Humans make mistakes and always will. We need to learn from events to stop events becoming incidents and incidents becoming accidents. We improve our regulations and procedures to help avoid future accidents but as air transport becomes safer fewer and fewer pilots have been associated with major accidents eg their company has experience an accident. No-one is taught 'safety lore' so more pilots are unable to recognise that they might be entering a similar situation in which a catastrophe occurred years previously. We need course modules on safety lore.
We are working with NASA Ames to explore ways to integrate human factors, technology and information to reduce human error.
The who history of System Safety is that organizations have to have procedures with controls that will catch and correct human error. Not human improvising to make a system work.
Boeing has tried numerous initiatives to reduce accidents in their manufacturing plants including aiming for zero workplace accidents as a viable goal.
This is a bogus request. Safety is perishable and can not be banked. Absolute safety is possible on a temporary basis or for short deliberate periods of time. Such as when a crew is focused on a demanding phase of flight such as approach and departure.
Human error can not be prevented unless the human is removed from the loop, but even then the human designer could have made an error. Error tolerant systems which highlight non conformance and designing to help the human be less likely to make an error are the way forward.
In ATC I don't think we have gone for a "total eradication" but work on the basis of tolerable risk

Q2c - 2. Please give an example of this:

Independent inspections
In one or two examples I can think of - Flaps were not set for Take-Off and although the barriers such as the Before-Taxi Procedure and Before Take-Off Checklist did not capture the omission, the Take-Off Configuration Warning did.
Vehicle runway incursion stopped from becoming a more serious incident through ATCO action and aircraft go-around
The presence of a safety back up team when carrying out hot fire training prevented a serious incident developing. The initial team experienced a failure of its firefighting hose which would have left them exposed to a fire situation without any protection, the safety team dealt with the fire and escorted the team from the risk area.
Fail to monitor the altitude, the aircraft hardware warning alert us
This is a daily event. Every TCAS RA or GPWS alert is an example of a final barrier or control activating after all the previous barriers did not function correctly. A light aircraft pilot finding a small amount of water in the gasoline during the morning preflight is a case. A well designed safety system will have multiple redundant barriers of different strengths to catch hazards. If there is only one barrier - the system is fatally flawed as there is no redundancy.
anytime an air traffic controller makes (or is going to make) a mistake and the other members of the "safety-chain" warn him(her) about the error (colleagues, pilots, automatic warning tool, third party...).
many examples with Reason swiss cheese
Distraction from task followed by automated system warning
non-conformance to procedure in ATC leading to potential incidents, prevented from developing by tools such as short term conflict alert or TCAS.
double check by supervisor or assist of controller
When an aircraft was on final to land it called gear down at the appropriate time. The visual inspection by the controller confirmed the landing gear was not down and re-confirmed with the pilot, after clarification the landing gear was cycled. Post investigation it was determined the aircrew had called the landing gear down but had not yet deployed the gear due to the workload within the cockpit.
i have seen examples of when flight and duty limits were breached, but safe operations were maintained due to a combination of factors including the level of training of the crew and increased vigilance from other crew
Mid air collision avoidance, lookout degraded but TAS detected the contact
Runway Incursion by Pilot. ATCO witnessed the incursion informed aircraft to stop. Error by pilot. Second barrier ATCO stopped an incident.
1) Supervisors making an on the spot correction. 2) TCAS saving a situation where a controller had missed it. 3) controller making a "gear save" and telling a pilot their landing gear was not down
The Authorisation process has multiple layers; a crew were due to go flying however when the Authoriser checked that all the crew were in date, one of the crew flagged up as being uncurrent a Standards check ride, therefore the flight was cancelled.
Someone undertaking a pre-flight check before handing over to the pilot, who then checked around the aircraft and found a safety pin that should have been removed beforehand.
By the other pilot. Pushing the wrong button, not activating the approach, using speed brake at the wrong time. Pilot monitoring picks this up.
Instabilities approach continued beyond 1000' criteria, but CRM intervention and subsequent go around
This happens all the time. For example, ATC trying to expedite arrivals and space aircraft at exactly 5 miles without the appreciation of different approach speeds. The crew are the barrier who can intervene to prevent a loss of wake separation.

<p>I cannot recall a specific incident but I am aware from my time as an ATC supervisor, instructor and examiner that there have been occasions where another controller has made a human error and that I or another individual stepped in to correct the error. One of the key differences between military and civil ATC service provision is the existence of an 'operational' supervisor in the former. One of the military's weaknesses is a lack of recognition of the effects of removing this mitigation by the involvement of the supervisor in purely administrative duties, or the removal of a dedicated supervisor outside 'core' hours.</p>
<p>Methods of preventing runway incursion by designing multiple barriers and reducing potential human factors. Air Traffic Control has many examples, such as the levels of technology and processes to prevent an mid air collision; including of course, systems on board aircraft to build in even more controls. Even that can fail, as it did in Germany several years ago.</p>
<p>Aircraft was given taxi clearance towards a runway and it continued through a Stopbar that had failed and was not noticed. The ability for ATC to use lights from the tower prevented the aircraft from continuing.</p>
<p>Pilot forgot to lower undercarriage - ATC spotted this and instructed a go around</p>
<p>Automated Aircraft parking aids. and the reintroduction of the Marshaller when they fail</p>
<p>I was driving a vehicle on the airfield and requested and was given permission by ATC to enter a runway. At that point I noticed an aircraft on short finals, I advised ATC that I would hold position.</p>
<p>A vehicle breaking the speed limit didn't stop and give-way to an aircraft pushing back. The pushback team spotted the speeding vehicle and halted the pushback.</p>
<p>Runway incursion, clearance to enter a Runway was granted by ATC but red stop bar lights prevented actual incursion and reduce likely impact from severe to near miss.</p>
<p>A runway incursion facilitated by two key and well trained people. The barriers were the training, experience, high standard procedures and a to an extent technology in place to prevent a vehicle entering a runway with an aircraft due to land. All of those barriers broke down because an instruction was misinterpreted. Even on replay of the recording it could have been misconstrued. A vehicle entered a vacant runway with no aircraft due but was still a serious safety breach. A detailed investigation followed and eradicated the format of the instruction. The incident occurred, a serious breach was prevented, the last barrier process was amended to prevent a reoccurrence.</p>
<p>A hang glider pilot prevented from taking off without having hooked in to their glider</p>
<p>ATC teamwork, second controller picks up the error before a loss of separation occurs</p>
<p>Aircraft on finals making an approach with their wheels up - picked up by the Tower controlling doing an active scan on the landing aircraft.</p>
<p>Aircraft cleared at a level that was different to flight plan. Check in process pre-departure highlighted the error before it became an incident</p>
<p>Too numerous, we have lots of layered barriers in place.</p>
<p>flight level verbally changed on clearance but not amended in the flight plan. only picked up after aircraft was airborne</p>
<p>Work in Progress on active runway at night. Multiple layers of physical barriers on runway but a works vehicle still drove past them onto the active section when freighter had landing clearance. Aerodrome controller saw the infringement and sent the freighter around in the circuit.</p>
<p>Formation flight, near mid-air collision, converging aircraft called by No 2, then seen and avoided by leader who's own 'see and avoid' hadn't worked.</p>
<p>[name redacted] F-16 whose hook had missed the cable ended up in the barrier which was serviceable.</p>
<p>A level bust. An aircraft can go "bust " their level but this does not mean there will be a mid air collision. barrier 1 ATC. Barrier 2 TCAS, Barrier 3 Pilots reactions.</p>
<p>Interrupted training with a student due to the bad judgement of the OJTI at huge amount of traffic.</p>
<p>VC10 on final called "gear down" & given clearance to land. Last look check by me - immediate go round - No Gear. Training flight with 2 CR crews plus STANEVAL on board. No one on VC10 realised until reason for Go Round was given.</p>

Radio communication failure is often mitigated by levels of redundancy, however single radio equipments can fail. In the event of fail there is a signal light used in air traffic control towers that can then be used. In summary the failure of the technical system results in the use of a visual based system.
Aircraft maintainers have a series of barriers in place to prevent an aircraft getting airborne in an unairworthy state. More than once all barriers were missed (supervision, independent checks, TFS & DFS) until the last barrier (aircrew walkround) when they found a belly panel on a Gazelle missing.
Too many times, but with a properly managed SMS there has always been at least one barrier remaining - the holes have never quite lined up for me.
through reactive proactive planning and management
Director identified an air system and descended on the [name redacted] QNH and received a readback, air system fed onto PAR where pilot readback an incorrect QNH which was 10hPa out which was corrected by PAR controller.
ATC teamwork. When one controller makes a mistake another one catches it. 7110.65. Ch 2 There is no absolute division of responsibility.
The simple authorisation process and an independent officer to ensure that all barriers are in place when operational pressure is felt by the crew conducting the mission.
AIRPROX Report No 2011129 refers. DIR instructed the Merlin crew to descend on the TACAN approach into conflict with the Puma in the ILS hold. Merlin crew became visual (intermittently) and descended to avoid confliction - 'See-and-avoid' was the barrier that worked.
Wire Strike - Planning barrier failed, obstacles not marked. Wire Protection System saved the aircraft.
Aircrew prepare to go flying unaware of crew currency problem. The aircrew would have flown if the DA had not 'captured' the discrepancy at outbrief
Aircraft misidentification; the wrong booked was signed for and then the boards were wrong and it was not until the pilots were sat in the aircraft and the new groundcrew checks (that had been introduced due to these errors) were conducted that it was identified they were in the wrong aircraft.
Authorisation Process - at its most basic, this prevented a crew from flying when one of the aircrew believed his was fit to fly despite appearing fatigued. The AO did not give the auth and cancelled the sortie. Whilst this may be seen as a safety barrier, how many times have aircrew flown were they are fatigued and made errors v aircrew that are fully refreshed, have flown and have still made errors, it is all very subjective!
Engineering error found by aircrew in walk-round.
when work was carried out on an aircraft, the supervisor of the task failed to that independent checks were required to be raised. the final supervisor check highlighted this and the work was carried out.
One could argue this is the case in the majority of hazard/obs situations, hence the bowtie model is an effective method of identifying all potential barriers to prevent a particular incident from occurring. Removal of one barrier does not necessarily lead to an incident e.g. a pilot states his gear is down and a clearance to land is issued, but the TRC notes the lack of gear and fires a red verey, therefore preventing the incident.
Helicopter underwater escape training. this has to be completed every 3 years. This training a barrier to a surviveable crash over water. During a period where the escape training was unavailable due to unserviceability, increased ground briefings were put into place to mitigate the risk.
flap selection during taxi before take off. missed initially but further check list brought to attention. Automated warning exists as final warning but not till point of thrust application for take off which might lead to unintended consequences for other aircraft.
Basic example would be something like the take off warning horn on an aircraft. Despite there being checks earlier in the flight, things are missed and then caught before it's too late by the activation of the warning horn at the satrt of the takeoff run. E.G. flaps are not set for takeoff - this could be disasterous, but will be highlighted by the horn sounding. Hwever the horn does not highlight if the INCORRECT flap setting is set, only that no flaps have been set.
Tower cleared aircraft to wrong level but error picked and corrected up when pilot reported airborne climbing to the wrong level.

Routinely and prevented by the application of oversight and assurance (audit, internal and external being just one tool in the box).
TCAS activation after pilot ignored ATC instructions
Our jet bridges at our airport have 2 safety mechanisms when attached to the aircraft. One, a safety arm has to be lifted and two the GPU has to be disconnected from the aircraft and stored in its locked position. An airline agent tried to move the jet bridge while the GPU cable was still connected to the aircraft, which caused the jet bridge to fault even though the safety arm was up.
My everyday work. Double check of data we provide, by min. two different persons
Many times. Aviation operates a Mandatory Occurrence Reporting System (MOR) where hundred of incidents are reported daily across Europe. Many relate to the failure of either equipment or people, but nearly all do not end in disaster due to other mitigations in place, such as Safety Nets (e.g. Short Term Conflict Alert [STCA], Runway Inursion Monitoring & Collision Avoidance System [RIMCAS]), or other humans in the system detecting and mitigating the system (like the watchful eye of an air traffic controller). I am not at liberty to divulge specific cases.
If you consider humans as a barrier, it happens all the time !
Refuellers didnt secure the fuel cap on the aircraft. Pre-flight visual check identified and corected.
A runway incursion as a result of ATC human error. The barrier of aircraft captain conducting a 'last look' as he approached the hold prevented the aircraft from fully entering the runway with another aircraft already cleared to land.
See and avoid being ineffective and TAS alerting to a possible collision.
Last look checks carried out by ground staff prior to aircrafts departure.
Maintenance operator error picked up by independent inspection
Failure to select gear down not spotted by Aerodrome Controller but go-around instructed by Runway Controller.
Memory item caught by checklist. Checklist error caught by design (e.g. takeoff config warning).
Aircraft attempted landing with gear up despite checklists and lights and warnings in the cockpit. ATC fired a red flare to instrcut the aircraft to go round
Air Traffic Management system in-built supervision
Flaps were not taken to takeoff flap settings and missed the flap setting due forgetting checklist but the takeoff confit warning buzzed and takeoff was aborted, saving a serious event.
I deal in situations where all the barriers have failed
Whilst on operations, ATC informed ac 1 to climb to block height en route to point B. This put them in direct conflict with 2 holding ac, ac 2 & 3 who were in a seperate temporary hold pattern which was anchored halfway along track of ac 1 route. These 2 ac, ac 2 & were completing their activities on a seperate ATC frequency. ATC was provided remotely and conflict was not noticed by ATC. It was night and standard lighting procedures were not being followed to avoid conspicuity. At 20nm, ac 1 track was noted by ac 22&3 on link 16 (a means for ac to track other ac). Using Link 16, ac 2 interrogate ac 1 position , hdg , track etc and then was able to deconflict themselves without ATC management who dod not notice the conflict. AC 2 & 3 descended to 1000' below ac 1 height and if no action had been taken would have hight chance of collision.
Many examples of runway incursions - the incident happens due to a barrier being breached yet there is no collision due to the presence of other barriers.
Weight and balance numbers for a different a/c sent to plane. First pilot didn't catch the mistake due to expectation bias, second pilot (as per procedure) did.
To many examples. In fact there are daily examples. Flying on the PIFR North in [name redacted] is one large example I remember. We had a comms "barrier" which allowed us to understand the position of other aircraft. We realised that an [name redacted] aircraft was travelling in our line of flight in the opposite direction. They were on the wrong side of the airway. Our TCAS warned us; however, we were already manoeuvring. Our mitigation was our SOPs which require meticulous vigilance within procedural airspace.

<p>Radar separation requires 5NM standard separation between 2 aircraft. But applying 1,000 feet vertical separation to ensure safety if ever the radar suddenly becomes off the air saved a lot of collision near misses</p>
<p>Doing a descending turn over water (intrinsically unsafe). Target fixation caused loss of SA of altitude and descent rate. Navigator alerted me to situation and I recovered just before impact with water.</p>
<p>I assume you are referring to Reason's Swiss Cheese Model. Here's an example. Yesterday, a refueller filled up my aircraft and exceeded the normal take-off weight (including passengers) by 240 lbs. Two maintenance engineers noticed the fuel level in the maintenance log. I pilot did a short 10 minute flight, and also recorded to weight (he did not carry passengers). The next day another engineer did a Before Flight Check and also recorded the excess weight. Finally, the dispatcher preparing the aircraft for me recorded the weight as he calculated the load sheet for my flight that day, which would have had six passengers (exceeding the aircraft's max all up weight by 240 lbs.). at one hour before flight, I did my own before flight check to discover the excess weight. The dispatcher was prepared to dispatch an overweight aircraft, and up to seven people were aware that the aircraft was over its regulated fuel weight (there is a published limit on the maximum fuel allowed for the aircraft. In short, I was the last barrier to a potential overweight flight. I refused to do the flight with six passengers, and had to calculate (for the dispatcher) what the maximum number of passengers that I could carry. Management were somewhat annoyed at this loss of revenue, but reluctantly agreed with me. Barriers are breached consistently for many factors; laziness, inattentiveness, cultural resistance, and for-profit greed, with little regard to consequences.</p>
<p>This happens all the time. The layers in the cheese if you will are the barriers.</p>
<p>Operator error spotted and acted upon by direct supervision</p>
<p>There are many barriers in place in an attempt to prevent people coming into contact or close proximity of running engines, e.g. training, paint markings, written procedures, visual cues etc. but there have been occasions when these barriers have failed to prevent people walking towards a running engine. There are occasions when their peers have intervened and potentially prevented a serious injury. Human intervention on human error!</p>
<p>IN every day operations</p>
<p>Non-adherence to SOP and best practice being "rescued" by fly-by-wire technology. FDM in a previous company at which I was DFO revealed a historic case of alpha-floor activation at 400ft aal following mis-handling of an unstable approach which should have been abandoned some considerable time earlier.</p>
<p>A practicing aviator is continually (and thankfully) running into the second, third, umpteenth barrier preventing an incident. As is a practicing driver.</p>
<p>an estimate was not passed to an adjacent FIR but our "check back" policy ensured the controller recognized the error before the aircraft entered the succeeding FIR</p>
<p>Supervision intervention</p>
<p>Loss of vacuum pump and loss of gyro instruments during instrument flight. Incident prevented because of pilot training to use alternate method of controlling the airplane using turn coordinator and compass.</p>
<p>I spoke up on the radio to inform the pilot his tailstand was still on!</p>
<p>Engine lost oil in flight. Fortunately the engine monitor identified a drop in oil pressure in time for an emergency landing.</p>
<p>ATC is one barrier. Its operation is intended to enhance safety, but it doesn't always work. An air carrier aircraft cleared for takeoff before another aircraft was found to be securely away from the active runway. The pilot of the departing aircraft recognized the problem and refused the takeoff clearance.</p>
<p>Incorrect QFE read back</p>
<p>accidents happen when all theses barriers (holes) co-inside, but if theses holes are too large, the possibility of them to co-inside is large as well, and accidents can increase. Also all these barriers need to be managed by design, and awareness, and not be left to randomness without an attempt to identify all those holes.</p>
<p>Attempting to land with the wheels up, with the circuit breaker for the warning horn pulled. An ATC call at short finals alerted me to the fact that the wheels were not down, and I initiated an overshoot.</p>
<p>Routinely it occurs due to staffing shortage or equipment failures and the requirment to continue will limited capabilities</p>

Aircraft were assigned the same altitude on converging courses. Traffic Collision and Avoidance System (TCAS) in the aircraft prevent possible collision.
Telephone coordination was bi passed for verbal and misunderstood. Another member of the sector team heard the coordination as well and corrected the controllers descent clearance error
WATCHKEEPER 006 SI: whilst the aircraft suffered a catastrophic recovery, other mitigations were in place and functioning to ensure that no ground personnel would ever be present at the impact site. Therefore, whilst the risk of hull loss manifest, the risk to life from the incident was fully mitigated.
Small errors happen all of the time with student pilots. Something may be omitted from a checklist, but it can then be caught by a caution light or warning note on a PFD.
In aircraft maintenance there is the maintainer and then the person who conducts a Quality check (QC) of the work done. Part of the QC is a tool box check. A new maintainer completed a job and was going through the QC process when a tool was noticed as being missing. The tool was later found in the tail section of a helicopter where it could have become lodged in the aft gears of the helicopter cause a catastrophic error of the gear box resulting in the loss of the helicopter.
Arming of the thrust reversers are normally completed when cleared for the approach. That is sometimes forgotten but it is backed up with the Before Landing Checklist at a later stage.
A trained and qualified maintainer, with supervision, incorrectly assembled a key component - which was spotted by the required independent check by a third party.
Gear down landing. We have landing checks, an audio warner, and a final "suitable surface, three greens" check. I have missed landing checks and been prompted by the audio warner before (with one safety barrier remaining).
Blank left fitted to aircraft during engineeringbefore flight servicing, picked up by aircrew before flight walkround. removed before aircraft powered on
The issue here is that in many cases the event goes unnoticed or unreported. If their was only one barrier breached, in a properly developed system, then you probably would not notice anything. For example if I have a flight crew that almost busts an altitude restriction but one of the cockpit checks allows the crew to realize and correct, then this would be considered ops normal and the checks did what they were designed to do. It's only when you have multiple breaches in multiple barriers, resulting in a close call, that people notice.
A controller climbed an aircraft into my sector without first completing required coordination. I saw the partial data block in time reroute another aircraft and prevent a loss of separation.
Radar associate controller detected incorrect call sign.
STCA
Poor supervision was identified (strong and appropriate supervision is a safety barrier), but additional buddy / independent checks identified a maintenance miscue by and individual and it was rectified before it could cause an incident.
As an aircraft was transferred from one ATC sector, the air traffic controller is an altitude clearance to flight level 230. The aircraft read back a climb to flight level 250. The read back was missed and the aircraft contacted the next controller. When the aircraft checked in, he advised the receiving controller that he was leaving 19,000 climbing to flight level 250 per standard operating procedure. The receiving controller noted the incorrect altitude and recleared the aircraft to flight level 230. The pilot then read back the correct altitude assignment.
Pilot setting incorrect QNH being corrected by the requirement from the Controller to "read back QNH set".
Simple example - aircraft pre-flight servicing incorrectly completed with a blank left on the aircraft, subsequently spotted by aircrew on pre-flight walkround.
A bad clearance given by one controller and caught by another
An example of this would be during an instrument approach when the pilot flying either inadvertently or purposefully descends below the minimum published descent height or MDA and the pilot not flying makes the appropriate call out or in rare instances takes control of the aircraft.

