RISK IN THE AVIATION CONTEXT: INVESTIGATING RISK PERCEPTION AND RISK COMMUNICATION FROM A BEHAVIOUR BASED APPROACH

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Frontpage Image: https://www.westonmuseum.org/wp-content/uploads/2015/06/The_Red_Arrows_display_over_RAF_Scampton_MOD_45147901.jpg (12 March 2020)

ABSTRACT

Safety is an essential part of aviation. Risk assessment is considered subjective, while the operational context necessitates conformity and a unilateral approach. Eventually, the results assess individual risk perception and risk communication and are not being planned proactively. Additionally, due to the diversity of organisations and cultures, there is further fragmentation of what is recognised as risk behaviour, what should be communicated, and what is hazardous. Considering risk perception and communication within the daily practice is seen as essential to explain the behaviours during an adverse event. Safety analysis and investigation methods (SAIMs) have the goal to suggest ways to achieve acceptable system outcomes and avoid unfavourable consequences on humans, equipment, facilities, and the environment. However, there is no widely common and accepted framework engulfing safety recommendations and proactive safety management such as a behavioural intervention to enhance risk perception and risk communication and minimise danger. Risk perception and communication have been underrepresented in studies regarding their complexity in aviation practice. They have not been explicitly addressed for their role in incidents/accidents, resulting in ambiguous proactive safety suggestions and planning. Based on the premise that risk behaviour results from inappropriate risk perception and risk communication, this thesis supports that a behaviour-based intervention can enhance risk perception and communication.

This thesis aimed to generate a holistic intervention plan to modify risk behaviour on the assumption that risk perception and communication are the basic factors. The hypotheses included that specific factors can be associated with risk perception and communication leading to risk behaviour, which may be influenced to enhance the latter. Also, a complete integrated intervention model can be generated and fused with a Strategic Communications approach, which makes it usable by most aviation air-carrier organisations. The objectives are to determine two sets of risk perception and communication factors, which lead to risk behaviour and then generate an integrated model applicable in the aviation context. This thesis followed the pragmatism paradigm and adopted a fixed multiphase mixed methods approach, investigating SAIMs, safety events reports, two groups of Subject-Matter-Experts, and the wider aviation workforce. The resulting behaviour based model consolidates the role of risk perception and communication factors as moderators of antecedent behaviour while holistically envisaging the aviation work environment. Contribution to theory and practice within the aviation safety context is provided, as well as future research for additional applications of the model.

DEDICATION

To those who believe in me.

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Table of Contents

LIST OF FIGURES

LIST OF TABLES

1. Chapter 1 Introduction

1.1. General Introduction

This study explores the factors associated with risk perception and risk communication in aviation safety. The study considers possible factors and sub-factors that influence operators' choices indulging the so-called ‘risk behaviour’, and more specifically, the factors influencing their risk perception and communication. The influential impact of each factor on risk perception and communication is determined by each factor’s impact on risk behaviour as an outcome. The broad context of this research is mainly focused on risk indications related to perception and communication that may lead to aviation safety events, meaning accidents and incidents.

This chapter aims to provide an overview of the study and present a description of the problem leading to the need for research. Moreover, this chapter demonstrates an overview of the research aim and objectives, the limitations, the research questions, and the thesis outline.

1.2. Background

Risk perception can be considered a mildly abstract construct, strictly depending on the most considerable portion of the operator’s subjectivity. According to a definition, risk perception is a belief which an individual holds regarding a risk, including beliefs about its definition, probability and outcome (Lundgren & McMakin, 2013, p. 377). In the face of subjectivity and complexity, efforts to comprehend risk perception concerning dimensions and factors or other measurable variables similarly could be deemed inappropriate to the least (Sullivan-Wiley & Short Gianotti, 2017). To the extent that psychology, ergonomics or human factors can contribute to this deliberation, there are countless interactions of operators, aircraft, weather, and many other factors (Shi, Guan, Zurada, & Manikas, 2017). Risk factors gathered by safety event reports are being processed by experts using manual identification (Shi, Guan, Zurada, & Manikas, 2017), which may or may not produce congruent taxonomies for risk perception factors as well. Also, risk communication factors seem to be in a similar debate, although studied more regarding different disciplinary fields, such as crisis communication (Benoit, 2018). Risk perception factors and risk communication factors do not possess an independent taxonomy. From another perspective, end-user groups' heterogeneity in high-risk industries makes it apparent that risk perception and communication can unfold in a wide variety of behaviours, yet with a probable harmful result for themselves or others. Among the high-risk industries, the aviation context stands out for the strain on its operators, which often supersedes human limits (e.g., fighting air force) (Shi, Guan, Zurada, & Manikas, 2017; Nicol, et al., 2019). It is only natural for risk perception and communication to be continuously tested in parallel with the absolute human limits in the aviation context.

Another intriguing perspective dictates that some of the constraints arise from the assumption that risk is not being apprehended out of its behavioural context and as a poor mathematical reasoning or a logistical approach. This approach may unavoidably lead to attempts of unending personification of qualities that involve risk perception and communication, yet the same qualities may not reach an end in numbers. Nonetheless, a rare alternative to investigate the two related constructs is to study the consistent involvement of factors, to the very least from a psychological perspective, as part of a process of implicit, explicit, antecedent and final behaviours. Derivative implications from this route indicate universal variables and the operators' context, diverting the focus from the individual psychological, physiological and moral culpable qualities. Through this lens, consistency could be achieved with the way risk is apprehended in multiple fields, such as the medical field (Kang, et al., 2018; Ferrer, et al., 2018; Hanoch, Rolison, & Freund, 2018). A little distant benefit from this approach is that the focus may switch from the 'culpable' and change-resistant operator to essential pragmatic solutions, as generalised behaviour intervention schemes. By relieving the depth of risk assessment off of individualistic properties to realistic factors, there can be a gain of rewards beyond the mere explanation of hazards' properties and possible consequences, reaching the development of practical and efficient risk perception and communication enhancement intervention initiatives.

The direct idea of risk perception and risk communication may be traced back to the beginnings of aviation. Ever since humankind had reached its potential by ruling the land and sea transports, but the air transports. The idea of flying was efficiently managed on December 17, 1903, by the Wright brothers (Petrescu & Petrescu, 2012). After three attempts, Wilbur Wright flew approximately 260m for 59 seconds. These attempts have been the first controlled, powered, sustained more substantial than air flight.

Along with that evolution, the technological progress in aircraft design has exponentially involved. According to Bejan et al. (2014), aeroplane development is similar to biological evolution. By utilising multiple correlations under the constructal law, Bejan et al. (2014) provided evidence that the aircraft has become larger, faster, and lighter through the years. This evolution targeted human convenience concerning time and expenditures. Also, this design approach has put the man in its centre. The complexity and usage of avionic systems required gradually more research. Among many issues concerning the aviation context, what is most important is the traits of its actors. Examination of the psychological characteristics of aviation context personnel allows the industry to hire only the most suitable personnel.

In order to abridge the route of safety, the aerospace domain remains in constant development. This developmental course aims at creating and evolving efficient and reliable air transport systems since human life is at stake. As Schagaev and Kirk (Aviation: Landscape, Classification, Risk Data, 2018, p. 1) have rightfully commented: "just recording data during an aircraft's flight or vehicle's mission in order to allow analysis after a crash is no longer adequate or acceptable". Safety is envisaged and applied as a somewhat reactive process than proactive suffers from a stagnant character, searching backwards to connect the dots leading up to the safety event, lacking strategic, proactive, dynamic adaptation. For example, traditionally, statistics are used to analyse hazards' trends. Thus this is valid only for the specific attributable hazards for a safety event while missing the chance to diagnose actively and suggest measures about current risk. Even though the statistics depict an ever-improving picture of fewer and fewer accidents, no safety event is ever acceptable (Airbus, 2018).

1.3. Description of the research problem

From a general point of view, a 'risky' deed refers to an act accompanied by a tolerable level of risk for the operator conducting it. The term 'risky', as a layman term, is more often attributed by others judging the operator's act, either before the act or after it is fulfilled. The use of the term 'risky' to describe behaviours implies that some risk assessment has taken place, possible hazards and their consequences have been judged and weighted, involving other operators, tools, facilities, and even the general public. The nature of that risk assessment may syphon a variety of practices and approaches towards risk; however, specifying only their following elements does not necessarily grant a deterministic account of the risk perception and communication factors.