<p>We use "vehicle on runway" reminders in the tower , but we also have a Controller-in-charge as well watching the entire operation, have seen the CIC act as the second line of defense/barrier to prevent an incident.</p>
<p>A fatigued pilot mishears an air traffic clearance and reads back what he thinks he has heard. The controller notices the error and corrects the pilot.</p>
<p>Rwy occupied warning lights were not switched on during maintenance works, but a specific strips layout made the controller aware of this</p>
<p>Dozens of examples available from daily operations. Refer to Prof. James Reason work.</p>
<p>A controller had the incorrect DH set on the PA Console and therefore in theory was talking a student act down to a lower DH. The radalt was set correctly in the cockpit which prevented the pilot descending lower than he was qualified to do.</p>
<p>Human error working in the aerodrome position and the supervisor did their job by stopping the action the controller was about to take.</p>
<p>Fuel tank overfill - operator failed to dip the tank as is required by procedures and training yet automated overfill protection system saved loss of containment</p>
<p>As an Air Traffic Controller we see this every day, one Controller missed certain information on a flight and another controller catches the mistake. That is why, "Teamwork" it's so important in the working environment.</p>
<p>Air traffic control operations.</p>
<p>System redundancy is a classic example in my experience. Where one system fails another can be used. In the Air Traffic Control 'system' this includes equipment redundancy (Main, standby and emergency radios), the use of Aldis lamps, flares, etc - all for the purpose of communicating with aircraft.</p>
<p>We place Runway Unsafe signs on the wind indicators in the Tower when a vehicle or personnel are working on the runway. We've had people lift the signs and begin to read a landing clearance. Our Total Tower Team Concept policy of all available personnel scanning the landing environment during landings and takeoffs, helped to remind the controller of the unsafe landing area.</p>
<p>Computer shutdown of a launch very close to T-0 after a failure of a relay to initiate the sound suppression system. (Titan program).</p>
<p>In military aviation, because of lack of money, the flying hours of pilots were reduced, but not to cause more risk from that fact, the commanders provided simulator training to the pilots.</p>
<p>independent review of sector record pages, identifying that an aircraft captain had raised an MEL entry for a defect that should not have been deferred</p>
<p>Loss of separation resolved by providence.</p>
<p>secondary walk around the aircraft prior to lift off</p>
<p>In India VIP treatment - time delays - airport out of whack lot of operational issues - parking and storage in some places costs thereat</p>
<p>team member pointing out an error in a clearance given to an aircraft.</p>
<p>An aircraft was put into conflict with another aircraft un-noticed by the controller. The short term conflict alert subsequently went off and prompted the controller to take appropriate action.</p>
<p>standing agreement internal coordination, prevented by ATCO action (so trg and experience)</p>
<p>An aircraft is cleared to a specific level but the pilot, despite reading back the correct level, climbs through his allocated level into potential conflict with another aircraft. TCAS alerted the pilot of his error and initiated a Resolutionary Advisory that prevent the aircraft climbing further.</p>
<p>Every time a TCAS RA is undertaken</p>
<p>The ongoing issue with Sentry maintenance standards. The intervention of the duty holder to insist on the early adoption of a modification revealed a number of issues that may otherwise have led to a more serious event</p>

Controller makes a mistake, ATC ground automation alerts and controller reacts incorrectly, TCAS activates and changes the results
A dead bird in the APU exhaust that should be normally discovered by the ground personnel pre-flight checks (1st barrier) was not discovered either from the two pilots during their pre-flight check (2nd barrier). It was discovered by the in-flight technician just before engines start-up during his final check (3rd barrier).
Changing of rosters post identifying fatiguing routes generated a different type of roster pattern that caused further fatigue later on in the flying programme
subject discussion
Controller not detecting conflict and ignoring STCA. TCAS saves the day.
Tristar go-around at very short finals where responsive RB211s enabled captain to successfully complete profile and land from night visual circuit (pilot handling skills final barrier).
During depth maintenance of a helicopter, the final 'independent' check of all the systems (locking/assembly etc) would be carried out by the crew chief (who, while overseeing all of the tasks, hadn't been 'hands on' with any tasks). However faults were still then being found during the flight test phase. An independent inspector was then employed to carry out these checks as he had no connection with the bay/aircraft/crew. This barrier did indeed work and faults were found prior to the aircraft leaving the depth bay.
Frequent AIRPROX reports highlight incidences in which flawed procedures or ATM error constitute a breach, but aircrew lookout and visual sighting of a confliction result in resolution.
As a supervisor on a Reaper squadron we were very alive to fatigue and other mental health issues amongst crews and ops staff. On a few occasions it was necessary to stand down personnel either before or during their shift as they were considered too fatigued to safely operate a live armed platform.
Supervising in an Area ATC ops room where a controller had failed to react to a conflicting aircraft until it was identified to him by myself and complied with my instructions to resolve the confliction.
Across the globe there have been repeated circumstances where procedural control is breached, short term conflict alert is missed and TCAS resolves the situation.
During an engine ground run, the operator failed to follow procedure and apply the aircraft brake. During the high powered runs, the aircraft jump the chock and the quick reacted safety man managed to insert another chock before the aircraft caused or was damaged and the slower reacting operator reduced engine power.
Mode S
As a military controller in the RAF a regular situation was a "wheels-up" approach made by the Harrier at a training base. This was prevalent because the Harrier required the landing gear to be retracted after take-off even when conducting aerodrome circuits, new trainees were used to keeping gear down for the whole circuit and often forgot to select "gear-down" when downwind. The controller was one layer of defence against this but we also employed a second observer in a RWY caravan positioned near the THLD who frequently fired a red verey (flare) to stop a "wheels-up" approach from crashing.
We have multiple backup systems to prevent our aircraft from being flown if one of our aircraft are not safe. If one step is missed by the primary person, there are multiple checks and procedures that must be followed before allowing that process to continue.
Maintenance was completed illegally simply because the pilot/engineer was allowed to sign for work done on his aircraft and had it not been completed he would not earn as much money as he planned to. The work was not completed properly and it was discovered by his co-workers who subsequently covered for him but completed the work correctly.
Proactive radar supervision identified an air traffic controller's error in time for the situation to be rectified.
Typically in weight and balance calculations, the trained and qualified person preparing a loadsheet may have overlooked a certain error in weight. This may be trapped by another group of people loading the shipments on board the aircraft. They may be able to intercept a miscalculated shipment before it got on the aircraft.
unstable approach

Some examples include TCAS alerts to ATC or Pilot error. Redundancy of mechanical systems e.g. failure of on magneto on an aircraft engine with dual magnetos.
Wheels up landing prevented by a safety number on the ground communicating via radio to the aircraft. The aircrew had become distracted and missed a section of the landing checks.
Non removal of ejection seat pins by aircrew; mistake identified through groundcrew cross-check
3 Crew concept- On returning from a sortie in [name redacted] I failed to conduct my 'fencing in checks' iaw the flight reference cards to ensure all weapons and defensive aids were made safe. On crossing the Threshold the Air Crewman always stuck his head between the two crew to ensure we had ' fenced in'. He prompted us and we made the aircraft safe stopping negligent release of DAS or weapons.
Maintenance failed to run an engine after task completion. Engine lost oil pressure in flight. Pilot and crew immediately put into play engine shutdown and landing procedures for a safe landing.
SOP broken by one flight crew member but caught and rectified by the other.
Flight crew were distracted during take-off and forgot to raise the landing gear. After take-off checklist caught this error.
Level busts! Usually picked up by the controller.
Misuse of a Fork-Lift Truck when lifting very heavy equipment - deliberate, unofficial countermeasures were created to mitigate the situation.
It sounds like you are talking about Reason's "Swiss Cheese" model to describe barriers to error. Certainly that model has some validity, and in that sense, I once saw a pilot start to taxi with an item hanging out of the door of the aircraft. So if the checklist and preflight checks, intended as barriers, were breached, the incident was curtailed because another pilot keyed his radio and told the errant pilot about the problem.
Aircraft given a clearance by ATC that would have resulted in an accident but caught by he flight crew.
Use of the Runway Caravan, use of the ATC Supervisor, use of the ATC Pinboard in the VCR.
Numerous times where a controller does not spot a confliction but the screen or supervisor does.
An aircraft in the visual circuit reported 'Finals, Gear Down', the tower controller on carrying out a vial check saw that the aircraft's gear was not down so told the aircraft to 'Go Around'.
Yes, kind of. The Trident 1 crash at Staines. The first safety barrier was breached when droops were retracted too early [against SOPs], the second barrier [the stickshaker] would have prevented the deep stall bu was breached when the stickshaker's circuit breaker was pulled [it was thought to be a nuisance warning]. Virtually the same accident occurred with the Air France A330 into the Atlantic and the DH8-Q400 at Buffalo. 'No lad, if the stickshaker is working, stuff the nose down first, then apply power to fly out of it. We can always figure out what went wrong over a beer in the bar later, but let's go upstairs first.'
Margins help. The intent to land with margin on unimproved airstrips has led to multiple times of "sliding" into the margin, but not sliding off of the airstrip. When investigated, in every case, there was good information that would have told the pilot to NOT land because the margins were not going to be maintained. But, the margin actually prevented the accident.
Normal operations as Ramp Agents pushback an aircraft. A wing walker, guide agent or even flight deck have acted together to prevent an incident.
Required Inspection items in aviation maintenance. The second set of eyes from the objective perspective of not having performed the job and not being responsible for the on time departure of the aircraft, from the position with that objectivity spots errors made by the technician.
United Flight 232. An uncontained engine failure took out a triple redundant hydraulic system yet Captain [name redacted] was able to use CRM to land the aircraft and prevent a total loss of life.
Yes, in-house policy that both crewmembers will perform an external walk-around prior to door main cabin closing... at least one of those after all servicing is complete. This final walk around has led to findings of fuel and lav doors opened and pitot covers forgotten.
Every incident has involved at least one barrier being breached. From airspace design, procedure, regulation through to co-ordination, ground based safety net and airborne safety net.
Numerous ATC losses of separation have been stopped by the next barrier in the chain. Most recently as many as 19 barriers were breached in one incident and even though some of the technical barriers had been

disabled a final human intervention reduced the outcome of the incident to 'acceptable' although the implications of the large number of barrier breaches are being treated as very serious.

Q2d - 4. Please explain how you would have managed the change differently:

More graduated change with adequate time for absorption.
Smaller but progressive (continuous) change is preferable - make change part of the system
Communication and education with ample lead up time.
Although answered 'yes', I think the scale is a bit too simplistic. A 'sometimes' response would have been useful. I don't think you can pin everything down to more and more regulations. The whole point of them should be to bring improvements to the 'system' but if their introduction is not properly managed then they can have unintended consequences that can percolate through to front-line operations.
More communication, training before the change is mandatory.
Publication of differences and associated rationale prior to the implementation of the change.
Start the messaging earlier, take people on the journey rather than presenting a fait accompli. Ensure there is an understanding of why, not just what.
By a combination of increased stakeholder consultation; early preparation of appropriate guidance material for both the regulator and industry; enhanced training for staff of the regulator prior to roll out of the rules.
Better publicity of regulation changes and an understanding of the capacity for aircrew to digest data. Some documents are needed for instant access in the cockpit, so should be committed to memory. Others are less applicable and should be afforded lower importance.
During change, the resourcing issues (time, effort, equipment, financial) will cause problems. IF this can be tackled, then the change can normally be successfully managed. So in future, fighting for adequate resourcing is paramount.
I may not have instigated the MAA who seem to produce regulations at a phenomenal rate which are often confusing to the operator. It is time to simplify aviation and I'm not convinced the creation of the MAA has.
EASA are introducing changes in regulations rapidly which in turn overloads the UK authority (SARG/CAA) this has led to CAA documentation being out of date in comparison and aerodromes left to decipher what regulatory requirements are actually correct. Specific examples are Mandatory Occurrence reporting. Change should be implemented at a pace industry can manage safely with a view on how long it will take the competent authority and then ANSPs to implement.
Numerous changes are being implemented by EASA. The amount of time and effort taken to digest and implement changes is enormous. These changes could be phased in (not all at the same time).
Formal training to identify the key aspects of the changes rather than publication of a revised manual where operators need to find the changes themselves.
It is too easy for top levels of an organization to blindly send out reminders or new material and assume that since it was distributed correctly the entire workforce has absorbed the information. This approach lacks the context of how many briefing items the controller has-how much time they have to study them- and whether or not they ever have a chance to apply the knowledge or practice the situation.
Ensure that the organisation responsible for change is properly manned and has the mandate to implement change for the good and benefit of all.
Too much information overload following an accident forced through not by proper accident investigators but bureaucrats and politicians who frankly had not a clue what was going on, knee-jerk public reactions as politicians are liable to do without taking full consultations from proper ground floor engineers, technicians, pilots who daily work with their aircraft and mechanical systems.
FTLs Better managed with scientific approach and consensus.
Our company have had lots of SOP changes, rarely through regulatory processes though. Too many changes lead to people using the old SOPs which are not necessarily a threat, but provided confusion and uncertainty. They could either have left them alone, or introduced them step by step. (The regulator is [name redacted] who make very few changes. We leave it up to our management to mess us around!)
introduce things slower and allow time to bed in before the next change is introduced

Typically, change doesn't account for an individual's reaction to the change and doesn't always assess their understanding of the change; these would be the factors that I would consider doing differently.
Stop driving it based on political motivations (Europe and EASA). We know that ICAO is a slow process, but that does at least allow it to be measured and understood.
Unless it is safety critical, there should be no requirement to rush through regulatory change. The Change Management aspects could have been handled much smoother if advance notification was provided of a change and it was introduced over a slightly longer time.
EASA regulations are changing CAA regs for almost the same things but in completely new language. Very confusing and unnecessary
More involvement and genuine consultation with those affected by the changes
the change from using CAP 168 to EASA regulations.
The EASA regulations for aerodromes are extremely difficult to understand as they are spread across a number of documents. The 'old' UK CAA publication CAP 168 contained all the information in a single and easy to read document. In my view political considerations have been prioritised over aviation safety
The pace of change is important. People need to fully integrate change within their workplace before undertaking more changes. Management of change procedures should take this into consideration. It's not unusual to receive dozens of changes (via email) from the regulator at one time. It is a challenge to sift through these and identify the ones which are important to you - then you have to impact assess them and notify the relevant people in your own organisation. Regulators should plan the changes well in advance and 'drip feed' them into industry. They can prioritise these changes to make sure the most important ones are delivered first. They should make sure these changes have been understood and adopted before releasing others.
Significant changes should be spread across a period of time so that each area can be reviewed, impact assessed and adopted in turn without too many changes together.
This is simply the desire to introduce too many changes in a short period of time. A number of both EASA and CAA regulations have hit the industry in a conveyor belt like fashion. Resources are simply too short to ensure everything is embedded thoroughly and effectively before moving onto the next regulation.
By ensuring that all the relevant information about that aspect of regulation was collated and kept up to date.
Allow a longer timeframe to fully complete integration with existing procedures. Consult with the current operators of procedures sooner to make sure integration occurs before introduction.
Further and more detailed warning of the change. One change at a time rather than mass changes. Better planned process of change. More in depth look into the practical implications of the change for frontline staff.
Through planning and training, if there are a lot of changes to a process and they are all inter related then a relevant training package should cover this. If there are a lot of unrelated changes occurring at the same time, sift them into similar groups - introduce them at staged intervals. Downside is that you appear to be in constant change. At times more prominence appears to be given to getting changes done to meet target dates (often unrealistic) rather than push through a system or procedure which is not 100% ready .
Would have requested a longer intro period to allow time to assimilate and promulgate and train.
Introduction of RNP nationwide on a date that did not permit training time for the controllers implementing the separations around the new procedure. It was extremely stressful. Senior management now include a tower controller on the project to ensure the coalface is not left hanging.
Recognised the compounding effect of regulation change/introduction. Involve users in the pre-implementation phase such that potential overload is recognised early and mitigated appropriately.
Having a regulation break every few years
Increase of sector capacity with prejudices to cut the overtime payment during the summer season.
Civil Aviation Safety Authority Australia has been trying to introduce new regulations for twenty plus years and keeps changing the model (FAA or EASA) - they also cannot bring themselves to get rid of the original Australian style regulations. Consequently there are too many anomalies within the system to allow sensible regulation and compliance finding. The problem lies within the regulatory structure of

Australian Aviation Safety Regulation in that all regulatory changes must go through Parliament and the Office of Legal Council instead of allowing the Authority to regulate by rule.
Staged introduction, more detailed analysis of scenarios where multiple changes can have big impact. Increased training, high levels of user acceptance.
Both the CAA (EASA) and the MAA have far too much regulation (process). The amount of paperwork with rules and regulations for all processes (aircrew, maintainers, ATC) is too much and adds pressure and complications to people's daily jobs. This needs to be simplified.
Change management is handled poorly in this industry with the regulator rushing changes out with too little consultation.
Staged integration of major rule changes rather than NPA and minimum acceptable means of compliance window
[name redacted] operating as Duty safety controller on night shift deconflicting gun target lines with traffic with hot airspace and Multiple requests from [name redacted] to clear the airspace. I as an ATCO had no prior training in these scenarios something I feel was missing from my deployment trg.
Airlines want to collaborate on making decisions and too often they become a nuisance to the mission of ATC
By information before the regulations stay in force
Too much regulation and establishments feeling that the best way to mitigate risk is indeed more regulation. We can only absorb a certain amount of information.
Wholesale adoption of the MRP from the JSP 550 series documents proved difficult to manage on the frontline - albeit the content of the regulations had not changed markedly.
Phased roll-out, Greater information campaign regarding new regulation and its impact
Briefings to explain any major changes and why they have been implemented - this would encourage better buy in from the pilots I believe.
Stop the proliferation of miniscule changes to rules and compliance that are bogging down the 'four worlds'. The mantra now being 'reduce output to maintain safety' is translated to 'don't fly'. Where the output reduction should be in the number of RAs, FOBs, ATM, ADS, RTS etc etc that are now hampering safe flying.
Less change regulations. Allow for periods of stability to reflect and understand regulation.
The RAF had very effective change management teams in the fast jet world in the 2000s. These teams have been reduced in size and scope, to the point that they are almost ineffective. The changes introduced when these teams were in their heyday were extremely effective at managing change. There is little or no apparent continuation of the methodology being utilised today in the MOD
Sufficient advance notice, ensuring the dist list reaches all affected parties. A regular schedule for updates - such as 6-monthly or quarterly - so all teams know when the next changes are due and can ensure they are sufficiently prepared.
only by better balance of time v pressure to operate, ie training before introduction
We often get told that regulation changes have taken place, however, it is always up to us individually to go through the regulations to determine what the changes are. This takes significant time and effort all of the time. We are regulated by soooooo many documents it is extremely difficult to keep on top of things.
During the current state of flux at my airline, manuals and procedures have changed 3 times recently, often we have the new manuals and procedures for only a few weeks before their introduction on a specified date and are expected to study in our own time and all adopt new procedures we are unfamiliar with (without practice) on an arbitrarily set date.
By steps
Changes could be spread over time to limit overload
Again, from a crewing perspective, my company failed to gradually implement the changes from Subpart Q to the new FTL, even with a period of transition available. If the company had prepared things better, changes wouldn't have been so overwhelming

<p>The change overload was due to multiple procedural and equipment changes. Better project management and realistic timeline planning (including the requirement for regulatory approvals) would have enabled easier management of change process.</p>
<p>Splitting the ammount of information into smaller pieces, providing it in regular time frames</p>
<p>[name redacted] reacting to changes at a European level. European regulations sometimes are very long and complicated and sometimes lack useful guidance material. Sometimes they are over zealous. The problem is they are designed by committee, trying to appease all players to produce 'one size fits all' regulation; but there are many different sizes and complexity of organisations across Europe (and the UK) where one size does not necessarily fit all.</p>
<p>More simulations with an up to date simulator model. And simulation exercises created by people who could be affected by the result of change (Like the kind of population gathered for a preliminary system safety assesment)</p>
<p>Change is normally never for changes sake but to improve the overall safety management process. Depending on the investigation and conclusion, a serious accident will normally generate safety related improvements. The expectation for an increased workload to implement safety related changes is a given.</p>
<p>Introduce the changes gradually rather than all at once.</p>
<p>Easier method of publisising changes by making the rule change relevant to the audience affected.</p>
<p>A complete restructure in terms of organisation and location of regulatory documents led to those familiar with existing documentation being swamped by change. Roadshows designed to educate existing staff on new structure would have been beneficial rather than relying on them being able to assimilate the whole process of change as it occurred. Those within the change process found it easier than the operators who were working to it.</p>
<p>It is important to make sure that there is proper and informed consultation with a regulated community before a change in regulation</p>
<p>More time spent considering the effects rather than knee-jerking in to a change as a result of every single incident.</p>
<p>The change that most quickly comes to mind was the Airline Safety and Federal Aviation Administrative Extension Act of 2010 (resulting from Colgan Air Flight 3407 Accident). This act resulted in sweeping and disastrous changes to the regulations that have crippled regional air carriers with downstream effects. Pilot shortages result in changes to quality of incoming candidates, non-standard hiring practices (e.g. hiring street captains), and managing delays and cancellations due to crew shortages. It has had a completely destabilizing effect on the regional air carrier industry.</p>
<p>Introduction of change, especially when safety criticality is involved should be staged with each stage bedded in and assessed for secondary (unwanted effects) prior to implementing the next phase. The changes to the military notam system (X,Y Notams) were a perfect ecxample of how not to introduce a policuy (and safety) change.</p>
<p>by more dedicated pre-training before introducing the change</p>
<p>As a manager in office I have several things going at one time, once there was a court house ruling which directed all data to be interpreted to local language along with English. I would not instead think about it, I would never do such an overload at all. Stick to the basic communication language.</p>
<p>More time and training</p>
<p>RA proposed amandments would benefit from longer lead in time until they become authorised to allow for contractual and commercial changes and compliance. RAs need to be less prescriptive to allow for easier application.</p>
<p>Regulation change, people change and organizational change can all happen coincidentally in a short space of time. This is when the risk increases, in which case recognition of this is needed and steps taken to assess the impacts, timescales and potential for error..</p>
<p>Overload due to procedural changes in checklists etc. due to merger, with virtually no training. A high rate of error and confusion was unnecessarily introduced into critical phases of flight to satisfy the whims of the controlling management. Five years and four checklists later that management and traing center is almost gone and the checklists and procedures are almost back to where they started, thanks to the FAA and the inferiority of the procedures. Simply involving all the parties, assessing the positives and negatives</p>