Additionally, the operator's subjectivity over risk implies a potential of conceptualising the process of risk assessment regarding factors that can be influenced. This intervention to influence and enhance risk perception and communication may take various forms, depending on the behavioural intervention models that fit each context and its operators. The variety of high-risk industry contexts does not supersede the fields where usually behavioural interventions take place, such as education (Noltemeyer, Harper, & James, 2018) or health (Soulakova, Tang, Leonardo, & Taliaferro, 2018), not to mention that this serves as a predisposing factor to argue they can also be decisively influential. Past analyses of risk describe a variety of factors or group of factors under the scope of multiple contexts and occasions, while others perpetrate comparisons among groups of experts versus less experienced or lay population (Deery, 1999; Sjoberg, Factors in Risk Perception, 2000; Thomson, Onkal, Avcioglu, & Goodwin, 2004; Doria, 2010). It may come to be that comprehension of risk cues necessarily draws from disciplinary biases. On the other hand, the nature of the hazards, their consequences, the operator's capacity to perceive and conceive the complexity of all possible associations, stranded to malignant local rationality, will all play a part in risk perception and communication.

Should this track be followed through, it will signify, at the very least, a clear and systematic view of risk perception and communication factors, and more importantly, a behavioural intervention scheme, elaborating over the possibility of enhancing them. Indeed, such an investigation may also realign and magnify the study's focus on the two constructs regarding the aviation human factors research. First, risk perception and risk communication can be conceived as processes, including a sequence of events, operations and factors that are usually interacting in multiple ways with each other (Sullivan-Wiley & Short Gianotti, 2017; Heath, Lee, Palenchar, & Lemon, 2017; Hicks, et al., 2017; Bergstra, Brunekreef, & Burdorf, 2018). Beyond this, the involved actors of the aviation context possess a reciprocal relationship with the cues they receive from their environment and their interaction with it, since the latter may define their behaviour according to the provided hazard or limitations (Stanton, Harvey, & Allison, 2019; Taisne, Perttu, Tailpied, Caudron, & Simonini, 2019).

Safety and security issues are very closely related. Safety and security aim to maintain the integrity of all system assets (i.e. human, infrastructure, software, capital), and both can derive from the same internal and external discrepancies (Karanikas, 2018). Thus, it should be more evident that any confusion or dilemma over a causal factor that may or may not cause a safety event should not lead to the assumption of strict security or safety labelling of the event. For this thesis, all examples and cases are considered from the safety perspective.

Unfortunately, the aviation field has offered many accidents and incidents of various consequences to reflect upon.

According to the European Aviation Safety Agency (2018), the critical risk areas between 2013-17 were runway excursions and aircraft upset, leading to graver consequences frequently though to a reduced number of individuals. The second stage is security, which depends on the intention to cause harm, which does not appeal to pure safety risk assessment, with one occurrence in the last five years at most. Third of importance came the runway and airborne collision risks. The same report iterates that from a 5-year occurrence data 2013-17, which relate to safety issues, perception and its outcome relative to risk and situational awareness, are first among 24 safety issues. Factors such as the inadequate monitoring of the main flight parameters, ineffective or incorrect management of the approach path, the detection – avoidance flying-in convective weather case are indicative causes for pilots to be led to an aircraft upset. Nonetheless, perception prevailed among aviation professionals and different types of flying operations as an insisting factor of accidents. As such, risk perception and communication are of paramount importance.

Examples of cases where risk perception and communication could have been significant contributors are many. Indicatively, some of these cases will be reported at this part, as included in the EASA's 2018 annual report (2018) or from corresponding authorities directly. First, on 24/3/2015 at Prads Haute Bléone in France, an AIRBUS – A320 impacted a mountainous terrain when the first officer initiated a rapid descent, 146 dead in total (BEA, 2015; Vuorio, et al., 2018). While the co-pilot was to be re-evaluated by a mental health professional and under great dept, none of these two occurrences was communicated to a responsible stakeholder within the working environment (i.e. Aeromedical Examiner or peer support groups for Germanwings pilots). Additionally, neither the private physician communicated any concerns about his mental state nor any co-pilots perceived or communicated any valuable information. Secondly, on 14/02/2010 at Reinhardt Dorf Schöna in Germany, a CESSNA – 550 disappeared from the radar screen at flight level 250, when during the climb, the crew lost control due to an aerobatic manoeuvre (BFU, 2010; Flight Safety Foundation, 2010). Based on the facts, the crew perceived the risks of aerobatics insufficiently while not having specialised training, the lack of visual references due to night-time, and the aircraft's capabilities. An additional issue concerning this case, communication was also problematic due to personal issues between the pilots. Third, on 24/02/2016 at Dana, Myagdi district in Nepal, a Viking Air DHC-6 Twin Otter 400 was destroyed with 23 fatalities on board (Commission for the Aircraft Accident Investigation, 2016). The crew misperceived the risk of the unfavourable weather conditions, and they repeatedly entered clouds during VFR (Visual Flight Rules) flight, leading to constant deviations until the CFIT (Controlled Flight Into Terrain) accident. Fourth, on 12/03/2016 at Kiunga Airport in Papua New Guinea, a Pilatus Britten-Norman BN-2T Islander impacted the ground shortly after take-off, killing all 12 individuals on board (Accident Investigation Commission, 2016). Following the reweighing of the aircraft, the operator did not perceive the need to make adjustments to account for a reduction of maximum allowable weight for luggage; neither had computed the centre of gravity of the flight. Beyond conventional flight operations, unmanned air vehicles (UAVs) are also accounted for; on 21/09/2017 at Hoffman Island, New York, a small unmanned aircraft system (sUAS) collided mid-air with a military Sikorsky UH-60M Black Hawk, delivering only minor damage to the helicopter (NTSB, 2017). The sUAS pilot did not perceive the helicopter visually due to a miscalculation of risk by flying beyond the visual line of sight.