<p>of each approach, using best practices and then training for full 18 month cycle would have solved the problem. (This was and once again is, the way things are done at my carrier).</p>
<p>Change management is a key step in the Assurance cycle. I would have used a change management plan in line with the JSP in order to ensure that everyone understands the change before it occurs.</p>
<p>Introducing changes in the workplace particularly involving operations must be gradual and mastered before loading in more.</p>
<p>The current regulations, while onerous to industry newcomers, does not significantly change. Those changes that do occur and usually in the interests of flight safety, so are logical in presentation, and therefore can be easily assimilated to those individuals who can reason within any paradigm of safety over profit. Students of aviation history will note that regulations come into effect only after accidents and loss of life. The accident rates in the 1920's and 1930's are horrendous. New technologies have significantly improved these rates, but the biggest improvements have come about with the introduction of SMS and FS programs (CRM, FS, Tool Control, etc.)</p>
<p>Train to the new regs before they take effect, as opposed to starting the training on the first day of the new reg.</p>
<p>The challenge is always to better articulate what a regulatory change means for the lay person. Cut the jargon, highlight clearly the so whats</p>
<p>TAKE MORE TIME</p>
<p>The introduction of new European regulation has unavoidably led to vast tranches of large documents and changes to regulation. The introduction has been phased and I don't think it could have been done any better but there have still been substantial amounts of regulation to digest.</p>
<p>Stagger over a longer time period</p>
<p>EASA !!!! These changes should never have been brought in in the way they were. There is too much legal language and too many difficulties in accessing the detail needed because indexing is poor and the documentation overly complex for the non-legal mind. Up until the introduction of JAR, manuals etc produced under the old UK ANO system were readable and understandable. Since then, they have been forced to be more and more indecipherable and unreadable to normal pilots, cabin crew, ops staff, managers etc. If a regulation is so complexly written that it needs both guidance material and acceptable means of compliance to make it understandable, it is an appalling regulation, however good its intention may be.</p>
<p>PBN is a current and prime example of change, in this case fundamental change in the conduct of flight deck management. These changes had to be regulated, but provided prime examples of how multiple agents of change could result in confusion, increase the stress associated with the change and reduce the beneficial outcome. I don't offer an opinion of how these could have been managed better!</p>
<p>Pain language and examples in context. The 7110.65 is written by lawyers and changes are hard to understand most times.</p>
<p>Incremental change or wholesale change</p>
<p>Introduction of revised Airmen Certification Standards for Private Pilot. Better training of flight instructors on the implication of the revised standard for demonstrating slow flight.</p>
<p>The change in regulation wasn't for the better. I would not have agreed to the change in the first place.</p>
<p>Implement them over a period of time.</p>
<p>Ask ATC to breakup the instructions and issue them separately.</p>
<p>I don't know, but it is not in my nature to say something cannot be improved. In the vast majority of highly developed systems they are still able to be improved by ever smaller margins.</p>
<p>We have too much antique regulations, and adding new regulations on top of old ones will lead to introducing new safety problems. Regulations need to be re-written from scratch by broad-experienced systems people, who understand interactions across technology and systems especially in areas where digital technology is used.</p>
<p>Continuous change continuously simply causes confusion and alienates staff at all levels. Make one, well-planned and well-considered change, then allow it to take effect. Do not make further changes until this process is complete.</p>

<p>Regulations often change without warning to the end user operators with enough time to consider how the change would influence the already established day-to-day and seamlessly incorporate these changes.</p>
<p>Would have utilized incremental changes.</p>
<p>Creation of new EU-regulations for commercial air transport limited to an annual update. Ensure new regulations will contribute to more effective and efficient operations.</p>
<p>Full impact statements should be drawn up in consultation with affected parties prior to regulation going live, and a wider view of overall organisational change is required to build this impact statement on. This is particularly relevant with new technologies and during times of significant staff reductions / re-organisation.</p>
<p>Too much information at once does not do anyone any good. It may be efficient but it just leads to more questions down the road that could have been handled in a more carefully designed training session about the changes.</p>
<p>There is always a better way to manage change; but, change is inevitable. Changes regarding safety are disseminated as soon as they are verified in order to get the information out to the fleet as soon as possible to avoid the occurrence from happening again. This is a necessary evil in order to keep from suffering another catastrophic event.</p>
<p>A key aspect is ensuring the time and training to understand change before it goes live.</p>
<p>Changes are often made with very little Flight Safety implication, but it changes the way in which you operate. These changes happen regularly via many different channels and it is very difficult to keep on top of - particularly when it is the same regulation that regularly changes between two options (e.g. RW - whether you have to reject to a suitable surface or not post engine failure). You often end up not being confident of the latest regulation and rely on legacy knowledge to keep you safe, which implies the change didn't have a large flight safety implication in the first place. Having no hard copy to refer to makes getting up to speed and refreshing your knowledge more cumbersome. Changes should be made as large changes at infrequent periods as rewrites of a minimal number of publications. We have too many different publications and it is impossible to keep on top of them all. Also, you are never given time at work to get up to speed on any updates. What I am describing is change fatigue.</p>
<p>New SIDS and STARs were implemented before the airspace was changed to properly contain them. Much greater user of ATC simulation to evaluate proposed new procedures prior to implementation and careful consideration of the number of new procedures implemented at the same time would make change much easier to manage.</p>
<p>Overly existing structure.</p>
<p>If moving towards a new facet of operations, you may have to accept that you must slow down current operations in order to plan and train for the new aspect.</p>
<p>The complexity of a change drives how it should be presented. Sometimes I have seen complex changes that should have been presented as proficiency training be distributed as a simple email. The result was numerous requests for clarification and explanation.</p>
<p>Flying almost stopped because of a complete re-issue of the entire 2000 series MRP. Yet on scrutiny, there were no material changes affecting helicopter flying operations on my Squadron at all. I believe the organisation (in this case [name redacted]) needs to establish positions which assimilate changes to regulations and present them to the regulated community. At present the onus seems to be on each individual to make sense of changes. I would also argue that perfect is the enemy of good enough and that minor changes to regulations in the interest of style should be avoided by the regulator; otherwise they simply create distraction and 'chaff' and contribute to the widespread notion that there is too much regulation and nobody can keep up with it.</p>
<p>Constantly having ad-hoc emails sent regarding changes to procedures (anywhere between 1- 6 times per week!). This has now changed to official notices issued periodically (approx. every 3 months) with a range of changes.</p>
<p>By introducing the changes in a more gradual manner.</p>
<p>At the time, I was working for the regulator. Changes in multiple European regulations needed to be managed concurrently. Some of these regulations introduced unintentional conflicts which created more work to resolve. Better co-ordination within the organisation drafting the regulations could have identified and removed the conflicts prior to implementation.</p>

Specifically in my occupation Wake Turbulence rule changes became extremely burdensome and I know most controllers I worked with just adopted a one size fits all approach to cover each situation.
Less changes, stepped introducing
When a new regulation is implemented, obsolete regulations have to be visibly cancelled. This is rarely done.
Through Simplicity.
When employed as the SATCO, on taking over it was clear that no work on SM had been done for a considerable period of time. This required a complete overhaul and change in culture particularly reporting. These changes had to be introduced gradually but fairly swiftly to ensure compliance with regulation.
In my 20 year professional opinion, some regulations require baby steps and not all implemented at once.
Australia's Drug & Alcohol Management Plan process that did not take into account all operations types. Despite multiple approaches and meetings, this remains unresolved 9 years after introduction.
I think That change is inevitable in the aviation industry but it has to be introduced in a phased manner to give people time to adjust. In the instance I had above there was a huge amount of change at the same time due to new EASA regulations. It is very difficult to deal with a lot of new information at one time and can only lead to errors.
By piloting the change with selected organisations before universal introduction.
With more information and more time spent on training
Established when the most effective time to implement change. Often it feels like change is being implemented without any consideration for when might be the best time - instead change is often implemented ASAP without any regard for any negative impact of the timing of the change.
Many changes in regulation are either unnecessary or misguided. Often this seems to be driven by someone's own personal goals or a desire to 'change something' for the sake of it in order to prove that a constant improvement is in progress. This is particularly true when regulations are rephrased or reworded with the resulting regulation being interpreted entirely differently with (usually) a loss in capability. Change only what is necessary and consult with the end user prior to release.
If they before the changes performs a change - effect research the problem and overload should had been avoided.
The transfer from JAR Ops 3 to EU Ops
Change is necessary. You just have to recognise that change brings with it additional risk (invariably cognitive failures)
Phasing and timing.
is over regulated sector for protection of govt moribund and sick enterprise would like that changed ..
Communication and more time for training. Phased implementation strategy.
Started preparations earlier and allowed time for the creation of a staged training package helping to build the knowledge required over time rather than in one big hit.
No1 risk held on my RR is the frequency of change - it's too much
Longer lead in time, better briefing on the regulatory changes and impact on operations and a thorough test of understanding.
MAA RISE process for ATM - effectively a 4 part safety case. Clunky, inefficient and an outdated concept, especially when applied to COTS equipment.
The industry tends towards 'knee jerk' reactions in the aftermath of accidents, such as the increase in minimum hours for new pilots after the Buffalo crash. True, the flight crew didn't respond adequately in the face of the 'stall warning' further deepening the stall; however that wasn't as a result of a lack of time on the pilots part, it was an instinctive reaction! Subsequent regulations raising the minimum number of hours for second officers did nothing to improve safety, it simply reduced the pipeline of new pilots coming onto the line. A clear case of regulation overload and a lack of understanding about the true cause of the accident.

<p>There is a lack of cohesion in large organisations. Many change initiatives occur concurrently, often overlap and are some times contradictory. Having an process through which change has to be authorised and its impact assessed before it introduction would help</p>
<p>Changes should be more realistic and be given time to be applied by everyone. Sometimes big change is introduced at once. The result is that people just don't follow the new regulations. In addition, change should be in accord with other regulations, or else it will again be rejected.</p>
<p>It is difficult to ensure that change does not overlap in such a dynamic and changing environment</p>
<p>although in my case NA can I say that there will always be a gap for improved management. "It isn't done until it is done properly" quotation from Arthur Bradshaw ATMS.(may be used)</p>
<p>Often felt frustrated by amount of change which could have been eased by improved (some) engagement with the RC before introduction.</p>
<p>Small changes frequently, rather than a whole host of regulations changing at once?</p>
<p>The perception of a consistent drive toward continuous improvement is understandable, but leads to a state of constant change in terms of business process. This in turn has potential to lead to distraction. A state of stability would enable process to be better understood and more holistically assessed, rather than working in a constant state of flux which manifests as a perception of a very reactive environment.</p>
<p>Difficulty was associated with operating a FMS platform for which we had limited access to technical information. This example related to the introduction of a significant software update which greatly affected how the platform was operated but we only received sight of the training package in the final days prior to its introduction. Crews were required to assimilate the information for a 'seamless' handover of software configurations whilst on ops inducing significant personal and operational stresses. The ideal change would be provide a decent lead-in time to allow all to be comfortable with the changes prior to initiation.</p>
<p>Improved consultation between organizations and the Regulator</p>
<p>The effect of change is cumulative. Small amounts of coincident change in different areas (technical, procedural, management) can combine to overwhelm individuals. The potential impact of change should be predicted and managed and coincident change should be reduced.</p>
<p>A phased introduction with more adequate addressing of training individuals on the change.</p>
<p>At least can be introduced on a regular basis. The problem is not with the new information but with the previous one. Sometimes happens to make confusions when this changes are not proper introduced. The human mind does not work like a memory stick. It needs time to adjust.</p>
<p>Adequate time between changes for staff to adapt before introducing the next alteration.</p>
<p>I have witnessed extensive change in the delivery of ATM recently and believe that it should have been subjected to more testing in a simulator environment to prove its validity. That should have been followed by a longer period of training in a simulator environment and the introduction should have been phased. Instead the testing and training were conducted more or less concomitantly and a "big bang" change was employed - this worked, thankfully, which will likely have the affect of reinforcing the strategy for future change!</p>
<p>Simply putting out a memo to highlight a change does not suffice as persons will always interpret changes to best suit their purposes which may vary from that intended. Changes should be introduced by experts who will also be available to answer questions regarding their interpretation.</p>
<p>Being able to present a change thoroughly to employees first to include appropriate training and immersion.</p>
<p>recent changes to flight and duty time rules FAR 117 - incomplete understanding by regulator of complexity of changes, lack of clear communications of "intent" of portions of the regulations</p>
<p>Better communciation more forewarning of change. Introducing training before the change is implemented</p>
<p>Change particularly within large organisations is rarely managed well, and safety implications do not appear high on the agenda</p>
<p>More effective and genuine consultation on changes and better education of the changes.</p>

<p>There have been times when several aspects of the operation have changed at one time. A better way to conduct this is to effect change in a staged manner, ensure suitable training/briefing is provided at each stage and allow time for the stages to become settled before moving onto the next stage.</p>
<p>Allow one change to 'bed in' prior to the next.</p>
<p>Take your time, resource the problem properly, new regulation is not the answer to change, and involve your people at all times.</p>
<p>Better communication by the Regulator, clear indication of what had changed v having to trawl through all the information. For multiple changes, consider a gradual phasing in of the new regs.</p>
<p>During airline mergers, pilots are asked to handle enormous amounts of change in a short period of time, (typically in order to "harmonize" the operation). I would mete these changes in much more gradually to effect a safer operation, as well as ensuring all of the changes were absolutely necessary.</p>
<p>Prior planning for implementation would have allowed for the information to be disseminated in chunks as opposed to all at once. This has also resulted in a very short timeframe to comply with the regulators requirements.</p>
<p>Not so much the amount of changes but Regulation coming into force without International or National Guidelines on what would actually be required. You cannot plan for something if you don't know what you are planning for. I think of ECCAIRS and MORs.</p>
<p>A phased introduction over an appropriate time period would allow for the changes to bed-in and their second-order or unintended consequences would then have been evident before additional changes were overlayed - this layering would mean that the effects were shielded from their causes and effective remediation was very difficult. As the overlaying would not yield the desired outcomes and could lead to MORE change, compounding the issue.</p>
<p>In the USA, the FAA often dumps new regulations on pilots without fully explaining them. The regulators could do a better job of providing online instruction, local presentations, or other instructional material so those subject to the regulation could better understand them - BEFORE the regulation is implemented.</p>
<p>Clearer explanation of the reason for the change.</p>
<p>When change is introduced it is important to explain why the change was made and how it will impact the operation.</p>
<p>Consult about changes before they are made. Role-play the changes at the [name redacted] to see what negative impacts the change will have before rolling them out and expecting the frontline to discover the problems with new regulation.</p>
<p>More gradual introduction and better training for all parties involved.</p>
<p>Begin earlier...as soon as you hear about the regulation change, rather than waiting until the last possible minute.</p>
<p>Applying basic concepts of project and change management</p>
<p>Chang followed by reversals has a long lasting effect of confusion. Such as LOAs and the recent Descend Via terminology confusion.</p>
<p>Most of the changes are not needed - we create huge organisations full of regulators who are going to do one thing. Many regulations have little or no improvement in safety.</p>
<p>Phased introduction and plain language</p>
<p>Regulations are published without understanding methods of compliance and the practicality of them. The states are represented as are trade bodies but the individual companies undertaking the tasks often are not. Therefore a detached view of what is possible is a risk.</p>
<p>Regulation changes in ATC tend to be delivered over a long time span and integrated into change projects. My experience is that we tend to be the creators of our own problems by looking to deliver too much change without having enough resource or time to cope with what we have set ourselves. we need to allow ourselves more bandwidth for the unexpected and the needs of the human in both accepting and delivering change</p>

Q4a - 1. If aviation were described as having a fly-crash-fly principle at the core of its safety management (i.e. an incident happens, cause identified, problem fixed, carry on flying), is there any other industry that you have experience of that can be described similarly?

Automobile industry, space flight, any engineering endeavor.
The medical profession is somewhat similar and it is good to see that there are now similar safety management practices coming into use - Medical Investigations similar to AAIB.
Fire and Rescue Services (Mainly Local Authority services due t a lack of incidents within the aviation RFFS)
Rail, marine, nuclear power, mining and extractive industries.
nuclear
Medicine
London Fire Brigade - not enough resource to take a holistic perspective, very reactionary. Get back up and running and carry on.
chemical engineering
manufacture(factory) - even surgery-....
Trains, ferries any form of transport (apart from Concord)
Most things in life are like that. Isn't that how children learn? We tend to think things will go well and we get religion when something bad happens or almost happens.
Spillages in the Oil Industry perhaps?
NHS - following incidents where for example operation instruments are left in body cavities post operation. Needles being used several times before replacement, slow urgent responses by ambulances to incident sites, patients dieing under whilst operations being performd. There are many such incidents. You cannot completely halt all medical procedures.
Rail network
Medical
Nuclear power.
Petrochemical, medical
No, but NASA got there after they lost the second Shuttle. Rail industry could be a good example.
Probably all transport systems have a similar approach.
Railways
Construction industry
I don't have experience in other industries but believe most other industries have a fly-crash-fly style of safety management - there is always a desire not to let the same incident happen again - but typically it does with slightly different circumstances.
Marine industry
Most industries would follow this principle. It is the learning from the incident which is important but usually, however serious, the incident does not necessarily mean the whole safety system is weak. Due to the many possible factors of an incident, it isn't appropriate always to stop operations. However, the Virgin Trains crash was the fault of another party due to poor maintenance, all operations on those same tracks had to be assured before they were permitted to operate again. But Virgin Trains did not stop operations across all its networks, just the effected incident track areas.
Health care
Air Traffic Control

Not to hand - possibly the oil industry - ie: oil rigs/refineries.
Oil industry
Surgery at hospitals?
Not directly, but the premise may apply to all industries with high potential risk and catastrophic outcomes.
rail
Most incidents are reactive until a management of change.
Auto racing
Formula One etc
Oil and Gas Refinement.
Rail Industry
Railways
Healthcare, maritime, railways, all the complex system with risks inherently embedded
The oil and gas industry
Training syllabus at CATCS. Changes to exercises. Change to achieve objective.
Petroleum exploration and transportation
The QMS has the same principle
NHS and their culture of keeping things 'hush hush' and the reliance on 'whistleblowers' to leak incidents to their Chain of Command or the press.
None that i can think of maybe the rail industry
I would say every other industry, you would be hard pushed to find one that doesn't operate that principle. Eat Mad Cows - Kill Mad Cows - Eat (not as) Mad Cows. Drive Car with false emissions - pay compensation, 'fix' fault - Drive Car with same emissions. Banks make bad investments, economy crashes - FSA intervene and make new rules - Banks still make bad investments!
NHS, motor, domestic appliance, electrical goods manufacturers, Amazon fulfilment centres
Medicine
Surgery
Medicine
The automobile industry could fall to this place, but the money spend on R&D is much less than the money spend on aviation. They can afford to crash test cars, it would be rather expensive to do the same with planes
Railways. Gas and oil.
Seems to be applicable to many industries: if it breaks during operation, find the fault, repair/improve and continue. Even in industries where the potential outcome of an accident are much higher than air transport (eg nuclear power plants), this principle is mostly applied (seldom, nuclear industry is stopped permanently on a permanent basis (even Japan restarted its nuclear production after Fukushima). I would however claim that the principle proposed in the question is not correct, as it suggests that safety is only done retroactively. There are proactive steps done to create, maintain and improve safety even if no crash happens.
We often correlate aviation safety to the development of vehicle safety. First we invented the seat belt, then that wasn't working so we improved the seatbelt, then we added in more and more safety features to improve the chances of surviving a motor vehicle accident.
Medicine but less advanced as in aviation, med still steep kind of military code followed the higher ranked person is (always) right...

Medicine
I believe the UK rail industry safety management approach is mature (RSSB)
Electricity Nuclear power plant operational activity (vs mainly ATC)
Winegrowing
Medical. Surgery etc.
Driving a car
Healthcare
US military aviation activities sometimes exhibit
Oil, space, railways etc, etc...
Auto, rail, space (virtually any form of transportation). Medical.
Automobiles
The rail industry!
Railways
Transportation generally
Formula 1, Transport, Health Service
I haven't worked in it but in my view the oil and gas industry used to be like this a few years ago.
Most of the transportation industry, all the down to the local level of placing stop signs and deciding speed limits.
The transportation industry. E.g. Train companies.
Automobile - I recall driving in the 1970's without seatbelts. Ralph Nader (US consumer advocate) literally changed the world in the automotive industry.
Commercial fishing, although sometimes they don't fix the problem, but still press's on.
Government counter terrorism
trains
Rail, marine, nuclear, oil and gas
Rail
Commercial Drivers
medical surgery
Any mass transportation industry
Any industry that has had a major disaster. Cross channel ferries etc.
Automotive
Auto
Medical industry
other transport industries such as rail or sea
NHS UK National Transport Merchant Shipping
Oil-industry
The hospital and emergency care industries are very similar that way. You can't stop treating people simply because there was an error made by a doctor or nurse. You just need to make sure that error is understood by all so that it does not reoccur.