Moreover, cases like XL888T (Hradecky, 2008), AF447 (Traufetter, 2011), Asiana 214 (Withnall, 2014), Lion 610 (BBC NEWS, 2018) and many others show that automation can be an accountable ‘operator’ in the safety research context. Concerning this issue, the UK civil aviation authority (CAA-UK) launched a warning on flight crew reliance on automation (CAA PAPER 2004/10: Flight Crew Reliance on Automation, 2004). Automation and AI can be a double-edged sword. Automation may decrease the workload by resolving seemingly trivial tasks. Nonetheless, the same tasks may be situation-awareness stimulators and direct the operator to stay in the loop. Additionally, automation may hinder the actual interactions and complexity within a task, consequently compromising risk perception and communication.

Concerning the intervention perspective, large authorities, such as the Federal Aviation Administration, have devised components infused to safety management systems (SMSs) to further safety oversight. The four components are (FAA, 2017):

1. Safety Policy (Establishes senior management's commitment to improving safety continually; defines the methods, processes, and organisational structure needed to meet safety goals.)
2. Safety Risk Management (Determines the need for, and adequacy of, new or revised risk controls based on the assessment of acceptable risk.)
3. Safety Assurance (Evaluates the continued effectiveness of implemented risk control strategies; supports the identification of new hazards.)
4. Safety Promotion (Includes training, communication, and other actions to create a positive safety culture within all workforce levels.)

Furthermore, the Human Factors Intervention Development perspective relies on organisational strategies based on error prevention and performance enhancement (USA Naval Safety Center, 2013). The FAA's methodology delegates the operators to focus on engineering as many hazards out of the system while implementing controls/safety barriers in tools, personnel and administration.

Nonetheless, this is a more reactive approach rather than proactive. By allocating risk perception and communication factors, the operator's focus changes from just setting controls/ barriers in the context, towards adjusting his/her capacity to withstand and become resilient over the face of new approaching hazards (safety assurance aim). This research attempts to suggest a comprehensive model of self-adjustment of risk perception and communication capacity in a behavioural approach after its initial application to the operator. For example, an intervention scheme applied to a Dutch hospital showed promising results should be the focus of interventions is realigned to another perspective (De Korne, Van Wijngaarden, Van Dyck, Hiddema, & Klazinga, 2014). As it was indicated, a broad-scale team resource management (TRM) program using safety audits of processes and team activities, interactive classroom training sessions by aviation experts, a flight simulator session, and video recording of team activities with subsequent feedback provided yet observational but original results that similar interventions may be useful to stimulate safety culture.

Based on the above cases, it becomes more evident that there are traces of implications deriving from neglected risk perception and risk communication factors throughout the years. Presumably, any interventions and safety suggestions that took place focused on the multiply inclusive field of decision-making without delving deeper into subsurface additional factors or dimensions. If the statistics had been improved, it would be more apparent that any countermeasures were working. Alas, this may not mean that risk perception and risk communication are the root-cause not yielded yet, but that there is the need for investigations to provide more practical and valuable recommendations to better the situation.

1.4. Description of the research gap

The initial gap in research was spotted due to a previous study on risk perception, which offered the motivation for this study and may be traced in the work of Chionis (2016). That study measured aviation engineers/technicians' risk perception and, more importantly, investigated whether professionals and trainees perceive risk similarly and the role of the context. Therefore, the risk was concerned within a theoretical framework that is regarded as a construct of sub-categories. Seventy aviation maintenance engineers were given a survey designed for the study regarding risk perception and risk behaviour. Risk perception was investigated regarding eleven risk dimensions, while risk behaviour was filtered through hypothetical scenarios. The findings suggested that further research should be conducted regarding (a) attitudinal traits affecting engineers' risk perception, (b) setting a study investigating communication of risk in training sessions, (c) ethnographic differences of risk perception, and (d) which pattern of risk perception's sub-categories adheres to risk avoidant behaviour. As part of this thesis's original contribution to knowledge, it seeks to broaden and elaborate on the suggestions for future research suggested by Chionis (2016).

Specifically, the comparison of risk perception's constructs among trainees and experts has shown that risk perception regulates risk behaviour. Risk behaviour is a massive step toward unsafe practice. So, to change and manage risk behaviour, there is a need to deconstruct how risk perception operates, what it does, and why it either averts or leads to risk behaviour. An additional construct closely related to risk perception is risk communication. This assumption is based on the premise that communication may work as a medium – connection for the individual's mindset and the environment; it regulates the elemental cues for risk perception.

An additional source of motivation for this study was the Chicago convention. In November 2009, several amendments to the Chicago Convention introduced further requirements regarding safety. Aviation service providers were required to conform to implement Safety Management Systems (SMS) (SKYbrary, 2017). The implementation of an organisational SMS framework mandated a formal risk management process. Risk management would serve as a moderating process, ensuring that risks would be systematically analysed, assessed and controlled. Risk Assessment is defined as the evaluative process based on operational judgment and analysis methods establishing the tolerable perceived risk (SKYbrary, 2017). Risk perception is defined as the understanding of the risks associated with a task and the related consequences in the given context (SKYbrary, 2017). Numerous safety methods have been devised in the last decades towards a unifying mind map of handling risk. Everdij and Blom (2016) have published an extensive review of the safety methods used in the Aviation context. From 1949 to 2012, over 200 safety methods have been applied, revised and evolved. However, the 'zero incidents' target or excellent progress has not been achieved yet.

Although the aviation industry has located multiple solutions on how to assess risk and promote safety, there is not yet a method dedicated directly and solely to risk perception and communication; instead, they hold a secondary role during the risk management cycle in other SMSs, as most factors with an additional qualitative scope (Everdij & Blom, 2016). Additionally, although there is a sufficient number of safety coaching, tutoring and training approaches, they are active in the commercial world and high-risk industries in general, which are not yet standardised for the aviation industry solely through academic research, but they are applied through means of workshops or even podcasts in YouTube channels. For example, David Sarkus, with 25 years of experience in coaching, has multiple commercial but not academic publications and a channel on YouTube delivering promotional speeches for his safety coaching packages (Sarkus, 2017). Furthermore, the existing safety methods and safety databases concur that there is a gap between them. There is an extensive list of incidents/accidents that steadily grows no matter the existent safety methods. In other words, the continuous evolution of SMS is still receptive to amendments. It appears that risk perception and risk communication lie at the heart of safety culture's behaviour intention.

The safety methods are the entity within the aviation context confronting risk. Safety methods are mere tools in the service of the safety personnel and all involved personnel in the aviation context. Safety methods involve techniques, methods, tools and models which delegate at eight different safety stages[1] (Everdij & Blom, 2016). However, there is no direct delegation at

[1] Scope the assessment, Learning the nominal operation, Identify hazards, Combine hazards into risk framework, Evaluate risk, Identify potential mitigating measure to reduce risk, Safety monitoring and verification, Learning from safety feedback

risk perception or communication, making it very difficult to attribute which related deficiencies led to incidents/accidents.