Space, nuclear, petroleum, medicine, but problem fixed is not quite the correct description, its more like preventive measure adopted and shown to be useful.
Railroads
Space/Rocket launching is the easiest coordination. Also, Car industry tends to find a issue with their system then they fix it in either a recall or new car type/model. The Tech industry does this at a much higher rate and speed with new phones that fix flaws and security updates and patches to software.
Medical field / Automotive
Medical industry.
The only other industry I can think of is military where events have a post analysis to the point that aviation does.
Rail network
Accidents happen in construction and the causes are identified which results in a change of operation. E.g, fall from height & reversing vehicles are statistically the biggest killers, therefore working at height regulations have been tightened immensely and all vehicles have reversing beacons and awareness is promulgated.
Automobile, Vauxhall with Zafira catching fire.
All
I'm a former military guy (aircrew) but understand that all branches can operate in this manner in order to meet the objectives of the mission. Sports can also be similar, specifically related to appropriate follow-up on a serious incident and the follow-up undertaken by the league management to investigate, communicate, debrief and move forward.
Seagoing ships, railroads, trucking industry.
automotive
Yes. Engineering works on the same principle. And medical world as well.
Railways.
Police, firefighters, and almost anywhere humans have to make split second decisions
Public train transit
Most factories I have been associated with have similar safety rules/procedures in place and react similarly to aviation industry when an incident/accident happens. Makeparts-accident-makeparts, etc...
Many other industries still go with this principle : road railroad and maritime traffic, pharmaceutical industry and hospital operations,
Oil and Gas
Medical
Trucking industry. (Goods Transportation).
Most construction industries, Petrochemical industry
Rail
All transportation industry operates under this premise
Medicine
British Waterways
The automobile industry. They issue multiple recalls based on problems that have occurred.
An SMS is proactive, so Fly-Crash-Fly is not the core of an SMS.
Yes - the Automotive industry is even worse.
The banking sector

The health care system (hospitals) is working on that way.
rail
Rail?
Rail
Medical
yeah most biz sectors
maritime, rail, chemical incidents.
Finance
Rail Industry
All industries are subject to this analogy. Aviation, perhaps more than most others, dedicates much effort to FMEA and identification of potential failures prior to implementation. The cycle of process implementation - process failure - corrective action - process reimplementation is a fundamental principle to Quality.
No. The approach to learning from events is being heralded as the way forward. In areas like medicine, there is a tendency not to learn from event - see 'Black Box Thinking'
Automotive, trucking, railways, maritime, military, background checks for people that coach/teach children
Oil and Gas
most !!!!!!! when there should actually be a proactive, preventive element...
Car industry eg recalls initiated in response to technical failings.
The motor industry wrt recalls for major issues that have caused crashes.
until the 1980's F1 Motor racing
No experience of, but I think the rail industry do.
Maybe car manufacturing industry?
Healthcare definitely should be this way. Their safety management and reporting system is way behind aviation, but could benefit from a similar model.
Rail industry.
Oil and gas service and support.
The manufacturing industry is the same. We see a number of product recalls occurring after a series of incidents. The recalls occur after the problem has been identified and problem fixed.
almost all other industries - automotive, oil field, medical, etc.
Oil Industry
Pretty much any transport industry could be said to operate on this mantra. No point changing something or putting a barrier in if there is deemed to be no reason. Only once the incident has occurred is there a reason to safeguard against its' repeat.
Not personally, but the rail industry was clearly in this situation.
The automotive industry- car gets released to market, car has safety issue that keeps occurring, car gets recalled to manufacturer, problem gets fixed, car released back to the market.
Rail
Rail industry.
Race car industry
The medical industry.

Oil, mining, construction, public transport.
Military logistics
I don't agree that aviation has a fly-crash-fly principle these days. The world has changed since that was true, and most aviation organizations are much more proactive. Fly-crash-fly is embodied in the older, more reactive methods of the past.
Railways in Canada have in recent years adopted this approach.
Any other high risk industry such as rail or oil and gas.
The Oil industry, in particular the North Sea Oil industry has had to learn from accidents and incidents and carry on producing.
Hospital emergency rooms
Oil and gas
Oil and gas Hospitals
The Military and the Oil and Gas industry
Healthcare and how they identify medically induced errors.
Surgery
All forms of transport - car, train etc. Nuclear, oil and gas.
Rail, maritime
Railways

Q4b - 2. If you know one, please give an example of how a non-aviation related industry deals with, or anticipates, an increase in risk:

Finance
Carrying out Hazard Operations analysis prior to carrying out new procedures or designing new facilities. These tend to take place in oil and gas as well as the chemical industry.
The onshore mining industry is very risk aware and active in identifying and managing risk. EG: they have developed a TCAS type system for both light and heavy vehicles on a mine site to avoid collisions and fatal accidents.
powerplant crisis management exercises
Data analysis
Generally ongoing training but with the back up of Insurance with the insurance industry tending to drive safety standards.
Oil & Gas
The insurance industry gathers more robust data on a given activity and based on their calculations, increases the cost of insurance for areas where they perceive higher risk or unknown risk.
Clinical risk management, in increasing drugs to registered users to stop them solving their addiction thirst by robbing and potentially killing for their drugs/money.
The nuclear power industry has many parallels to aviation. They have learned the hard way in several high profile incidents. Future risk is never easy to quantify - you think you have all the angles covered then Fukushima happens. the report identifies Japanese culture as a factor - something which would not be readily apparent to the individuals trying to manage risk as they were a part of that culture. To them, it was the norm.
Petrochemical industry began to utilise a formalised SMS approach in the 1980s following the Piper-Alpha disaster. Medical only really began to become 'risk aware' in the 2000s. However, both industries use approaches that are analogous to the SMS operation witnessed in aviation.
I'd suggest looking at Network Rail, perhaps Maritime Industry or certainly Oil, Gas and Chemicals industries.
As a building increases in size and height the risks increase
Police - when they have an increase risk of a terrorist attack they deploy more staff into key areas. Typically the threat dissipates, the police are withdrawn and then the attack comes (when it wasn't expected).
The security services often address differing levels of security and the significance of a threat. Much could be said about examples but the subject matter is vast and examples can be complex.
Offshore oil drilling. Deepwater Horizon.
Hospital procedures where possible medical misadventure investigated and procedures are amended to better mitigate against future risk. I understand that Christchurch hospital look at CRM and TRM in aviation to better address their team work in surgery etc.
Medical industry
NACAR and all auto racing try to decipher limitless possibilities that could happen in any accident and what could be done to minimize any injury and make things safer
Similar to aviation, but the risk to drivers remains in order to generate the excitement for the paying spectators - subtle but different expectations and tolerabilities.
All the industry using an SMS
Oil and gas. Due to the dynamic environment, volatile product, geographic locations and geopolitical considerations, risk is an inherent factor in production. Consequently a large percentage of the planning to the end user involves active understanding of the acceptable level of risk, with mitigations available.
Manegement by ISO 9001 is very usefull

Oil industry. very very HSE aware. However, not necessarily a good example of an industry who has got it right!
Amazon used examples of non-compliance to safety regulations with dismissal as gross misconduct. No human factors investigations, just blame culture.
Hospitals roster more staff at A&E on Saturday nights
nuclear power plant finding technical issue potentially degrading material properties and hence strength of power vessel. Research is done to confirm issue, quantize it and safety assessment is repeated based on new information in a quantitative and non-quantitative way.
Consult the RSSB
Same initial statements, training,rating,standard check,safety assesment...etc
The wine industry has a volumetric risk assessment process. The higher the volume the greater the risk to a compromise in food safety. On the one hand the Government increased Excise and alcohol tax and the industry introduce Wine Safety Management Planning processes and compulsory audits undertaken by non-industry auditors. Value - Very Little; Safety improvement - Sameoh, sameoh; Risk Management - Minimal; Compliance Cost - Significant; Risk Management - Lost in translation.
In my opinion and experience, they don't. A surgeons decision is final and unquestioned. If a surgeon makes a mistake, it's almost always put down to 'complications'. The risk is never dealt with and therefore never articulated or managed.
Health care and needle stick injuries. They have largely removed needles from as many areas as possible to reduce the risk of needle stick injuries.
Rail 'yellow book' guidance Embedded within Nuclear regulations
Use of crash testing dummies in automobile design testing.
Product recalls
The Railway Industry
Health Service - Theatre rooms have been redesigned to help Theatre nurses. Certain medical equipment has coloured power leads, power plugs and plug in points to more easily identify which plug should be used to speed up . This is example of larger scale re- design of procedures and policies within theatre which have come as a direct result of failings wiithin location and process which led to greater risk for patient.
Local, county, state and federal governments use this philosophy for the management of all roadways by maintaining statistics on accidents and where they occur. Enough carnage and signs are placed, lights are hung, roadways are improved and limits are enforced.
I worked recently with [name redacted] to introduce them to the BowTie concept. This is also true of the UK Road Safety Team who are still operating in the 1980s space.
Automobiles. Airbags are now mandatory in new cars. ABS, seatbelts, better lighting systems for night driving, ergonomically designed seats and dashboards, tempered glass, puncture-resistant tires / gas tanks, GPS (accident location) etc.
Avalanche experts are outstanding risk managers. Check out the Alaska Avalanche school...they have some great RM material.
Graduated response/gradual escalation of risk sign off dependent on changing scenarios. Ability to react quickly and sign off risk at appropriate level
Training
Rail
Driver training courses and refresher courses.
medical surgery has less risk managment than aviation, and more cover-up than investigation
The health service reminds those at risk over flu season to get their jabs.

Automotive, however a fly-crash can work well with automotive, but not with aviation. This is because most automotive accident are not deadly. In aviation too much accidents and loss of life well happen, especially with the increased use of digital technology.
relying on traffic lights for bi-directional single track rail operations
Private / Corporate Security Financial Industry - although here risk and reward arguments have a tendency to compete in perverse ways such that some "risk managers" may see an increase in risk as a premonition of an opportunity!
Hospitals have adopted surgery checklists much like the airlines so that simple mistakes are not overlooks and caught early.
BNSF Railways has recently started using Unmanned Aerial Vehicles(UAV) to exam track before a train uses the track looking for problem spots. The use of UAVs enables BNSF to examine three times as much track than a track team could. This has reduced the likely hood of track related derailments.
Rocket/Space launches delay the launch until another day. Car industries add in systems.
Medical industry.
Network Rail appears to strive for a similar safety management culture as aviation.
The construction industry looks at accident statistics determine areas of risk, just like aviation.
Use of warranty to replace defective parts
Center of gravity, weight and balance coefficients for designs in new ships.
most industries apply regulations in order to avoid costly litigation. Money drives safety
Routine maintenance often lead to overlooking possible future causes of fatal incidents. Therefore external random inspections have become excellen tools to deal with potential risks. The objective evaluation and input from a 3rd party can sometimes highlight a potential risk in routine tasks. During management meetings of our Bible School we often invite external lecturers to evaluate our methods and material in order to identify potential risks.
Again my neighbor owns a diecast factory and deals with this issue daily. When new equipment is implemented or a new method of dealing with a part or parts is considered.
Any industry should identify the hazard and treat the risk appropriately.
Petrochemical industry
They don't as far as I can see.
Due to a perceived increase in risk to its users (in part due to poor design) British Waterways have implemented what is effectively an MOT for boats which helps owners identify poor safety design and to drive change to unsafe designs. An example of this is the introduction of a regulation to have different nozzle diameters for fuel and water - thus reducing the likelihood of fuel coming out of drinking water taps. This is a very real example and has unfortunately led to multiple fatalities in the past.
Police and medical
Some self-driving car manufacturers are accepting unnecessary risk involving human life!
If there is an epidemic infection they identify the source and type of infection, isolate it and simultaneously start begin healing the sickness.
rail industry, the number of maintenance planning and reliability engineers recruited to support the development of aviation style maintenance programmes
When manufacturing acquires a new machine.
Just culture utilized to help promote medical event reporting and assess a root cause from which broader learning points for the organization can be gleamed or policies developed or altered to increase safety
regulations work for regulated industry - now as an example SEC in US is for control of securities - yes not maybe . regulation is for CYA work is not for mitigation oftentimes
Sporting/events industry - crowd control measures depending on type of event, http://www.crowddynamics.com/crowd-modelling-simulation.php

Regulation, oversight, criminal action
Automotive - FMEA analysis, process measurement to identify anomalies and develop process improvement or corrective actions.
Highway perhaps? The recent changes to motorways to change the type of barriers in use could be an example. If this was not a safety related change why is it being done?
mining, construction, rail transport in most cases and at least on paper have similar visions, however less urgency attached generally
The outdoor industry conducts daily risk assessments prior to undertaking any activity - this takes into consideration all factors such as weather, location, experience of participants etc.
F1 cars are now over-engineered to protect the drivers, the courses are now over-engineered to protect the crowd. This is only possible because of the massive commercial value of the races.
Many recalls from motorcycle and car manufacturing industry.
Well the land transport ministry deals with road "risk" in a very different way to aviation. Deaths on the road seem to be an accepted (if undesired) part of life. Campaigns to reduce speed, drink-driving, poor driving etc. seem to continually fail to deliver credible improvements. If aviation had as many fatal accidents as our roads we would be under intense scrutiny - it seems that perception plays a major part here - a "air proximity" incident will make headlines with demands of please explain. Where another fatal road accident is just considered a statistic that barely gets a mention.
The development of hazard management programs such as the rail and nuclear industries.
The nuclear power generation industry is better at dealing with risk. The environment in which they operate is more stable with less changes compared to commercial aviation. The consequences of their actions have a wider impact to an entire region plus the lack of competitors allows the more time to anticipate potential hazards and stopping manifestation of these risks.
I would say most organisations are reactive in the way they deal with risk, in that an accident happens and only then do they pay it appropriate attention and only for a short period of time
The maritime tanker industry ensured safer standards for tankers as the vessels got bigger to safeguard against catastrophic environmental damage. I.E. a small tanker running aground would spill less oil than a super-tanker, hence the improvements in hull design. Although the Exxon Valdez obviously had an effect on this improvement as well, even could have been the catalyst for it.
Most small businesses will have a Risk Management plan that will be reflected in the business plan. This plan should be live and constantly updated to deal with changing markets etc They will have a detailed insurance plan that will help to financially offset any unforeseen risk and employees should all be trained to understand and deal with relevant risks to the business.
Safer barriers on race tracks after fatal crash. Hans device required for drivers before and after fatal accidents.
The medical industry closely parallels the aviation industry in using an HFACS type of approach to risk-management.
Again, the common theme here is SMS. Oil, mining, construction, and energy are all required to have some form of basic SMS. This is particularly true for the energy industry post Chernobyl.
Railways, marine operators, and commodity pipelines have all adopted this approach in Canada.
The medical profession is woefully short of the regular and structured exchange of information, implementation of changed procedures that might be necessary and takes little account of the principles of Crew Resource Management.
Through good communication and use of the awareness of team dynamics.
poorly
Medical field and much human error research is conducted there.
Research, proactive use of other industries safety lessons

Appendix G - Corroboration of the interview analysis

The extracts from the interview reports at Appendix C were sent for independent analysis to a researcher in New Zealand, who is a retired Air Traffic Controller and has recently completed a master's degree in Air Safety Management.

Originally, the eight 'suppositions' referred to in this thesis were termed 'hypotheses', but to avoid confusion with hypotheses used for statistical testing in the quantitative analysis, the word was latterly substituted. This occurred after the corroboration was conducted, and so the terms hypothesis/hypotheses/H_n exist in this Appendix, despite being presented as supposition/S_n elsewhere in the thesis.

A table containing the objectives and hypotheses was sent to the independent analyst, together with Appendix C and Appendix B for context and background. The analyst was asked to complete column five with their comments on whether there was evidence in the interview reports to support the hypotheses or not.

The analyst returned a completed MS Word document, which was then exported as a pdf to be archived on the University of Portsmouth drive. Screenshots of the five research objectives are included in the following pages.

Obj _n	Objective	H _a	Hypotheses	Is there an answer in the interview reports? Independent Analyst Comments
1	Determine if there is a correlation between an increase in the likelihood of an Airprox and changes to aviation regulation.	1	The introduction of regulatory change can increase the likelihood of an Airprox.	<p>A: Nil B: Nil C: Limited information. D: Stated that the introduction of new regulations can have an impact safety. Stating further that if regulatory change was "poorly introduced and could have caused an accident". E: Nil</p> <p>The information that D was singular and not corroborated in any other interview report, therefore the Hypothesis NOT ANSWERED.</p>

2	Assess if individual endeavour and management practices can enhance safety when introducing regulatory change in aviation.	2a	Errors occur, but only if left unmanaged do they increase risk.	<p>A: Nil</p> <p>B: Stated that as “humans inconsistent machines” errors were inevitable. It was further stated that the “management of errors important”.</p> <p>C: Confirmation. Correlated majority survey view.</p> <p>D: No comments directly relation to the hypothesis.</p> <p>E: Confirmation. Stating that “errors always an inevitability”.</p> <p>From evidence from interviews the hypothesis APPEARS TO BE TRUE.</p>
		2b	Humans make safety through their efforts and expertise; this implies that new regulation can be safely introduced through human endeavour and training.	<p>A: Nil</p> <p>B: Stated that this can only be achieved through leadership; “individuals at management level can make a difference”.</p> <p>C: Correlated majority survey view</p> <p>D: Nil evidence found.</p> <p>E: The hypothesis could not be fully corroborated but leadership was mentioned and “subsets of effort”.</p> <p>Combining the key points from B, C and E led me to believe that the hypothesis APPEARS TO BE TRUE.</p>

3	Analyse whether humans are the weak-link in the aviation safety chain.	3a	It is widely considered in the aviation industry that eradicating Human Error will achieve safety of operations.	<p>A: Stated that the “overall system intrinsically safe”.</p> <p>B: Stated that “humans will always be involved” and therefore Human Error will always occur. “Assurance not yet satisfactory”.</p> <p>C: There will always be a human in the chain somewhere.</p> <p>D: Nil</p> <p>E: Mostly safe, but not possible to completely remove error in the workplace.</p> <p>There was some support for this hypothesis during the interview, however, and on balance, interviewees stated that the human element will always be there and therefore the hypothesis APPEARS TO BE FALSE.</p>
3b			Humans can be subject to information overload during regulatory change.	<p>A: Stated this was “unsurprised” and gave a number of examples.</p> <p>B: Stated that this was true and added that they “felt overloaded themselves at times”, thus giving first hand evidence of the problem.</p> <p>C: Additional corroboration of the statement and again gave a personal account of being overloaded.</p> <p>D: Agreed with the statement and added that the AIRAC cycle induces overload.</p> <p>E: Reported overloaded by regulatory change.</p> <p>There was overwhelming evidence in interview that the hypothesis APPEARS TO BE TRUE.</p>

4	Assess if there is an active culture of learning from incidents within aviation.	4a	There is a temptation to rationalize every incident with hindsight bias and not acknowledge that some events are 'Black Swans'.	<p>A: Clear from interview that this was an emphatic 'yes' to hindsight bias.</p> <p>B: Stated that there was 'no blame' and that their process was to "identify which risks are important" and to train in order to mitigate or reduce these risks. It was stated that training against bias could be better.</p> <p>C: Correlated majority survey view.</p> <p>D: Stated that it was realistic to be biased.</p> <p>E: Stated that Black Swans events "were not at all appropriate in aviation".</p> <p>Evidence from all 5 interviews seemed identified that The hypothesis APPEARS TO BE TRUE.</p>
		4b	The capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome.	<p>A: Dismayed at the people who said 'rarely'.</p> <p>B: Best run SMSs knows key risks and collects appropriate data. B stated that there was a danger of too much data not enough analysis.</p> <p>C: Debate on the realistic utility of capturing all of the trivia.</p> <p>D: Stated that the process was to "capture evidence of near-misses and perform trend analysis".</p> <p>E: Law of diminishing returns, when have you got them all captured.</p> <p>In general, the hypothesis APPEARS TO BE TRUE, although the interviewees seemed to suggest that there was a balance of effort vs reward, rather than capturing all minor inconsequential errors.</p>

5	Determine if changes are required to regulations to integrate drone operations.	5	There is not enough regulation on the use of drones and more is needed urgently.	<p>A: Stated that more was needed urgently.</p> <p>B: Stated that most were fit-for-purpose but need some form of tweaks.</p> <p>C: Need some bolstering.</p> <p>D: Stated that “current regulations were confusing” and need development but not too much regulation.</p> <p>E: Far wider than drones, “the entire regulation set needs boosting”.</p> <p>The hypothesis APPEARS TO BE TRUE, although perhaps ‘urgently’ not necessarily agreed with by the interviewees.</p>
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Appendix H – Crosstabulation Results

Q3b3) In your organisation, is it normal to apportion blame to an occurrence? * Country where survey conducted Crosstabulation

	AE	AL	AU	BB	BE	BR	CA	CH	CO	CY	DE	ES	EU	FI	FR	GB	GF	GR	HK	HN	HT	HU
Q3b3) In your organisation, is it normal to apportion blame to an occurrence?	2	3	0	1	0	0	1	0	0	1	1	2	0	0	1	24	0	0	1	0	1	0
Count	2	3	0	1	0	0	1	0	0	1	1	2	0	0	1	24	0	0	1	0	1	0
% within Q3b3)	2.6	3.8	0.0	1.3	0.0	0.0	1.3	0.0	0.0	1.3	1.3	2.6	0.0	0.0	1.3	30.8	0.0	0.0	1.3	0.0	1.3	0.0
% within Country	25.0	30.0	0.0	14.3	0.0	0.0	14.3	0.0	0.0	14.3	50.0	100	0.0	0.0	12.5	11.1	0.0	0.0	25.0	0.0	100	0.0
% of Total	0.5	0.7	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.5	0.0	0.0	0.2	5.8	0.0	0.0	0.2	0.0	0.2	0.0
No	3	3	0	3	1	8	1	4	0	2	0	0	1	0	3	136	0	0	1	1	0	1
Count	3	3	0	3	1	8	1	4	0	2	0	0	1	0	3	136	0	0	1	1	0	1
% within Q3b3)	1.5	1.5	0.0	1.5	0.5	4.0	0.5	2.0	0.0	1.0	0.0	0.0	0.5	0.0	1.5	67.3	0.0	0.0	0.5	0.5	0.0	0.5
% within Country	37.5	30.0	0.0	42.9	100	100	57.1	0.0	0.0	28.6	0.0	0.0	100	0.0	37.5	62.7	0.0	0.0	25.0	100	0.0	100
% of Total	0.7	0.7	0.0	0.7	0.2	1.9	0.2	1.0	0.0	0.5	0.0	0.0	0.2	0.0	0.7	32.9	0.0	0.0	0.2	0.2	0.0	0.2
Some times	3	4	1	3	0	0	2	1	1	4	1	0	0	1	4	57	1	2	2	0	0	0
Count	3	4	1	3	0	0	2	1	1	4	1	0	0	1	4	57	1	2	2	0	0	0
% within Q3b3)	2.3	3.0	0.8	2.3	0.0	0.0	1.5	0.8	0.8	3.0	0.8	0.0	0.0	0.8	3.0	42.9	0.8	1.5	1.5	0.0	0.0	0.0
% within Country	37.5	40.0	100	42.9	0.0	0.0	28.6	100	100	57.1	50.0	0.0	0.0	100	50.0	26.3	100	100	50.0	0.0	0.0	0.0
% of Total	0.7	1.0	0.2	0.7	0.0	0.0	0.5	0.2	0.2	1.0	0.2	0.0	0.0	0.2	1.0	13.8	0.2	0.5	0.5	0.0	0.0	0.0
Total	8	10	1	7	1	8	1	7	1	7	2	2	1	1	8	217	1	2	4	1	1	1
Count	8	10	1	7	1	8	1	7	1	7	2	2	1	1	8	217	1	2	4	1	1	1
% within Q3b3)	1.9	2.4	0.2	1.7	0.2	1.9	0.2	1.7	0.2	1.7	0.5	0.5	0.2	0.2	1.9	52.5	0.2	0.5	1.0	0.2	0.2	0.2
% within Country	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
% of Total	1.9	2.4	0.2	1.7	0.2	1.9	0.2	1.7	0.2	1.7	0.5	0.5	0.2	0.2	1.9	52.5	0.2	0.5	1.0	0.2	0.2	0.2
IL	0	0	0	1	0	0	1	0	0	3	0	2	1	0	0	0	0	0	0	31	1	78
Count	0	0	0	1	0	0	1	0	0	3	0	2	1	0	0	0	0	0	0	31	1	78
% within Q3b3)	0.0	0.0	0.0	1.3	0.0	0.0	1.3	0.0	0.0	3.8	0.0	2.6	1.3	0.0	0.0	0.0	0.0	0.0	39.7	1.3	100	
% within Country	0.0	0.0	0.0	100	0.0	0.0	100	0.0	0.0	12.5	0.0	100	33.3	0.0	0.0	0.0	0.0	0.0	47.0	50.0	18.9	18.9
% of Total	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.7	0.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	7.5	0.2	18.9	18.9
No	1	1	0	1	2	0	0	1	3	6	1	0	1	1	1	0	2	0	12	1	202	202
Count	1	1	0	1	2	0	0	1	3	6	1	0	1	1	1	0	2	0	12	1	202	202
% within Q3b3)	0.5	0.5	0.0	0.5	1.0	0.0	0.0	0.5	1.5	3.0	0.5	0.0	0.5	0.5	0.5	0.0	1.0	0.0	5.9	0.5	100	100
% within Country	100	100	0.0	100	66.7	0.0	0.0	100	100	25.0	100	0.0	33.3	100	100	0.0	100	0.0	18.2	50.0	48.9	48.9
% of Total	0.2	0.2	0.0	0.2	0.5	0.0	0.0	0.2	0.7	1.5	0.2	0.0	0.2	0.2	0.2	0.0	0.5	0.0	2.9	0.2	48.9	48.9
Some times	0	2	0	0	1	0	1	0	0	15	0	0	1	0	1	1	0	1	23	0	133	133
Count	0	2	0	0	1	0	1	0	0	15	0	0	1	0	1	1	0	1	23	0	133	133
% within Q3b3)	0.0	0.0	1.5	0.0	0.8	0.0	0.8	0.0	0.0	11.3	0.0	0.0	0.8	0.0	0.8	0.8	0.0	0.8	17.3	0.0	100	100
% within Country	0.0	0.0	100	0.0	33.3	0.0	100	0.0	0.0	62.5	0.0	0.0	33.3	0.0	100	100	0.0	100	34.8	0.0	32.2	32.2
% of Total	0.0	0.0	0.5	0.0	0.2	0.0	0.2	0.0	0.0	3.6	0.0	0.0	0.2	0.0	0.2	0.2	0.0	0.2	5.6	0.0	32.2	32.2
Total	1	2	1	1	3	1	1	1	3	24	1	2	3	1	1	1	1	2	66	2	413	413
Count	1	2	1	1	3	1	1	1	3	24	1	2	3	1	1	1	1	2	66	2	413	413
% within Q3b3)	0.2	0.2	0.5	0.2	0.7	0.2	0.2	0.2	0.7	5.8	0.2	0.5	0.7	0.2	0.2	0.2	0.2	0.2	16.0	0.5	100	100
% within Country	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
% of Total	0.2	0.2	0.5	0.2	0.7	0.2	0.2	0.2	0.7	5.8	0.2	0.5	0.7	0.2	0.2	0.2	0.2	0.2	16.0	0.5	100	100

Appendix I – Case Study on the introduction of SERA regulation

Background

For many years, ICAO has tried to harmonise the rules of the air in order to allow cross-border flights to occur safely around the world. Prior to 2012, a study conducted by the European Commission, Eurocontrol and EASA found that there were over 1700 national differences to these ICAO regulations in European Member States, the reason for many of which could not be found (EASA, 2012a). Although pilots were required to have studied these differences before international flight, “in practice no pilot could realistically be expected to know them all when flying across several states” (p. 2). The first part of the Standardised European Rules of the Air regulation was designed to remove 760 of these differences, and Commission Implementing Regulation (EU) No. 923/2012 became European Law on 4 December 2012, albeit with Member States allowed two years’ derogation, which the UK implemented (CAA, 2014c).

The CAA therefore decided to implement the first two parts of SERA on 4 December 2014, but all aeronautical documentation is amended as part of an AIRAC cycle, with the nearest change being 13 November 2014. There was some confusion in the community as to what the date of implementation was (Spry, 2014b) and whilst many documents were amended in November, official SERA adoption was scheduled to remain as 4 December. Even though SERA became UK law on the implementation date, many elements of the industry were not ready, and the CAA issued a two-month exemption to compliance, and the MAA held off publishing its new regulations awaiting further clarity. The MAA even withdrew Notice of Proposed Amendment (NPA) 14/19, which was supposed to update the Rules of the Air Regulatory Article (RA) 2307, after a meeting with the CAA on 17 November 2014. Furthermore, the CAA itself was not formally recognised as a competent authority to issue permissions or exemptions under SERA until the Air Navigation Order was changed on 10 December 2014. An interim exemption was issued by the CAA for the period 4 – 10 December 2014; this was publicised in their Safety Notice dated 5 December (CAA, 2014c). Further complication arose when the MAA had to delay the changes to the Air Traffic Control series of regulations that were due to come in to force on 12 January 2015 as these referred to the SERA changes, which had not yet been implemented at this point (Spry, 2014a).

The changes brought about by SERA parts A and B were fully implemented on 2 April 2015 (CAA, 2015b; Drake, 2015) even though the Statutory Instruction for the new Regulations on Rules of the Air 2015 (UK Government, 2015) didn’t come in to force until 30 April 2015.

An example of the introduction of SERA changes at a UK military aerodrome

Three months prior to the original planned introduction of SERA (4 December 2014), the staff in Air Traffic Control analysed the SERA documentation to look for the changes therein that would affect the flying community at that Unit. These were assessed as:

- Quadrantal rules to be replaced by Semi-Circular cruising levels.
- Formation Flights.
- Minimum heights over built-up areas.
- Withdrawal of the Right-Hand rule.
- Amendment to right of way on the ground.
- Aerodrome Markings.
- VFR at night.

- VMC criteria.
- Special VFR.
- Reclassification of the London Control Zone (CTR) from Class A to Class D.
- Replacement of Class F airspace – some to be reclassified as Class E whilst some removed completely.

The amended RA2307 was due to be released ahead of the original date in order to provide greater military specific detail. This was subsequently withdrawn during the delays and re-issued in time for the final introduction of the changes. ATC supervisory personnel were told to ensure that all of the controllers were verbally briefed on the expected changes prior to implementation. Additionally, a group brief was scheduled to allow an opportunity for discussion and to clarify any misunderstandings. Squadron liaison officers were told to go out and brief their respective squadrons prior to the end of October 2014, reporting back via the feedback form provided when complete. After the delays, liaison officers were expected to remain engaged with their squadrons (normal business anyway) and keep them apprised of the developments.

None of this was mandated but seemed to be good practice. Most the feedback forms reported engaged squadron personnel who knew that the changes were coming but appreciated the effort that ATC had gone to by briefing them and in most cases, had gleaned an extra nuance or two that they had not noticed themselves. Pertinent extracts from the feedback forms are replicated below:

A squadron was disappointed at the lack of information flow from headquarters, the only information received was from ATC and online reading. Aircrew voiced concerns regarding changes to rights of way on the ground. Raised further concerns about the lack of information flow in regard to SERA Part C because they had found some information on the internet that concerned them; they were briefed that this wasn't due to be implemented until 2017.

A separate squadron reported "No specific SERA feedback as it is reasonably uncomplicated."

A third squadron asked if the changes would be reflected in regulations and whether SERA would come in to force on time? The squadron were already well prepared, as they were due their routine assurance visit, but were most concerned about the confusion over the date of implementation.

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Appendix J – Article for Pakistan International Airlines safety magazine

An article about the research was accepted as the lead article for the July 2017 issue.





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Change on Air Safety

By Ian Fyfe-Gree BSc MSc CMgr FCFI FInstLM, post-graduate student at the University of Portsmouth, England | www.ifgairsafety.co.uk | ian.fyfe-green@myport.ac.uk

Introduction:

September 11th 2001 was not the first time in aviation history that an act of terrorism caused the deaths of hundreds of innocent passengers. The Lockerbie disaster in December 1988 was not the first time that a PanAm jumbo jet had crashed killing every passenger on board. In March 1977 at Los Rodeos airport in Tenerife two heavily laden airliners collided on the ground killing 583 people as a result of a series of events, each of which potentially insignificant, but when combined in sequence formed a catastrophic chain of errors. In October 2001 a Scandinavian Airlines MD87 collided with a Cessna 525 on the runway at Milan Linate killing 114 passengers, crew and ground staff and in 2002 a mid-air collision over Uberlingen between a Boeing 757 and a Tupolev TU164M killed 71 more. Lessons were clearly not being learnt and operational safety was being compromised. Is failure inevitability in a complex and hazardous industry?

Literature Review:

Busby and Bennett identify a number of determinants that were causatory to the Uberlingen mid-air collision, categorising them as 'functional' or 'behavioural' (2007). Within the functional section, they list interactions between systemic fault and structural vulnerabilities, whilst in behaviours they cite a lack of professional rigour and redundancy, with evidence directed towards management failures. Similarly, with the runway collision at Linate, they list evidence that exactly correlates with the categories found from Uberlingen, with structural, managerial and individual behavioural traits or faults. The prevention of incidents relies on the continuous monitoring of safety as a dynamic phenomenon (Mearns, Flin, & O'Connor, 2001). To achieve the right balance of attitude and belief, the perception of risk must be shared between employees and management. This shared responsibility shows how conflict and misunderstanding can be linked to the concept of Crew Resource Management (CRM) in human factors training.

Labib suggests that near-misses can be presented as either failures or successes dependent on the interpretation applied to them, including the interpretation of the word failure itself (2014). He also suggests that whereas a high impact low frequency event can be disastrous, it is repeated high frequency events that indicate a failing Safety Culture.

Kontogiannis and Malakis (2009, p. 693) argue that "total elimination of human error may be difficult to achieve" and that the cognitive strategies associated with the detection of error, alongside a safety culture, form the basis for training in error management.

When learning from failures, it is noted by Olive, O'Connor & Mannan (2006) that immediately after an incident the focus will be to change the safety climate within an organization. However, if the safety culture is not robust enough to support the climate then any changes could prove futile. They offer an example of this as being the "duality of the Challenger and Columbia disasters experienced by NASA" (p. 133). Labib describes in the analysis from the two space shuttle accident reports, the flawed decision making processes that were found in both, including a lack of foresight and hindsight, with no assimilation of the lessons identified in the earlier accident. It was concluded in the analysis that both reports were caused by human error and extremely similar, showing that learning had not occurred. With regards to the safety climate, the point is made that for an organization whose values are founded on curiosity of the universe NASA seemed unable to apply this same inquisitiveness and scientific rigour to itself (2014). The same similarities can also be found when looking at other organizational accidents such as BP with Texas City and Deepwater Horizon. Labib (2014, p. 77) lists lessons learned in the latter which include a lack of effective communication, poor safety management and "insufficient organizational cultural change". Inconsequential errors need to be captured and reported in order to prevent a future version of events where the outcome could be very different. It is Labib, in describing learning from error, that mentions Black Swan events with Taleb (2007) explaining the principal of a Black Swan as being an outlier when considered against the field of normal expectation, usually because there was no indication beforehand of its possibility. He also states that Black Swan events have enormous impact and that human nature will often try to rationalize the incident with hindsight with no

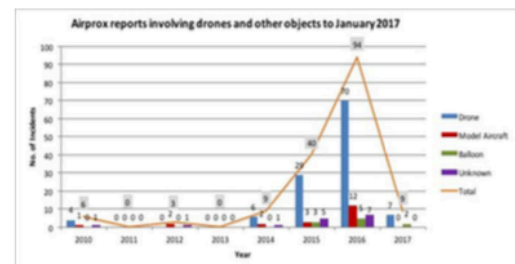
assimilation of the lessons identified in the earlier accident. It was concluded in the analysis that both reports were caused by human error and extremely similar, showing that learning had not occurred. With regards to the safety climate, the point is made that for an organization whose values are founded on curiosity of the universe NASA seemed unable to apply this same inquisitiveness and scientific rigour to itself (2014). The same similarities can also be found when looking at other organizational accidents such as BP with Texas City and deep water horizon. Labib (2014, p. 77) lists lessons learned in the latter which include a lack of effective communication, poor safety management and "insufficient organizational cultural change". Inconsequential errors need to be captured and reported in order to prevent a future version of events where the outcome could be very different. It is Labib, in describing learning from error, that mentions Black Swan events with Taleb (2007) explaining the principal of a Black Swan as being an outlier when considered against the field of normal expectation, usually because there was no indication beforehand of its possibility. He also states that Black Swan events have enormous impact and that human nature will often try to rationalize the incident with hindsight and therefore attempt to make it predictable. Labib uses this term in relation to High Reliability Organizations (HRO) and specifically when describing the events at Fukushima (2015), which Taleb describes as extremist in that Black Swans occur infrequently, but have enormous consequence on history. Taleb (2007, p.xi) questions what the lessons learnt from 9/11 were, saying that this should ideally be "that some events, owing to their dynamics, stand largely outside the realm of the predictable". He opines that instead of this the lessons learned are entirely related to the precise avoidance of terrorism with relation to tall buildings. He goes on to say that "we do not spontaneously learn that we don't learn that we don't learn."

The aviation industry has for many years been subject to a steady change in its regulations. Transformational changes of regulations can involve completely new strategies and involves organizations doing things differently rather than just better. Kotter's model of change is considered by Flouris & Kucuk Yilmaz to emphasise that an organization confronted with transformational change must consider a "reworking of the organization's mission and strategy, its leadership and its organizational culture" (2009, p. 12). They conclude by stating that "holistic change management integration" (p.14) is required in order to introduce change without increasing risk. For any system to be considered truly functional, it must look from the perspective of overall assessment of all elements including the interactions between the human and technical systems (Cacciabue & Vella, 2010).

Furthermore, it is suggested that to do this there are two paramount points that must be compared, how risk is evaluated and how this evaluation is audited.

It is these different perspectives on risk and safety between managers and workers that underpins the theoretical framework analysis in the Bakx and Richardson paper looking at risk assessments in the Royal Netherlands Air Force (2012). They believe that significant factors in risk assessments can perceptually vary dependent on hierarchical level, citing the difference between an operator who physically bears the operating risk vice the level of risk that management deem acceptable. The acceptance of this risk therefore depends on the level to which the risk-bearers trust their management. When considering risk severity versus risk frequency (the usual method by which a risk assessment is conducted), Bakx and Richardson found that the perception of severity remained consistent between worker and manager but the frequency with which a risk event could occur was deemed "consistently slightly higher at the operator level than at the headquarter level" (2012, p. 601). Woods, Dekker, Cook, Johannsen & Sarter (2010, p.xviii) describe "an almost irresistible notion that we are custodians of already safe systems that need protection from unreliable, erratic human beings" with a list of human flaws such as perception, tiredness and irritability. They open their preface (p.xv) with "Human error is a very elusive concept"; the broad array of interpretations that this concept has leads to organizations thinking that they can achieve safety if they seek out and eradicate human error. They also comment that attribution of an error to someone is "fundamentally a social and psychological process, not an objective, technical one." A different viewpoint is offered by Dillon- Merrill, Tinsley, & Cronin, (2012) where they conclude that capturing near-miss data makes people believe more in the potential positive outcomes from the resilient misses thereby leading them to make riskier decisions and complacency.

According to data from the UK Airprox Board (2017), the number of Airprox reports filed in UK airspace between manned and unmanned aviation, rose exponentially in 2016. This can be seen in the figure below, which shows the data up to January 2017.



In their magazine (UK Airprox Board, 2016) the opening article covers the increasing prevalence of drones, and in it comment is made that “not only are the numbers of incidents increasing but the close shaves seem to be getting even closer” as well as the lack of understanding of the current regulations.

:: Research ::

From the review of the literature, the following hypotheses were established:

1. There is a temptation to rationalize every incident with hindsight bias and not acknowledge that some events are ‘Black Swans’.
2. Humans make safety through their efforts and expertise. This implies that new regulation can be safely introduced through human endeavour and training.
3. Errors occur, only if left unmanaged do they increase risk.
4. Eradicating Human Error will achieve safety of operations.
5. There is rarely a single cause of a failure event, more commonly a chain of events.
6. Operators frequently deal with information overload; new regulations can exacerbate this.
7. The capture of minor inconsequential errors is necessary to prevent a future version of events with a different (worse) outcome.
8. Using hindsight bias, all negative events are labelled with a cause.
9. Operators perceive the frequency of risk possibility to be higher than management does.
10. There is not enough regulation on the use of drones and more is needed urgently.

These hypotheses are being tested with a web based survey questionnaire aimed at members of the four worlds of the aviation industry, namely Aircrew, Engineers, Air Traffic and other support staff. To date, the survey (<http://www.ifgairsafety.co.uk/how-can-you-help/>) has been completed by 350 people from 55 different countries. Initial analysis of the results so far, shows the following:

1. The temptation to rationalize every incident is proven by the result that 63% of respondents believe that events are never random and 25% support this by saying that randomness is not very applicable to aviation.
2. Overwhelmingly, 94% of respondents believe that safety can be enhanced or made through their own endeavours.
3. 91% believe that errors are an inevitable part of day-to-day business in the aviation industry and 65% of all respondents feel that it is how errors are managed and dealt with that determines whether or not an error becomes an incident.
4. Only 20% of respondents believe that aviation operations are intrinsically safe, with 3% thinking it possible to completely remove human error.

5. Proof that it is common for there to be a chain of events that causes an incident is demonstrated by 90% of respondents saying that they had witnessed a time when a barrier had failed but another had prevented the incident occurring.

6. Whilst 77% of people had at some point in their career felt overloaded by the amount of change being introduced, 59% of these confirmed that it was because of the amount of regulatory change. Interestingly, 5% felt that the change could not have been introduced any better than it was.

7. 49% of respondents thought that it was always important to identify all errors, no matter how trivial, in order to prevent future accidents. This was supported by 38% choosing “most of the time” as their answer. Encouragingly, 64% stated that most or all the time a well-run Safety Management System captured every error and analysed them appropriately, whilst a further 26% agreed that this happens sometimes. Disappointingly, 4% felt that this never happened.

8. This hypothesis is somewhat disproven by the results of the survey, because even though 90% of respondents report that hindsight bias has an impact on safety investigations, only 13% state that a single cause is determined.

9. Most respondents felt that their management perceived risk possibilities as either the same as them or higher (62%), therefore disproving the hypothesis. Encouragingly though, 80% stated that they felt that they had a Just Culture within their organisation.

10. With regards to the amount of drone regulation in existence, only 1% felt that there was too much regulation, with 41% stating that extant regulations need some development and 43% saying that more regulation was needed urgently.

Another theme that has come out of the survey so far is that of endemic fatigue throughout the industry. This is not just tiredness, or even longstanding overwork, but many people are reporting change-fatigue, which seems prevalent across the global industry. Fatigue formed part of the article Safety & Security in the September 2016 edition of this magazine, saying that “It is a human problem that we tend to underestimate our level of fatigue and overestimate our ability to cope with it”.



:: Conclusion ::

How many times have you heard someone say, “not another change in regulations”? So how do we in the aviation industry manage changes better in the future? That is what I hope to find out in my thesis, and perhaps propose a better framework for the future introduction of change. The biggest changes that lay ahead are how we deal with the following two questions: “What will aviation regulation look like after the UK leaves the EU”, and “what do we do about drones”? The first is entirely our problem; the latter I suggest is of more global concern.