Beyond the individualistic and cognitive perspective of risk perception and communication lies the social dimension of the subject. Counting on the probability of social factors influencing decision-making, the same factors are eligible to divert the course of risk judgement (Eller & Frey, 2018). Under the claims of a comprehensive overview of the social implications of groups over risk appreciation by Eller and Frey (2018), views deriving from social psychology also take their toll on risk perception and communication. Social psychology's concepts, such as group conformity enabled by social proof (i.e. trust in consent of the group risking disclosure of information) (Klumpe, Koch, & Benlian, 2018), and social identity theory (i.e. group affiliation bias or within-group conformity bias) (Tajfel & Turner, 1979; Ellemers & Haslam, Social Identity Theory, 2012; Warkentin, Sharma, Gefen, Rose, & Pavlou, 2018) (Tajfel & Turner, 1979; Ellemers & Haslam, 2012; Warkentin, Sharma, Gefen, Rose, & Pavlou, 2018) lead to the conclusion that risk perception can be inaccurate depending on the size of the decision-making body (Nemeth, 2012), while risk communication may also be hampered (Sohrab, Waller, & Kaplan, 2015). Nonetheless, the implications of this theoretical knowledge have not yet been put to the test to investigate practical improvement on risk perception and risk communication. Therefore, the connection among risk perception, risk communication and risk behaviour needs to be specified and modelled. This endeavour will give an opportunity to facilitate an intervention approach to interrupt the course toward failure. So, in this thesis, there will be a choice among behavioural intervention models based on their capability to explain risk perception, risk communication and their connection to risk behaviour.

The concept of a risk perception/communication intervention using a behavioural intervention method is a new field for academic research in the human factors field, and no published studies have been found on the topic. Consequently, it would be captivating to investigate how such a method could be set up. In other words, the research aim of the current thesis is to enhance risk perception and risk communication competencies in aviation personnel by applying a behavioural intervention method focused on behavioural change. Extensive research on behaviour modification through interventions, which will be given a more detailed analysis in chapters that follow, has shown that by understanding behavioural intention, one may intervene in modifying a behaviour (Gibson & Frakes, 1997; Godin, Conner, & Sheeran, 2005; Tlou, 2009; Marquardt & Hoeger, 2009; Cheon, Lee, Crooks, & Song, 2012; Shaw, Baume, & Mwita, 2012; Greaves, Zibarras, & Stride, 2013; Ajzen, 2015).

1.5. Conceptual Framework Analysis

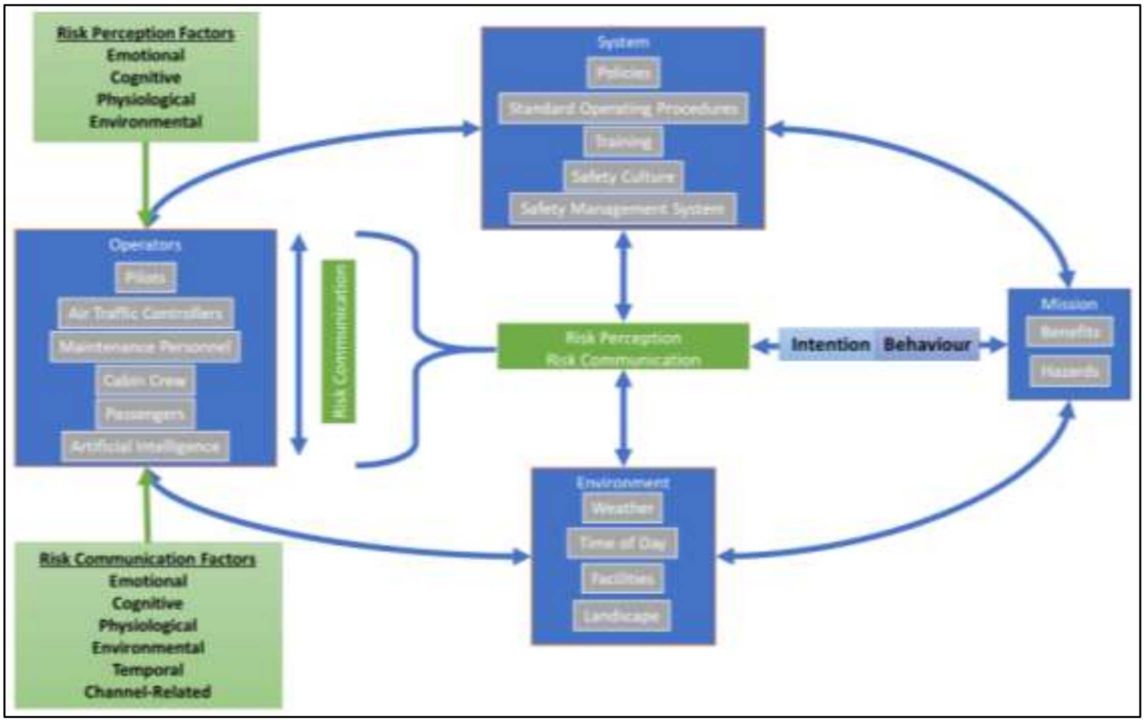
At this early point of the thesis, only a conceptual framework (Figure 1-1) of these interactions may indulge the reader in comprehending the upcoming chapters. The following content assumes the existence of a malleable relationship between the end-user and the hazard cues; there may or may not be the adequate capacity to perceive all cues and to communicate them as well. Nonetheless, the emphasis is needed on the limitation posed by the vagueness of the sum of risk factors, both task and not-task related. As task and not-task related are considered risk factors related to the task context or the operator's public sphere of living, respectively. Past considerable efforts investigating risk perception took no set barrier among task and not-task related risk cues (Brewer, Weinstein, Cuite, & Herrington Jr, 2004; Sullivan-Wiley & Short Gianotti, 2017). However, the conceptual framework will serve its purpose to create a systematic research agenda for this thesis.