Do other countries share our concerns for the safety of manned aviation? Should drones be subject to mandatory registration? Should they carry high-intensity lighting, or perhaps electronic conspicuity? The counter-argument is that collision with a drone will do no harm, why the fuss? It is not at all surprising that the risk of drones to the safety of aviation is being worried about by members of the industry, with most respondents declaring that more regulation is required soonest. This is countered by a general feeling of regulatory change-fatigue!

It can be seen from my research that human error is inevitability in the aviation industry and that the way that it is managed is key to preventing accidents. This management often consists of a rationalisation of previous near misses and errors into a single cause, which is often blamed on human factors, but if further investigated could be seen to be rooted much deeper in equipment design or in regulation. Encouragingly, much of the industry is felt to have a just culture, with the perception of risk being communicated between managers and their staff appropriately. Whilst there are plenty of proponents of a Safety Culture, there are many differences of opinion as to what constitutes one. What constitutes error is well understood, how best to manage it in relation to risk is not, especially during any regulatory change.




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Appendix K – Slides from AOA conference presentation

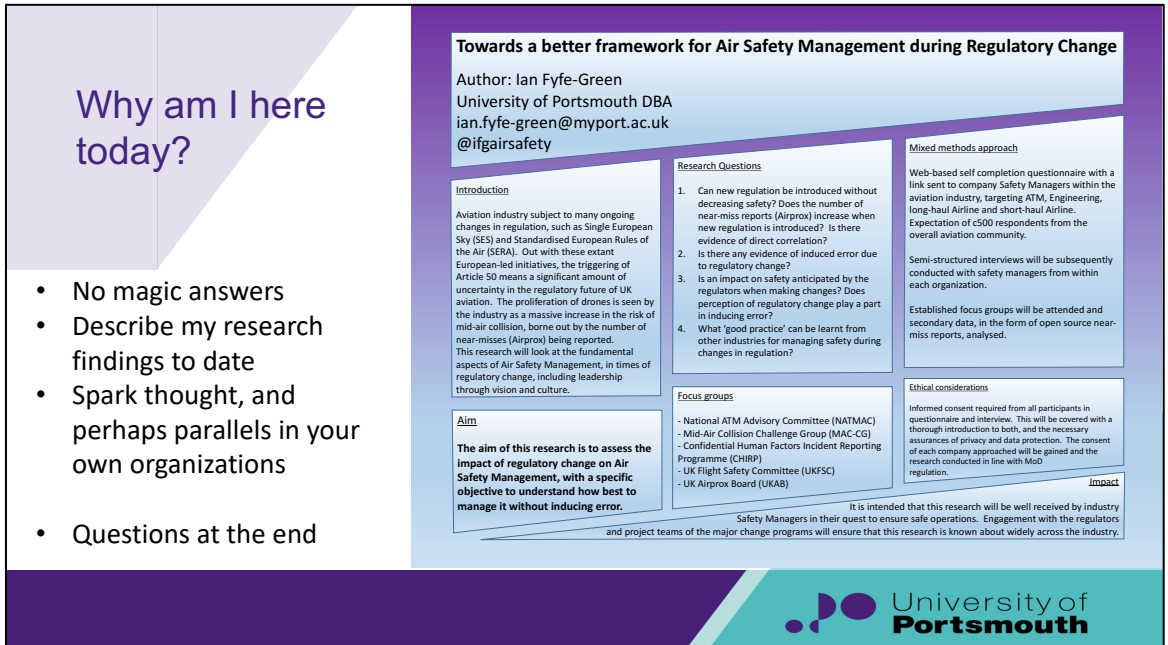
After reading the article at Appendix J, the Operations & Safety and Commercial Director of the UK Airport Operators Association (AOA) proffered an invitation to present the research¹³⁶ at the AOA's annual safety conference, which was held at Carden Park Cheshire between 19-20 June 2017. The presentation lasted for 30 minutes, with 20 minutes of questions at the end. The slides from this presentation are included below:



A Global Look at the Impact of Regulatory Change on Air Safety

Ian Fyfe-Green
BSc MSc CMgr FCMI FInstLM RN

University of Portsmouth



Why am I here today?

- No magic answers
- Describe my research findings to date
- Spark thought, and perhaps parallels in your own organizations
- Questions at the end

Towards a better framework for Air Safety Management during Regulatory Change

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@ifairsafety

Introduction
Aviation industry subject to many ongoing changes in regulation, such as Single European Sky (SES) and Standardised European Rules of the Air (SERA). Out with these extant European-led initiatives, the triggering of Article 50 means a significant amount of uncertainty in the regulatory future of UK aviation. The proliferation of drones is seen by the industry as a massive increase in the risk of mid-air collision, borne out by the number of near-misses (Airprox) being reported. This research will look at the fundamental aspects of Air Safety Management, in times of regulatory change, including leadership through vision and culture.

Aim
The aim of this research is to assess the impact of regulatory change on Air Safety Management, with a specific objective to understand how best to manage it without inducing error.

Research Questions

1. Can new regulation be introduced without decreasing safety? Does the number of near-miss reports (Airprox) increase when new regulation is introduced? Is there evidence of direct correlation?
2. Is there any evidence of induced error due to regulatory change?
3. Is an impact on safety anticipated by the regulators when making changes? Does perception of regulatory change play a part in inducing error?
4. What 'good practice' can be learnt from other industries for managing safety during changes in regulation?

Focus groups

- National ATM Advisory Committee (NATMAC)
- Mid-Air Collision Challenge Group (MAC-CG)
- Confidential Human Factors Incident Reporting Programme (CHIRP)
- UK Flight Safety Committee (UKFSC)
- UK Airprox Board (UKAB)

Mixed methods approach
Web-based self completion questionnaire with a link sent to company Safety Managers within the aviation industry, targeting ATM, Engineering, long-haul Airline and short-haul Airline. Expectation of 500 respondents from the overall aviation community.
Semi-structured interviews will be subsequently conducted with safety managers from within each organization.
Established focus groups will be attended and secondary data, in the form of open source near-miss reports, analysed.

Ethical considerations
Informed consent required from all participants in questionnaire and interview. This will be covered with a thorough introduction to both, and the necessary assurances of privacy and data protection. The consent of each company approached will be gained and the research conducted in line with MoD regulation.

Impact
It is intended that this research will be well received by industry Safety Managers in their quest to ensure safe operations. Engagement with the regulators and project teams of the major change programs will ensure that this research is known about widely across the industry.

University of Portsmouth

¹³⁶ It has been discussed in several chapters that a review of the Research Question, aim and suppositions/hypotheses was conducted in the Autumn of 2017. This presentation pre-dates the changes, but the message portrayed would not have been any different.

Research genesis

- Aviation - Tenerife, Milan-Linate and Uberlingen
- BP – Texas City, Deepwater Horizon
- NASA – Challenger and Columbia
- **Fail to learn or learn to fail?**



Research questions

1. Can new regulation be introduced without decreasing safety? Does the number of near-miss reports (Airprox) increase when new regulation is introduced? Is there evidence of direct correlation?
2. Is there any evidence of induced error due to regulatory change?
3. Is an impact on safety anticipated by the regulators when making changes? Does perception of regulatory change play a part in inducing error?
4. What 'good practice' can be learnt from other industries for managing safety during changes in regulation?

Conduct of research

- Literature review to form hypotheses
- Test hypotheses with online survey – www.ifgairsafety.co.uk
- Conduct interviews to validate survey results and to answer the elements of research questions not covered by the survey
- Publish thesis in late 2018 in the hope of influencing future regulatory change programs

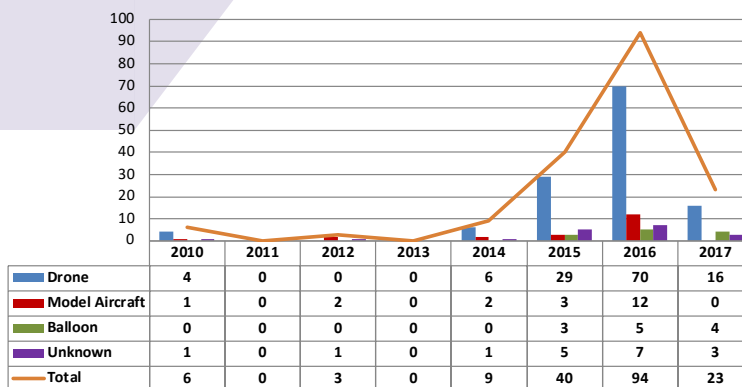
What does the literature say?

- Immediately after an incident the focus will be to change the safety climate within an organization
- The perception of risk must be shared equally between employees and management
- Near-misses can be presented as either failures or successes
- Inconsequential errors need to be captured to prevent a future (worse) version of events
- Fundamental to a safety culture is an appropriate organizational and management culture

Some opinions in the literature:

- Learning from errors is not spontaneous, or always obvious what the lesson is – 9/11 lessons relate to the precise avoidance of Islamic terrorism in relation to tall buildings (Taleb, 2007)
- “We are custodians of already safe systems that need protection from unreliable, erratic human beings” (Woods et al, 2010)
- In relation to Airprox reported with drones, “not only are the numbers of incidents increasing but the close shaves are getting closer” (UKAB, 2016)

Airprox reports involving drones and other objects to mid-April 2017 (www.airproxboard.org.uk)



Hypotheses to test

1. There is a temptation to rationalize every incident with hindsight bias and not acknowledge that some events are 'Black Swans'
2. Humans make safety through their efforts and expertise
3. Errors occur, only if left unmanaged do they increase risk
4. Eradicating human error will achieve safety in operations
5. There is rarely a single cause of a failure event, more commonly a chain of events

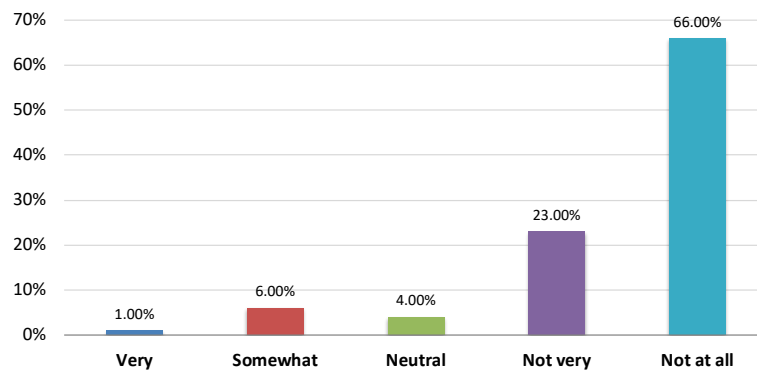
6. Operators frequently deal with information overload; new regulations can exacerbate this
7. The reporting of minor errors is absolutely necessary to prevent future major errors
8. Using hindsight bias, all negative events are labelled with a single cause
9. Operators perceive the risk possibility to be higher than management does
10. There is not enough regulation on the use of drones and more is needed urgently

Survey coverage

Countries Surveyed



In his 2007 book called *Black Swans*, Nassim Taleb stated an opinion that all major catastrophic occurrences are just random events and as such have no rational answer as to why they occurred. The implication being that although there is a temptation to rationalise every incident with hindsight bias, attempts to identify the cause of a past event are a waste of time and we should just acknowledge their randomness. How much do you agree that this is applicable to the aviation industry?



Research answers

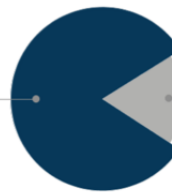
1. This data shows that there is a temptation to rationalise every incident, as 89% of respondents do not believe that there is such a thing as a Black Swan event whose randomness should be accepted
2. Overwhelmingly, 95% of respondents believe that safety can be enhanced or made through their own endeavours
3. 92% believe that errors are an inevitable part of day-to-day business in aviation, with 98% somewhat or completely agreeing that it is how these errors are managed as to whether the error becomes an incident

Default safe?

4. No

Do you believe that aviation operations are intrinsically safe until the point a human becomes involved?

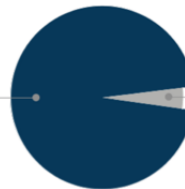
82%
No



18% Yes

In your opinion, is it possible to completely remove human error from the workplace?

96%
No



4% Yes

Research answers

- 90% of respondents stated that they had witnessed a time when multiple barriers were in place when one was breached, thereby preventing an incident occurring
 - Were these events reported?

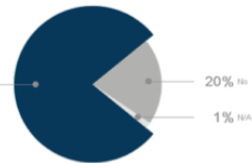
Overloaded by change?

- What can we learn from these results? Did we know this already?

Have you ever felt overloaded by the amount of change being introduced at once?

79%

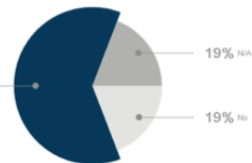
Yes



If Yes, was this in relation to changes in Regulations?

62%

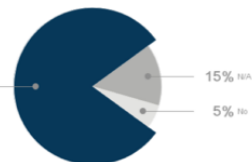
Yes



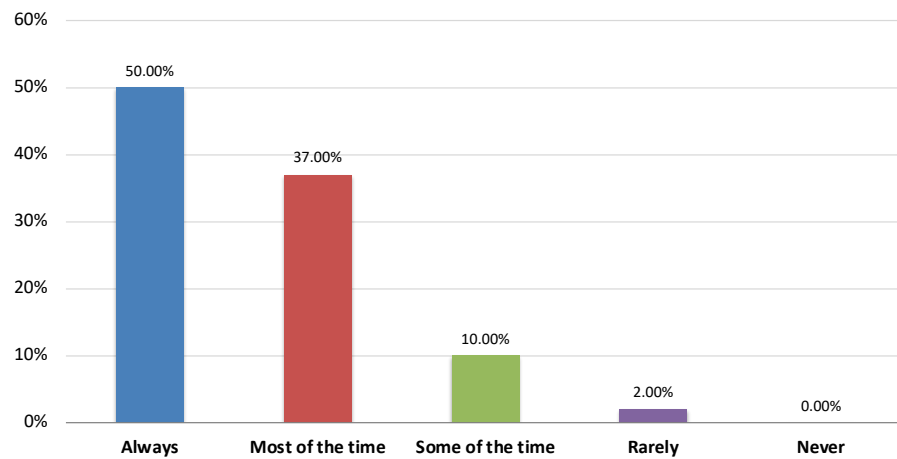
In your opinion could these changes have been managed better?

80%

Yes



How much do you think that it is important to ensure that all errors are identified, no matter how trivial, in order to prevent future incidents?

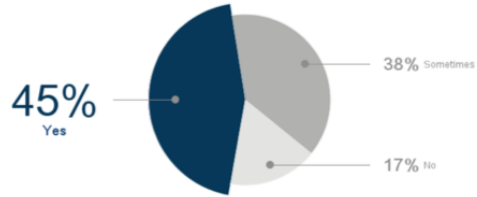


Research answers

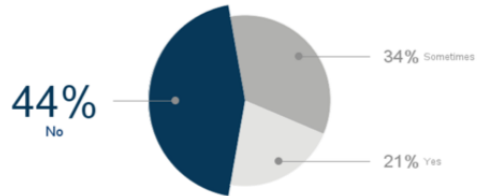
7. Curiously only 50% feel that it is important to ensure that all errors are identified in order to prevent future incidents
8. When it comes to Safety Management Systems, only 9% have experienced an SMS that always captures errors, with 57% saying 'most of the time' and 24% 'some of the time'
9. Most respondents believed that their management perceived risk possibilities as either the same as them or higher (55% + 10%), and encouragingly 82% felt that they had a 'Just Culture' for reporting within their organization's SMS

Hindsight & blame

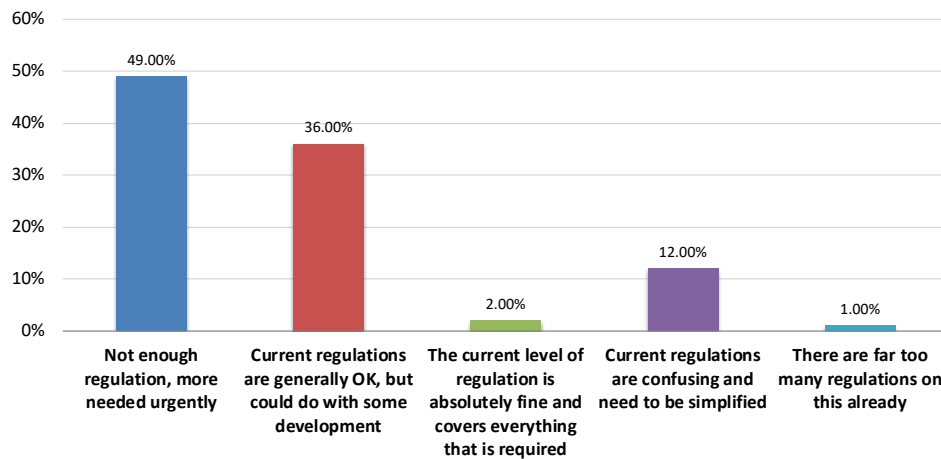
In your experience does hindsight bias impact on safety investigations?



In your organisation, is it normal to apportion blame to an occurrence?



With the numbers of unmanned aircraft (drones, SUAs, UAVs, UASs, RPAS, models etc) increasing, how do you feel about the current level of regulation?



Conclusion...or 'so what?'

- How many times have you heard someone say 'not another change in regulations'...usually phrased slightly differently
- So, how do we in the aviation industry manage changes better in the future?
- What will aviation regulation look like in say 3 years time?
 - Post-BREXIT UK-only regulation trying to dovetail in to EASA, whilst keeping up with SES developments
 - UTM – what are we going to do about sharing the airspace with unmanned aviation and importantly, how do we introduce these changes safely

Conclusion...or 'so what?'

- Research has confirmed my own instincts that human error is an inevitability in the aviation industry; it is the way that it is managed that dictates whether the error becomes an incident
- This management often consists of rationalization of previous near-miss events into a single cause, which is routinely blamed on 'Human Factors', but if further investigated might be found to be rooted deeper in design or regulation
- The results so far have been encouraging for someone entrenched in the industry - a Just Culture prevails with the perception of risk communicated between managers and their staff

Appendix L – Journal article submitted to Safety Science in December 2017

In aviation, when does a Safety Culture become a Safety Climate? A review of the literature.

Abstract

The terms 'safety culture' and 'safety climate' are prevalent in everyday parlance in the aviation industry, yet there is no common understanding or definition of the delineation between the two terms, which are often used interchangeably. An organisation's safety culture has often been cited as contributory in accident reports, despite investing finance and resources into managing safety. Is the safest airline the one that has just had a crash, or the one that has never had a crash? The perception is often that the absence of any incident implies safety, but conversely it could indicate a poor safety climate or a dysfunctional safety culture. A commonality in the literature is that a safety culture is determinant on the shared values and beliefs of its stakeholders, which shapes the behaviours and attitudes of the employees. Leadership is key to successful risk management, and the force behind how an organisation manages safety. Both of these elements need to operate in unison to develop and maintain a successful safety culture, whilst also acknowledging that the human is both the problem and solution, the human in the chain often being the final barrier to prevent an accident. A safety culture is not only considered to be a facet of an over-arching organisational culture, but also the strategic concept that stimulates a demonstration of this culture through an organisation's safety climate. The aim of this article is to review the literature to seek clarity in the two terms by exploring the essential components of each.

Keywords: Safety Culture; Safety Climate; Safety Management; Leadership; Learning from Incidents; Safety Performance.

1. Introduction

"The culture of safety has really progressed collectively over the years...when it comes to safety, we do truly collaborate as an industry...this is not an area to compete" said Boeing's vice president for safety, security and compliance (Richter, 2017). Richter comments that there has not been a fatal crash of an airliner in the US for over 4 years and that improvements in technology and increased regulation have meant that pilots are nowadays less likely to fly into terrain or have a mid-air collision. Richardson claims that "safety does not actually exist", suggesting that it is instead a 'condition' generated by action to reduce harm to what can be considered a tolerable level (2017, p. 1). On many occasions in aviation history, an organisation's 'safety culture' has been brought in to question during the accident investigation. Events such as the runway collision at Milan-Linate in 2001 (Catino, 2010; Flottau, 2001; Johnson, 2005), the loss of an RAF Nimrod in 2006 (Haddon-Cave, 2009) and a recent National Transportation Safety Board (NTSB) ruling that a company's safety culture was "directly responsible" for a crash that killed 9 people in a floatplane in Alaska in 2015 (Klint, 2017) show that in the subsequent investigation 'safety culture' is considered important. The coroner's inquiry into the 2013 helicopter crash in Vauxhall, London, commented on the commercial pressures that the pilot was under to fly on that day and found his decision "unsafe" (Aerossurance, 2017b; BBC, 2017b). So, what of a company's

'safety climate'? "An organisation's policies and culture are also good indicators of its climate" (Duque-Arrubla, 2016), but how do the two relate to each other, which is more important and does one follow the other?

This article is a review of the literature, aiming to clarify some of the confusion between the two terms and to answer the question posed in the title. The review initially looks at the use of the two terms, the behaviours associated with each, how they might be measured and how they are associated with risk. It is found that leadership plays a significant role in the debate, as does compliance and the importance of considering a system as a whole. Section 3 presents a small number of discussion comments from a public posting on LinkedIn, comparing the review to a convenience sample of opinions from practitioners in the aviation industry.

2. Literature Review

2.1 Safety Climate or Safety Culture?

In many cases, the terms 'safety climate' and 'safety culture' are used symbiotically, but it is questionable if they are indeed the same thing. A previous review found 108 different definitions of safety culture or climate (Vu & Cieri, 2014). Organisations are known to invest a significant amount of money into improving safety, yet accidents still happen (Stanton et al., 2017). Is this because of an organisation's climate, culture, or just a general lack of learning from experience; is this not what a culture is, or should be? The culture of learning is, of course,, one of Reason's five elements of a safety culture (1997).