Given the lack of previous research with the exact purpose, it is explicitly necessary to declare that the assumptions are not limitless. It might be the case that grouping risk perception and risk communication factors into aggregate categories could serve as a sound starting assumption. A more distant assumption is that the decision-making process works in a specific manner when dealing with risk perception and communication. This could be speculated as a very absurd statement, given the fact that the decision-making process is universal (Kahneman & Tversky, 2000; Ito & Doya, 2015). However, the connections made within each individual may fall into patterns that possess some differences (Chang & Wang, 2010). The reasons for an operator to become involved in a hazardous situation are fundamental to address the capacity to perceive risk and communicate it. Possible answers may lie within the psychological context of the individual, the cultural context of the aviation field and the utilitarian context of rules and equipment, on which behavioural forces operate.

Volitional acts of of overly risk behaviour may be interpreted in two ways, depending the approach; the old safety approach considers a perfect system but a culpable operator attributing blame to human nature (Hollnagel, 2013). On the contrary, the new safety thinking approach considers the operator as part of an equally culpable system as well, to the very least (Dekker S. W., 2007). By no means this does not absolve human or even Artificial Intelligence (AI) operators; on the contrary, this approach utilises any shortcomings, delving deeper into the system to search and rectify serious abnormalities (Reason, 2008; Katsakiori, Sakellaropoulos, & Manatakis, 2009). From another perspective, risk behaviour that did not manifest into a detrimental consequence may also involve some temporary benefits for the operator. Presuming that the operator perceives enough the case of a particular hazard, he/she even might benefit in terms of experience, satisfaction, or even self and other approval status; nonetheless, continuous risk behaviour involving possible self-harm, at least, may be an indicator for low impulsivity, anxiety, impulsivity, and poor use of positive coping strategies (Stanford, Jones, & Hudson, 2018). The personal benefit can be a considerable motive that may blur the operator’s perception in a case resembling self-serving bias (Myers, 2015). Throwing luggage from a great height down a transfer truck next to the aircraft without using the transfer belt for speed is one example of this (KTLA 5, 2019); speeding up take-off checklists and omitting steps can be another (Schneider, 2021).

Beyond the cognitive state, the emotional state can also influence risk behaviour negatively, as it is known from other fields. According to a collective review on the influence of cognitive and emotional factors on decision-making under risk (Kusev, et al., 2017), anticipated emotions are felt due to an individual's choice over an alternative. Also, immediate emotions refer to all the local feelings accumulated to the individual during decision-making, while the rational individual is supposed to choose based on utility, independent of context and non-calculable information. Nonetheless, the context's power over decision-making cannot be easily disregarded since factors such as time restriction are contextual and yet influential (Hawkins, Brown, Steyvers, & Wagenmakers, 2012). Moreover, interdependent contexts among individuals or groups may positively affect self-choice, while interdependent contexts have the reverse effect (Rigoli, Preller, & Dolan, 2018). From an additional perspective, choice stochasticity should be incrementally related to risk perception and communication. In other words, embattlement and reflecting among rational and emotional choices, based on a context and the premise that either the choice will have self-consequences or other consequences, should depend on factors affecting risk perception and communication.

Figure 1-1: A Diagrammatic Conceptual Model of Risk Perception and Communication Influence on Behaviour



The diagram in Figure 1-1 outlines in a general logic the array of influence links acting upon the operators, the system and the environment and how these connections may affect risk perception and communication. The essential core of the diagram illustrates the aggregated influential factors on risk perception and communication. It is consistent with efforts of modelling behaviour patterns based on psychological principles and through structural equation modelling (Taehun, MacCallum, & Browne, 2018; Howard, Gagné, & Forest, 2018; Asparouhov, Hamaker, & Muthén, 2018).