According to the literature (Akselsson, Koornneef, Stewart, & Ward, 2009; CANSO, 2013; Cooper, 2000; Cox & Flin, 1998; Edwards et al., 2013; Flin, Mearns, O'Connor, & Bryden, 2000; Labib, 2014; Morrow, Kenneth Koves, & Barnes, 2014; Stolzer & Goglia, 2015; Von Thaden & Gibbons, 2008; Zohar, 2014), the genesis of the term 'safety culture' was the Chernobyl nuclear accident report published in 1986. In that report, and other major industrial disasters that followed, significant failings in the culture of safety were noted within the relevant organisations.

Can safety culture and organisational culture be considered to be the same thing? Glendon and Stanton believe that no matter how organisational culture is defined, it is fundamental to whether the business fails or succeeds (2000). A culture of safety must be an intrinsic part of the organisational culture and "organizations often espouse their requirement for appropriate safety cultures in their Policy Manuals" (Flannery, 2001, p.5) but what does safe look like? Dictionary definitions of what safe is, stop way short of anything useful in this context and it is often assumed that everybody knows what safe means already (Hollnagel, 2014). Public perception of safety plays a significant part and there is supposition that the absence of any incident means that an organisation is de-facto safe (Flannery, 2001). Indeed, Richardson goes as far as to say that "safety does not exist; it is a condition that is created wherein the chance of safety harm is reduced to and maintained at an acceptable level" (2017, p.1). Hollnagel uses "the absence of unwanted outcomes" as his working definition and describes how humans have an underlying need to both be safe and feel safe, and it can be argued that a safety culture is more aimed at the latter (2014). Hepler believes that "the term "safety culture" has been overused to the point that it has become virtually meaningless"

which has led to a “false sense of security” (n.d., p. 3). Yet the Civil Air Navigation Services Organisation (CANSO) declares that “all organisations operating in safety-critical industries, including Air Navigation Service Providers (ANSPs), have a safety culture” (2013, p.1). So, what is a ‘safety culture’?

Annex 19 (ICAO, 2013a) is the over-arching document on International Standards and Recommended Practices for Safety Management in aviation. Neither safety climate nor safety culture is defined or explicitly used in the document. The term organisational culture is used in relation to safety promotion by States and in the context of both internal and external training that “fosters an effective and efficient” State Safety Plan or Safety Management System (p. 37). Subordinate to this is Doc 9859, the Safety Management Manual (ICAO, 2013b). This book is the ‘how to’ and covers safety culture in some detail, stating the generic that “culture is characterized by the beliefs, values, biases and their resultant behaviour that are shared by members of a society, group or organization.” A safety culture is further stated as encompassing “the commonly held perceptions and beliefs of an organization’s members pertaining to the public’s safety and can be determinant of the behaviour of the members”. This viewpoint is supported by Reiman and Rollenhagen in their paper on countering bias, but in the context of organisational culture, with safety described as an “emergent phenomena” in an overall “sociotechnical system” in which no individual element can be ignored (Reiman and Rollenhagen, 2011, p. 1267).

Safety culture can be defined as an ‘object of knowledge’, working alongside reliability engineering and a focus on human factors (Bergström, van Winsen, & Henriqson, 2015; Henriqson, Schuler, Van Winsen, & Dekker, 2014). These elements, both the entities of individual and organisation, should be working in unison to maintain a healthy safety culture. Flannery attempts to unravel some of the confusion around climate versus culture and discusses their relevant positioning (2001). He proposes that a climate is influenced by attitudes, perceptions and opinions, with the term safety climate being utilised by an organisation to measure the health of their safety system, often with the use of a climate survey. Perceptions and attitudes of staff are also things that Williamson et al. (1997) pick up on in their discussion on the assessment of safety needs in relation to underlying issues. Schneider, Ehrhart and Macey (2013) talk about the strength of a climate, not its health and emphasise that safety is one facet of an overall organisational climate, which can include other climates for such things as service delivery. They suggest that the processes within these focussed climates can indicate where issues may lay and not only provide foresight (accident prevention) but also help by validating measures that have already been introduced (customer gratification). Reiman and Rollenhagen (2014) talk about the strength of the attitudes of the workforce to safety as a way of describing and measuring a safety culture. They also challenge the balance of actual ‘safety’ in safety culture descriptions, theorising that there is a mismatch between the research on culture vice the actual delivery of safety, and the disproportionate effort expended in each area. On the subject of safety climate, deemed a “somewhat similar concept” (p. 6), they point out that Zohar’s “pioneering” work (1980) pre-dates the universal adoption of the term safety culture and that the two expressions are now very differently associated, despite being inter-changed routinely.

Zohar (2014) refers to his 1980 work in introducing an early definition of safety climate and explains that in that era, a safety climate was considered to be

consensual and about perceptions of the relative gravitas associated with the balance of productivity versus safety from the workforce. He goes on to say that this has developed since then to the emergence of communication of shared experiences from management aimed at developing behaviours and attitudes towards safety and establishing expectations and management priorities. The “core meaning of safety climate” is proposed as being when employees feel protected by their management through comprehensible, wide-ranging and regularly communicated safety policies (p. 318).

It can, therefore, be seen that there is much confusion as to what many of the terms mean, or even if they are just synonyms. One proposed delineation is that ‘safety culture’ is predominantly used by High Reliability Organisations (HRO) and ‘safety climate’ favoured elsewhere (Von Thaden & Gibbons, 2008). However, Edwards et al. (2013) conclude that even though there is much discussion in the literature about culture versus climate, there is no coherence or lucidity as to what each actually comprises, which leads to multiplicity of understanding and “a risk that safety culture may become little more than a catchy title for safety management” (p. 79). This would seem to support Hepler’s earlier comment. Guldenmund differentiates safety culture and safety climate by reference to Schein’s 1992 framework from organisational culture, with “basic assumptions” as the central pillar of a culture and “espoused values” directly relating to attitudes and behaviours, which he suggests are indicative of climate (2000 p. 215). He also states that in 1980s organisational literature the word climate was unilaterally replaced by culture, and that at the turn of this century, culture now has exactly the same meaning as climate used to have.

In addressing the difference between safety climate and safety culture, Zohar (2014, p. 318) notes that sixteen years prior, Cox and Flin (1998) asked the question ‘what does good look like’? They asked not only if the two terms safety culture and safety climate were synonymous, but also what the crucial elements of a good safety culture were and how best they could be measured. They also questioned the validity of the whole concept of a safety culture saying it was academically unproven, citing the lack of a formal widely accepted or recognised definition and the psychological belief, and disproportionate expectation in the concept, despite the paucity of evidence to support its utility. All this, despite the term organisational climate appearing in 1930s literature on social psychology and organisational culture being discussed in the 1950s.

And yet progress remains thwarted by the fact that many authors still fail to discriminate between safety climate and safety culture, using many terms that have no progeny in organisational literature; “such a practice threatens discriminant validity of both constructs... resulting in conceptual ambiguity” (Zohar, 2014, p. 318). Zohar proposes that safety climate should only be used to refer to the perceptions of employees as to the management’s priorities associated with safety. In his earlier paper (Zohar, 2010), reflecting the thirty years that had elapsed since his original safety climate work, he comments that much of the development has been “focused on methodological rather than theoretical or conceptual issues” (p. 1517). He states that research has been conducted into the measurement of a climate, and the production of scales to support this, but suggests that this work is ambiguous as it does not focus on the aspect of safety, the emphasis being on the organisational climate.

Schneider et al. (2013) believe that senior management invariably does not care about any distinction between culture or climate, and will ordinarily use the term culture. They give an example of this as the review of the safety culture at BP after the 2005 Texas City incident, where the report includes a 'culture survey', which they suggest as being in the standard format of what is normally considered a 'climate survey' as it concentrates on the company's policy, process and behaviour. At Board level, the company must have strategies in place to concentrate on the delivery of cost-effective output, in this case safe operations, as part of an over-arching corporate culture which will also include the corporate reputation and identity. Thus, in a business sense, there is much overlap between culture and climate with neither having distinct definition. This said, a boundary between the two could be seen as anything tangible being climate, with the intangible being culture; therefore a physical change to the way that something is done (process or routine) requires a change in safety climate (Schneider et al., 2013).

Zohar (2010) summarizes his article by showing a "conceptual model linking the occupational safety and organisational climate literatures" (p. 1520, reproduced at Figure 1). He developed this model from the seminal works of Heinrich and Reason (1959, 1997, cited by Zohar, 2010, p. 1520), representing the likelihood of an incident as a function of a hazard, unsafe act or randomness. This model is particularly clever in that it incorporates three distinct layers, showing the organisation at the bottom, the workforce as a group in the middle and then a focus on the individual error propensity at the top. This retains Reason's original progression from the unsafe act conducted by an individual to the impact that has on, or can be resolved by, the wider group or organisation can still be seen (Reason, 1997). Zohar believes that with the incorporation of the added dimension of safety climate in to the model, several additional benefits are provided, primarily the indication of the impact of safety climate on the unsafe act/condition and "the inclusion of employee safety behaviours emanating from their shared climate perceptions (e.g. unsafe behaviour as a result of poor safety climate)" (2010, p. 1521).

Figure 1 not shown due to copyright

2.2 Behaviours, feelings and attitudes

Optimising safety culture is, therefore, one of the best ways for an organisation to protect itself from developing behaviours and practices which may otherwise only manifest themselves for the first time in an accident investigation. (CANSO, 2013, pp. 1-2).

Turning to the medical world for comparison, Pousette et al. (2017) comment that an organisational climate greatly influences the behaviours of both staff and patients; both their paper and that of Schneider et al. (2013) cite Kuenzi and Schminke's critique of organisational work climates (2009). Pousette et al. explain that there has been a dramatic increase in the interest shown in organisational climate in relation to patient safety, with empirical support suggesting a direct link to safety climate and an association with patient safety culture. They opine that the amount of detail within regulations is a key point to keeping patients' safe, claiming a relationship between both too little-defined detail in safety procedures and too much, in increasing the risk of error. They also criticise the general organisational climate research as primarily focusing on individual domains rather

than taking a holistic view of multiple “goal areas” and their complex interactions (p. 188). Furthermore, their statement that “positive relations between occupational safety climate and patient safety climate are highly feasible” seems a curious one to make. They hypothesize that a safety climate’s quality directly influences behaviours in taking risks, complying with rules and reporting incidents. However, they do not explicitly propose what determines the ‘quality’ of a safety climate, or indeed how to go about measuring it. Flannery also suggests that to measure a culture it must first be determined and then understood (2001), whilst agreeing with others (CANSO, 2013; Cooper, 2000; Eurocontrol, 2017b; Guldenmund, 2000; Harvey, 2002; Henriqson et al., 2014; ICAO, 2013b; Mannan et al., 2013; Mullen, Kelloway, & Teed, 2017; Nielsen, 2014; Nordlöf, Wiitavaara, Winblad, Wijk, & Westerling, 2015; D. Parker, Lawrie, & Hudson, 2006; Petitta et al., 2017; Reiman, Rollenhagen, Pietikäinen, & Heikkilä, 2015; Schneider et al., 2013; Strauch, 2015) that any culture within an organisation is at its root a systemic understanding of shared beliefs and values. The literature also suggests that a safety climate is a direct function of the shared values of its employees, but relies heavily on how they perceive their environs, therefore implying that the climate is a subset of the culture (Kuenzi & Schminke, 2009; Schneider et al., 2013).

Research advocates that even though organisational climate in the workplace has been studied for many decades, the initial thoughts of holistically looking at how employees were influenced by the work climate was fraught with issues such as consensus of opinion, consistency of methodologies used and the accusation of a lack of theoretical underpinning to the research (Kuenzi & Schminke, 2009). In taking their research forward, Kuenzi and Schminke sought to define what an organisational climate was. However, they found this task very difficult and commented that “the literature has often been murky on the relationship between climate and related contextual factors such as culture” (p. 637). They suggest that confusion related to the term ‘climate’ revolves around its conceptualisation and a lack of any form of objective description including such elements as which characteristics of the workplace should feature as ‘climate’ and which as ‘culture’. They propose that to be classed as part of a ‘climate’ something must be an activity, such as the use of procedures and how employees relate to them. This establishes a clear gap between the two terms, with ‘culture’ being used to describe contextual considerations and the unconscious assumptions. Culture is therefore proposed by them as being the over-arching concept, whereas a climate is developed to meet this culture. Interestingly they also question whether a climate actually matters, and whether or not it can add any value to an organisation. However, Kuenzi and Schminke suggest that their research has proven that climate does indeed matter, but in a far more multifaceted way than anticipated (2009).

2.3 Measuring safety performance

According to Neal et al. (2000), safety climate predicts safety performance, which begs the question as to how a climate is measured. They claim a direct link between safety climate and organisational climate in its influence over perception and that this impacts upon safety performance. Assessing the variance in responses to a survey can indicate whether an organisation’s safety culture is clear, i.e. significant variance would imply that the core underpinnings are not there, conversely consistent answers would demonstrate alignment of organisational policy and practice (Von Thaden & Gibbons, 2008). Reiman and

Rollenhagen also point out that a safety culture can be measured by what is ignored as much as what is considered significant (2014).

In attempting to develop a measurement tool, the Health and Safety Executive (HSE) (2005) drew upon the work of Cooper (2000) to propose that safety culture should be used in relation to behaviours and the structure of the organisation, whereas safety climate relates to the feelings of employees. Given that they also state that there is general acceptance that “a high proportion of accidents, incidents and near-misses on the railways follow unsafe acts by people” (p. 5), it is of no surprise that they identify five Key Performance Indicators (KPI) in relation to assessing a safety culture, namely: “Leadership, two-way communication, employee involvement, learning culture and attitude towards blame” (p. 19). This compares favourably with the 9 KPIs that Morrow et al. (2014) identify, the main addition being how safety is prioritised. However, the number one conclusion from HSE’s review is that “measuring the behavioural and situational aspects of safety culture reveals more about what is shaping the culture of an organisation than measuring solely attitudes and perceptions” (p. 36). The term ‘safety performance’ is used as an overarching reference to outcomes of safety assessments made against cultures, including behaviours (Morrow et al., 2014), although it is said that safety performance is a consequence of the safety culture “rather than the focus of investigation” (Edwards et al., 2013, p. 75).

Accident reports in HROs often cite failings in safety culture as contributory factors, and much focus is then placed on this aspect to leverage rapid improvements which usually commence with leadership (Morrow et al., 2014). In the desire to improve the culture, attention is drawn to safety performance, but without defined KPIs a true measure of ‘how safe’ cannot be achieved, and the use of a safety survey is but one method of acquiring a snapshot health check without particularly going in to any depth of understanding (Frazier, Ludwig, Whitaker, & Roberts, 2013).

2.4 Risk

In describing Hepler’s report (n.d.), entitled ‘Stop Talking About Safety Culture and Get Real About Risk’, Smith (2017) comments that it dispels the myths surrounding safety and addresses the issues associated with a purely safety compliance attitude, recommending instead that companies re-focus their efforts in to ‘risk competence’. This is aimed at moving away from the safety checklist approach and exploring potentially risky areas instead. Hepler (n.d.) uses the ironic example from the BP Deepwater Horizon disaster that on the day of the explosion senior management were at the plant celebrating seven years’ free from incident. She states that this focus on the past lack of incidents led to a presupposition that things were safe, which in turn led to complacency and assumption that there would not be any incidents in the future because of it. Accordingly, it is suggested that communication is the single most important aspect in creating the required culture of risk competence within an organization. Saleh et al. (2014) suggest that in order to support the communication of risk, thorough analysis must be conducted with the aim of influencing risk management.

Smith (2017) summarises Hepler’s report by suggesting a five point action plan for establishing the correct risk culture (as opposed to a safety culture), which consists of ensuring everybody realises that safety is part of their job, getting the message across from management that “safety is as important at performance” (p.

1), defining what risk actually is within the context of the company and in terms easily understood by all, measure what the risk is today not what it might be or should be, and finally ensure that the data collected is actually analysed and used to focus attention on the riskiest risks. “Risk management therefore appears to be an inherent characteristic of being safe” (Flannery, 2001, p.3).

2.5 Leadership

It can be said that “Leaders create climate” (Lewin et al., 1939, cited by Zohar, 2010, p. 1519), which in a strategic management construct is also linked to the culture and a leader’s role in every aspect of its creation, maintenance and any change required (Shirvani & Shojaie, 2011). Furthermore, Zohar proposes that the leader’s association with safety climate is predicated upon welfare concern for the group, indicative of the efficacy of the relationship between the group and its leader. He recommends further research be conducted into how best this can be achieved in high-risk situations to improve safety climate. In his paper on cultural differences in aviation, Liao comments that “managers are essential for delivering the safety concept of the organisation to subordinates”, but the delivery of this training, education and persuasion of the workforce requires a demonstration of leadership (2015, p. 194). Surely safety is everyone’s business; “Safety leadership is not a one-person, one-department job” (Hepler, n.d., p. 6). The literature discusses the role, qualities and styles of leadership required to enhance and support a safety climate (for example Kuenzi and Schminke, 2009) and Provan et al. (2017) present the relationship between substandard leadership and inadequate safety culture.

Conversely, it can be claimed that leadership style does not have any impact on actual safety performance, when in the presence of an active Safety Management System that is risk aware (Fernández-Muñiz et al., 2014). So, whilst a leadership style can influence the happiness and satisfaction of employees, it is perhaps irrelevant to the outcome as long as the workforce is engaged in the safety culture, which is also seen as compliant. However, Fernández-Muñiz et al. propose that a transformational leadership style is the most successful in accident prevention because of the management influence over behaviours, feelings and attitudes, defined above as the essence of a safety climate. The link is therefore made between leadership, safety management, procedures, compliance, safety performance and employee satisfaction. This view is supported by Ayree and Hsuing (2016), whose study found that when workers were fully engaged in the process of formulating the rules by which they are expected to be bound by, compliance levels were seen to be much higher and behaviours adopted that proactively supported the management’s drive for safety.

Von Thaden et al. state that “even when the importance of organisational safety factors is understood and acknowledged, many airlines struggle to balance safety and profitability”, with an example given as staff specifically employed to oversee safety routinely reported that they did not have the time or resources to process the immense amount of data that is gathered, instead expending the majority of their capacity on emergent issues (2008, p. 6). Once again leadership plays a key role in how an organisation manages its way out of this loop of being ‘data rich’ but ‘knowledge poor’, with senior management required to identify areas of weakness where they can best deploy scarce resources in order to make the biggest impact. This resource deployment is commented on by Dekker (2014), and captured in Section 2.6, in the context of nugatory work for already

overstretched staff. The need to deploy scarce resources wisely is perhaps one of the reasons why regulators are moving towards a regime of risk-based assurance and a policy of Performance Based Regulation (PBR) (described in CAA, 2015a, 2015b, 2014; CAAi, 2016; Kneepkens, 2012; May, 2003).

Although evolutionary, this prioritisation and promotion can be described as a major factor, or even the epitome, of a safety culture (Gnoni & Saleh, 2017; Littlejohn, Margaryan, Vojt, & Lukic, 2017; Luria, 2008; McDonald, Corrigan, Daly, & Cromie, 2000; Provan et al., 2017; Saleh et al., 2014; Von Thaden & Gibbons, 2008) leading to adaption of safety behaviours amongst the workforce. Although it should be noted in context, that Littlejohn et al. use climate and culture interchangeably without clear differentiation. However, it is suggested that perception plays a key part in how a workforce interprets the priorities of its leaders, but that there is very little empirical evidence to explain how a climate is formed (Luria, 2008). Despite this, it is felt that “leadership and management commitment to safety are often considered the cornerstones of good safety culture” (Reiman and Rollenhagen, 2014, p. 9) and therefore a tangible measurement of its strength.

2.6 Compliance (or more importantly non-compliance)

Non-compliance is very often reported as a significant contributor in incident or accident investigations, and whilst differing in proportion between industries, it is particularly true of aviation and is routinely grouped under the label of ‘human error’ (Dahl, 2013; de Melo, Costa, Álvares, & Irizarry, 2017; Dekker & Nyce, 2014; Duque-Arrubla, 2017; Haddon-Cave, 2009; Helmreich, 2000; Hopkins, 2011, 2014; Hutter, 2001; Kern, 1995; Neal et al., 2000; Shorrock, 2007). Dahl’s opinion is that this shows that compliance with safety regulation is critically important in ensuring safe operations and that the main effort should be on working out why employees break the rules (2013). This comes back to the point about leadership, and the key supervisory roles that can often be employed but under-utilised; studies show that there is generally less compliance with safety rules amongst the workforce when their supervisors are not seen to be enforcing them (Griffin & Hu, 2013; Petitta et al., 2017).

Indeed, the aviation safety management guidance manual (ICAO, 2013b, pp. 2-4) highlights that the normalisation of deviance “is indicative of operational contexts where the exception becomes the rule” and makes the case for correctly resourcing an operation so that the management does not force their staff in to the invidious position of having to cut corners in order to achieve the required operational output, “often involving constant violation of the rules and procedures”. The example of BP Texas City can be used again to reinforce the consequences of a culture whereby the rules are seen as guidelines rather than mandatory (Hopkins, 2011). Vaughan is cited by many in the context of the ‘normalisation of deviance’, due to her 1996 report into the Challenger space shuttle accident (for example: Cannon and Edmondson, 2005; Dekker, 2015, 2014; Grabowski and Roberts, 2016; Haddon-Cave, 2009; Henriqson et al., 2014; Hopkins, 2011; Kirwan, 2011; Kohn et al., 2000; Labib and Read, 2013; Madsen and Desai, 2010; Nordlöf et al., 2015; Pidgeon and O’Leary, 2000; Reiman et al., 2015). Kirwan introduces the concept of drifting towards normalisation, with humans learning to tolerate risks increasingly over time and the impact that this can have on what becomes acceptable; left unchecked this can lead to normalisation across the workforce, for example new staff being shown the “tricks of the trade” (2011, p.

17). Appropriate supervision is the important point and Reiman et al. comment on the association between organisational drift and the normalisation of deviance, saying that drift happens locally and minor changes in patterns do not immediately impact upon other elements of an organisation (2015). It is also claimed that in everyday working life, people grow accustomed to ignoring deviations, especially if they save the company money or the individual time; indeed, for these reasons, they can even be encouraged by management (Duque-Arrubla, 2017).

A contrary argument can be made that engendering a strict culture of compliance can stifle creativity and nurture an environment where employees are just following the rules no matter what, without consideration to their own safety or remaining risk-aware (Hopkins, 2011). Grote (2015) also found this to be true and proposes that by capitalising on uncertainty and making the rules less stringent for example, things can be made safer in some situations. This accords with the comments of others (Mannan et al., 2013; Neal & Griffin, 2002; Neal et al., 2000) in regard to participation and promotion of safety by encouraging freedom of thought and initiative rather than adhering to compliance measures.

Reiman et al. (2015, p. 83) take this a step further and as well as normalisation and drift, they introduce two further phenomena of “information flow and system accidents.” They cite Pidgeon and O’Leary (2000) and Vaughan (1996) in their description of how the flow of information, and corporate confidentiality, can impede safety through behaviours, especially in larger organizations. They describe how leaders can be seen to improve communication, but how this can often be ineffective due to the dilution of detail in favour of volume, or through codification using imprecise descriptors in reporting software. From an assurance perspective, information flow can be seen to be happening in these cases, but what is not always captured is the comprehension of the information by the workforce.

In his book on human error, Dekker (2014) indicates that compliance drives behaviours, which have often developed over a significant period of time. He also suggests that there is too much bureaucracy and regulation associated with safety, an example being that in order to comply with regulations, companies are having to employ extra staff to satiate the information demands of a succession of regulators, rather than being able to concentrate on managing safety. Furthermore, Dekker highlights that “safety bureaucracies can sometimes institutionalize and confirm the Old View” by recording and acting upon the data in terms of the negatives, for example the numbers of incidents or non-compliances (Dekker, 2014, p. 148). Given that “non-compliance with procedures is the single largest cause of ‘human error’ and failure” (p. 69), the implication is that if rules are followed accidents don’t happen, therefore bureaucracies seek complete compliance and measure safety management against this metric.

Dahl (2013) cites the work of Dekker and Hopkins in reference to this association of rule violation with accident reports and the label of ‘human error’. It is then claimed that this shows that compliance is directly linked with the maintenance of a safe working environment and that the key to managing safety is to pinpoint why employees break the rules. Although Hopkins’ viewpoint is that it is the combination of the rule that is made, and the compliance with that rule, that ensures safety, which needs some mechanism for enforcement (2011). He also draws upon the lessons of BP Texas City to highlight that a culture of non-compliance, where employees feel that the rules are not fit-for-purpose, can lead

to disaster. This again links to the concept of compliance behaviours and the casual attitude that Dekker suggests can be claimed to cause 85% of workplace incidents (2014). Dekker proposes that the “New View” is to comprehend that an incident is not necessarily caused by the recent unsafe act of an individual, but instead “something that gets incubated over a much longer period” (2014, p. 199). Hopkins does seem to agree with this statement, but also extols the identification of multiple causal factors over the desire to seek just one cause, explaining the difference between “sufficient cause” and “necessary cause” (2014, p. 11). This concept of a new way of looking at an old problem is also supported by Hollnagel’s Safety-II perspective, where more focus is placed upon variability, emergent outcomes and what went right in the chain, rather than the traditional viewpoint of looking for what a person did wrong (Hollnagel, 2014). Almklov talks about a new regime inculcated after the 1990s which tackled the outdated moulds and suppositions, instead forming models of accountability and assurance through audit (2014). These theories are brought together by the recent series of articles on Learning from Incidents, introduced by Stanton, Margaryan and Littlejohn (2017) and although Hollnagel’s methodology is cited by Rollenhagen et al., along with the requirement to always include context in an investigation (see also Provan et al., 2017), they suggest that at an executive level it is less appropriate or useful.

2.7 Systemic issues and learning lessons

System safety is particularly important for many industries, such as the nuclear and the airline industries, and broadly speaking, it refers to the state or objective of striving to sustainably ensure accident prevention through actions on multiple safety levers, be they technical, organizational, or regulatory. (Saleh et al., 2014, p. 283).

Dekker et al. (2011) use the term ‘system accidents’, citing Rasmussen (1997), and then this term is picked up by Reiman et al. (2015), additionally cited against Leveson (2004), Hollnagel (2004) and Perrow (1984). The term ‘system accident’ is therefore well understood in the literature and relates to the interactions of the components within a system as a whole and not to a specific individual component of the system. In their paper, Saleh et al. (2014, p. 283) establish a set of “high-level principles...domain-independent, technologically agnostic, and broadly applicable across various industries” designed to allow the examination of system safety.

A Safety Management System (SMS) is an example of this case, where a failing of the SMS could be a contributory factor to an accident, without any one component of it failing *per se*. Woods et al. are cited (by Reiman et al., 2015) as stating that “the enemy of safety is complexity”, disparate to human error, but they then go on to describe how to look for the root of the complexity and learn “strategies tame them” (Woods et al., 2010, p. 13). Human nature, coupled with the expectations of stakeholders, will usually demand an explanation for an accident as soon as possible after the event, which can lead to a rushed answer which is often linked to human error somewhere (Woods et al., 2010). This ‘hindsight bias’ relates to the desire to always rationalize an event rather than accept the randomness concept of it being a ‘black swan’ and not at all foreseeable (Taleb, 2007).

Reiman and Rollenhagen (2014) point out that whilst all cultures could be considered to be systems, the same is not true of the opposite. But if a safety culture were to be perceived as belonging to a wider “sociotechnical system”, then

the whole structure would display “emergent properties that cannot be deduced from the study of safety culture alone” (p. 11). They conclude by saying that new thinking should view the term ‘safety culture’ with the same distrust as ‘human error’ and that “in general, safety culture research and practice has so far missed the opportunity to integrate with systemic perspectives” (p. 14).

2.8 Learning lessons

Moura et al. (2017, p. 59) cite an Airbus statistic from 2016 that “around 1200 A330 airplanes are operated by over 100 companies, meaning that an aircraft takes off or lands somewhere every 20 seconds” by way of an example as to how complex and large a ‘system’ can be. Furthermore, they say that this high degree of technological complexity, together with the interface between public opinion through the media, is what drives the desire for immediate explanations from stakeholders. They use this to extol the reflective process of wider learning from failures and the stimulus that an accident report can give to mutual acceptance of events and support the understanding and awareness of both safety and risk. Research has found that the greatest benefit from the learning process can be gained by challenging the operating norms and digging deeply into identified systemic issues (Lukic et al., 2012). It is therefore imperative that at the heart of any safety culture is a learning culture, and by necessity a reporting culture to capture potential lessons (Appelbaum et al., 2012; Liao, 2015; Littlejohn et al., 2014; Silva et al., 2017). An SMS must link these cultural facets together, underpinned by leadership and “internal systemic alignment” whereby all “policies, procedures and rules should be consistent with each other” (Littlejohn et al., 2014).

Statistics presented by the European Aviation Safety Agency (EASA) show that in 2016 there was a general overall trend for fewer accidents when compared against the 10-year average (EASA, 2017a). This makes learning lessons more challenging as there are fewer examples from which to identify lessons that can be learnt, and it is commented that the accident rate is not high enough to ascertain a meaningful measure of safety (O’Connor et al., 2011). However, Figure 2 shows the number of Airprox (aviation near-miss) reports filed in the UK during 2016 compared against the 5-year average, and it can be seen that there has been a noticeable increase (UKAB, 2017b). This, therefore, means that there are ample opportunities in the UK aviation industry for learning from incidents, supporting the editorial comments made by Stanton et al. in relation the special series on this learning process (2017).

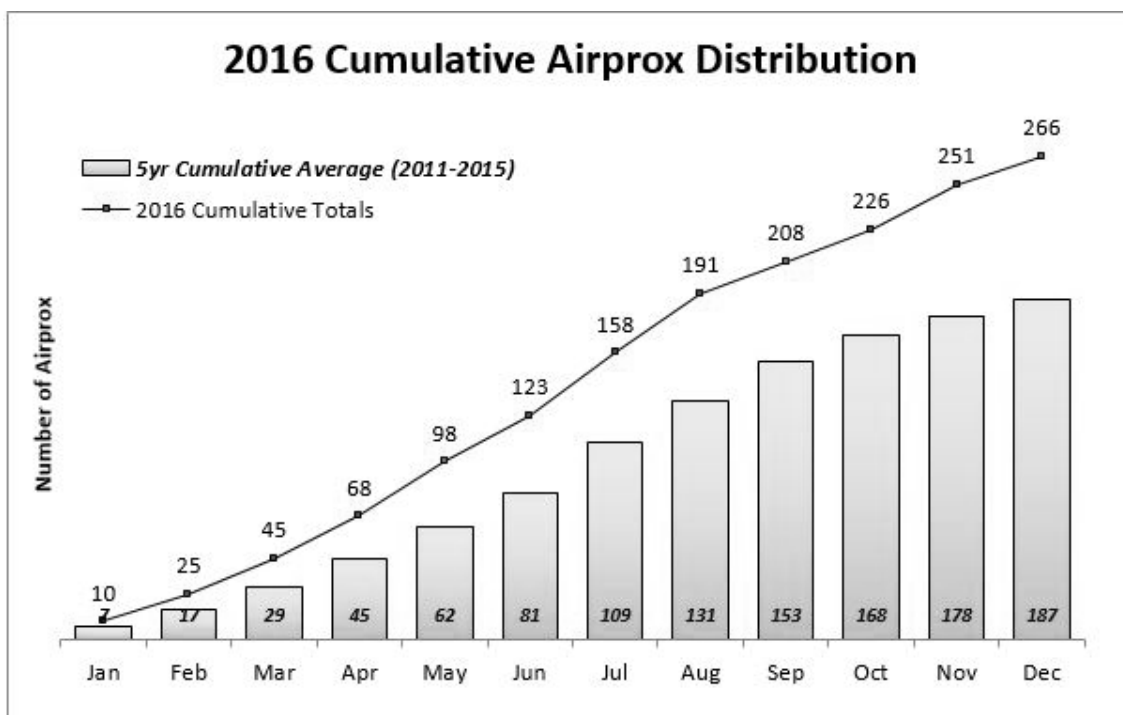


Figure 2: Chart showing the number of Airprox filed in the UK during 2016, compared to the average of the previous five years. Copyright 2017 by the UK Airprox Board.

3. Discussion

In order to support this review of the literature, opinion was sought in an open article posted on LinkedIn entitled “When does a Safety Culture become a Safety Climate?” (Fyfe-Green, 2017). The article introduced the topic and explained that a journal article was being written, with comments and opinions invited. The article was viewed by 358 people, liked by 42, commented on by 21 and forwarded to others by 13. Although the article, and comments, are open to public scrutiny, quotations below have been anonymised and are therefore not referenced.

An airline safety manager commented that “a safety climate is something you create”, whereas a safety consultant said that “the climate is the short term view, the culture is the long term view of the same thing”. A safety expert representing an aircraft manufacturer proffered the concept that “Climate=State & Culture=Trait”, whilst also suggesting that the transition from climate to culture is achieved “when you pass from safety being something the organization HAS to what the organization actually IS”. A senior executive sees safety culture as being “a thought pattern or process that has deep rooted concepts” whilst a safety climate “is not as strong and can be easily modified by maybe removing an obstacle such as a manager or process”. Another version was that culture “essentially is a company policy statement” whereas “climate is the actual/real working environment...”. All of these comments support the literature.

One commentator referred to ICAO Annex 19 (referenced in this paper) for a definition of safety culture, also offering their own understanding as being “everything which triggers an inherently safe behaviour, regardless of any regulation or enforcement”. ICAO does not discuss safety culture in Annex 19, but it is covered in ICAO Doc 9859 (also referenced in the literature review), but there

is no mention of safety climate. The commentator felt that climate was “just another word for culture”; this accords with some of the literature reviewed in Section 2.1 in relation to the multiplicity, and synonymic nature of the terms. An opinion expressed by a pilot was that “if you have a strong safety culture then by default you would be existing in a safety climate but I’ve never thought of the two as independent, in my mind they are symbiotic”. Another opinion was “that while safety culture is the enduring value an organization might possess, safety climate is a snapshot of the culture”. An aviation instructor and university lecturer commented that “culture is the gathering of beliefs and values shared by a community of people”, whereas “the climate reflects the environment wherein such a culture is maintained and transmitted”.

Another consultant introduced the idea of regional differences, controversially saying that “in Africa and Asia, the idea of a safety process is non-existent” where the commercial aspects take precedence. A separate comment was made that “safety culture is mostly found on the Board, Charts and ppt” which was supported by the flight safety officer of an Asia-based airline by saying that “The culture has two elements. The target and the reality...It is the climate which allows your safety expectations to be met.” These comments reinforce the ‘catchy title’ statement by Edwards et al., cited in Section 2.1.

All of the comments were from professionals within the aviation industry, and the main theme emanating from them was that there is no clear definition, or common understanding of the differences between safety culture and safety climate, with some agreeing with the literature that the terms are interchangeable. Interestingly, there were no comments made about the leadership aspect, except perhaps for an inference in the opening comment that a climate is created. Equally, there was no comment on the measurement of a culture or climate, although admittedly this wasn’t asked for in the introduction to the discussion. However, the introduction did include a hypothesis that a safety climate follows a safety culture, and whilst challenging this in some respects, the comments did not specifically agree or refute this statement.

4. Conclusion

This review paper has attempted to present the delineations between safety culture and safety climate from the literature, acknowledging that in many cases there is confusion between what the two terms represent and that they are often used synonymously. Zohar (2014, 2010) has presented much research on this and reflects that there has been significant progress in understanding that a safety climate is indicative of an organisation’s safety performance, with leadership and safety commitment of higher management at the heart of the issue. As with any description of safety management within aviation, human factors are prevalent in both the problem and the solution, in that human error is often cited as being the cause of an incident, whilst it is the behaviours and attitudes of the workforce that form the fundamental core of an organisation’s resilience to these unsafe acts. Indeed, the workforce can be seen as the ultimate, and final, barrier to preventing an accident and loss of life (Fernández-Muñiz et al., 2014). Furthermore, it is down to key individuals to run an efficient SMS, proactively manage risk, ensure employees adhere to safety standards and assure the senior management, and ultimately the Regulators, that the ‘system’ is safe. It is even plausible to introduce shareholders and insurers to this list. A lack of money, and more generally resources, is often blamed for poor safety performance, with many organisations

(State and private enterprise) having to prioritise their scarce resources accordingly.

Errors are seen as an inevitability within the aviation industry, as they are in many other HROs, and the focus of research has often been to discover and prevent the impact or outcome of these errors (Von Thaden & Gibbons, 2008). However, Von Thaden and Gibbons suggest that the focus should be beyond simple error and be developed around organisational dynamics and the effects of oversight from the many regulatory bodies associated with HROs. Safety and business processes must be interlinked at every level and system safety should be conceptualised, with appropriate emphasis on safety as well as culture (Reiman & Rollenhagen, 2014).

Human error is still prevalent when looking at aviation incidents, but it is the explanation or investigation as to 'why' at a corporate level that is becoming seen as being the more important, especially when being looked at by a Regulator. Von Thaden and Gibbons explore the latency of errors and suggest that often the incident shows only the symptom and not the root cause, stating that there is often a significant time delay between what should be considered as the cause (perhaps software programming) and the final event that caused the incident. There is much recent literature on the process of learning from incidents, with examples from across multiple industries, and according to UKAB statistics, there are an increasing number of near-misses in the UK to learn from.

Whilst authors such as Reiman and Rollenhagen suggest that the differences in terms are clear in the academic literature (2014), much of the practitioner literature, and practitioners themselves, remains beset with confusion as to the delineation between safety culture and safety climate. It is said that that whilst there is still evolution in the safety literature, there is broad agreement that safety culture is a facet of organisational culture underpinned by collective values and attitudes; on the other hand, although safety climate is described in terms of sharing, it is in perception as opposed to values or beliefs, and can be thought of as a demonstration of the culture (ICAO, 2013b; Nielsen, 2014; Nordlöf et al., 2015; Petitta et al., 2017; Reiman et al., 2015; Schneider et al., 2013; Vu & Cieri, 2014; Zohar, 2010, 2014). Kuenzi and Schminke describe culture as the overarching concept and climate as the activities that support it, which accords with a number of the comments in Section 3, especially the transition from culture to climate being the journey from 'has' to 'is'. This leads to the crux of this paper and the answer to the title question, which is proposed as: A Safety Culture becomes a Safety Climate when a series of routine assurance audits (not just one 'snapshot') clearly demonstrates that the organisation is safe, and it has therefore transitioned from having a safe culture to being a safe climate. This perhaps underscores the move to performance-based regulation for UK aviation.

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Appendix M – Critique comments from prototype survey

Participants in the prototype survey (described in Chapter 4) had one additional question, where they were asked to provide feedback to the survey itself.

This is shown in Figure M – 1, and their comments, as downloaded from the QuestionPro software unedited, are presented in Table M - 1.

University of
Portsmouth

Towards a better management framework of aviation risk during regulatory change

100%

[Back](#) Questions marked with a * are required [Exit Survey](#)

* I would be very grateful if you could provide any comments about the questions posed within this survey:

[Done](#)

Portsmouth Business School, Richmond Building, Portland Street, Portsmouth. PO1 3DE
Academic Supervisor: Professor Ashraf Labib

Figure M-1 showing the additional question posed to the prototype survey participants

ID	Comment
65483856	about right
65479976	Vey good, possibly more tick boxes on opinions.
65406580	Well structured, although I would recommend perhaps that question 1 would benefit from rewording and simplifying.
64211603	Good survey
64193107	None
64036193	I got distracted half way through and the survey timed out so I had to start again. I have some experience of UAV regulation and would suggest this possibly isn't the best example. The problems are less to do with the regulation and more to do with the attitude of the individuals flying them. Whatever the regulation the risk comes from ignorant or reckless people.
64006855	The questions are good however the airlines are run to make money. Our COO stated that safety was important but business is more important as with out the business there is no point of being super safe. There lies the problem !
63970279	Some need to be simplified.
63969688	Merry Xmas
63950357	Could have been clearer as to what sort of examples required to assist with thought process
63867381	Useful
63861916	Reasonable and well thought out.
63856553	Some participants may not be familiar with certain areas that are being questioned. It may be useful to have an option such as 'Unknown / Not familiar'
63855977	Good, broad range of questions posed.
63854906	no comment
63835749	There are more than 11 questions.
63814562	As a Flight Safety Investigator working within a commercial airline SMS I believe the questions to be very relevant.

Table M-1 showing the comments made by the prototype survey participants

Appendix N – UPR18 Ethics Review Checklist

FORM UPR16

Research Ethics Review Checklist



Please include this completed form as an appendix to your thesis (see the Research Degrees Operational Handbook for more information)

Postgraduate Research Student (PGRS) Information		Student ID:	475376
PGRS Name:	Ian Fyfe-Green		
Department:	PBS	First Supervisor:	Professor Ashraf Labib
Start Date: (or progression date for Prof Doc students)	October 2014		
Study Mode and Route:	Part-time <input checked="" type="checkbox"/>	MPhil <input type="checkbox"/>	MD <input type="checkbox"/>
	Full-time <input type="checkbox"/>	PhD <input type="checkbox"/>	Professional Doctorate <input checked="" type="checkbox"/>

Title of Thesis:	A study of the perceptions of air safety and mid-air collision prevention during regulatory change
Thesis Word Count: (excluding ancillary data)	53898

If you are unsure about any of the following, please contact the local representative on your Faculty Ethics Committee for advice. Please note that it is your responsibility to follow the University's Ethics Policy and any relevant University, academic or professional guidelines in the conduct of your study

Although the Ethics Committee may have given your study a favourable opinion, the final responsibility for the ethical conduct of this work lies with the researcher(s).

UKRIO Finished Research Checklist:
(If you would like to know more about the checklist, please see your Faculty or Departmental Ethics Committee rep or see the online version of the full checklist at: <http://www.ukrio.org/what-we-do/code-of-practice-for-research/>)

a) Have all of your research and findings been reported accurately, honestly and within a reasonable time frame?	YES <input checked="" type="checkbox"/> NO <input type="checkbox"/>
b) Have all contributions to knowledge been acknowledged?	YES <input checked="" type="checkbox"/> NO <input type="checkbox"/>
c) Have you complied with all agreements relating to intellectual property, publication and authorship?	YES <input checked="" type="checkbox"/> NO <input type="checkbox"/>
d) Has your research data been retained in a secure and accessible form and will it remain so for the required duration?	YES <input checked="" type="checkbox"/> NO <input type="checkbox"/>
e) Does your research comply with all legal, ethical, and contractual requirements?	YES <input checked="" type="checkbox"/> NO <input type="checkbox"/>

Candidate Statement:

I have considered the ethical dimensions of the above named research project, and have successfully obtained the necessary ethical approval(s)

Ethical review number(s) from Faculty Ethics Committee (or from NRES/SCREC):	E417
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If you have *not* submitted your work for ethical review, and/or you have answered 'No' to one or more of questions a) to e), please explain below why this is so:

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Signed (PGRS):	<i>Ian Fyfe-Green</i>	Date: 10 th June 2018
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