To develop the intervention approach further, an additional figure below (Figure 1-2) depicts potential relationships among certain factors met in the working environment at a point of decision-making steering points, expressed as a conceptual pathway that the operators might take to perceive and communicate risk. This illustration delves deeper into the possible influences of factors affecting choices explicitly and implicitly. Due to the complexity limit, singular dimensions cannot necessarily meet local rationality limits for every safety event. For simplicity, three salient contexts posing as variables have been identified that might influence risk perception and communication unilaterally:

1. Operator's Local Rationality Context

The operator's local rationality context relates to current and within the case contextual influence. These influences can also be embedded in any past experiences that are similar, depending on which cognitive bias or heuristic is active at the time. The past influences can be of high value since they represent experience from family, religion, society and culture (Kim, Schroeder, & Pennington-Gray, 2016). The factors related to risk perception and communication sourcing from there may, in a sense, act as precursors on the immediate/local context regulating the operator's motivation, prohibition, intention and behaviour. Practically, the operator comes in immediate contact with conflict resolution, hazard anticipation, and coping with organisational change and policies. In other words, the local rationality principle describes the ties to decision-making patterns, to current knowledge of the situation, the situation itself, and processes with goals that are probably in conflict (Woods & Cook, 1999; Vlaev, 2018). As such, the finite capacity of the human and AI operator to weigh risk and communicate is fundamental.

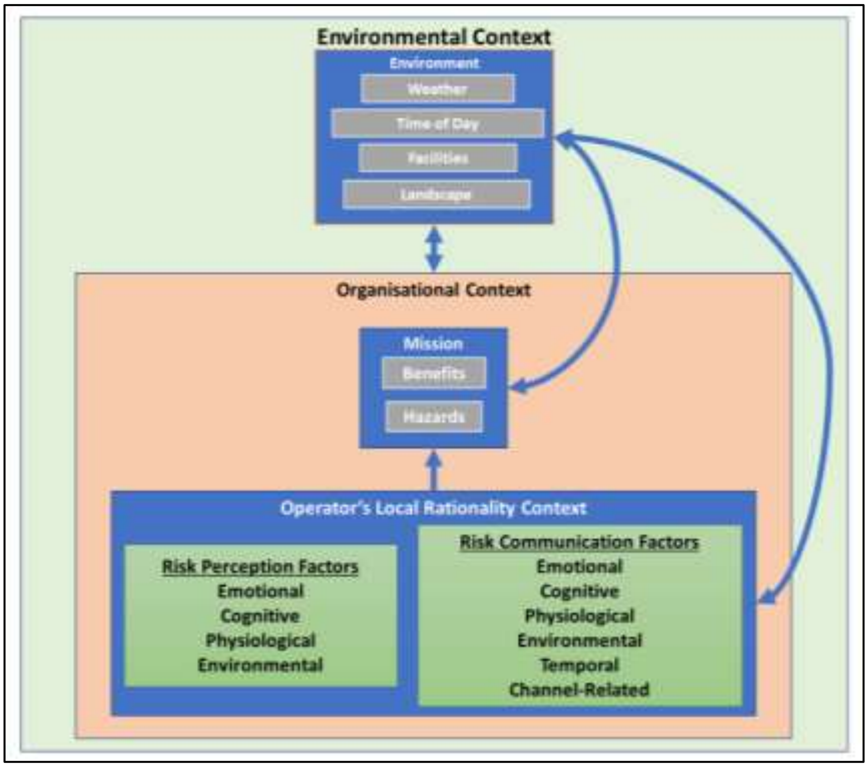
2. Organisational Context

The organisational context relates to the cultivated culture and habitual behavioural patterns within the organisation. The organisational culture affects the subset of safety culture (Zhu, Von Zedwitz, Assimakopoulos, & Fernandes, 2016; Almklov, Antonsen, Bye, & Øren, 2018). Many organisations envisage a safety culture as compliance with rules and safe behaviour in general (Bieder & Bourrier, 2013; Antonsen, 2017). Nonetheless, the organisational context, including culture and style of management, can be of great importance since production may burden safety, and reactive measures may overcome proactive ones. In other words, the organisational context refers to factors, such as the management's commitment to safety, operator involvement, training, communication, and compliance with procedures, regulate the cues which an operator may perceive and communicate (Anderson M. , 2004; UK HSE, n.d.; Lundell & Marcham, 2018).

3. Environmental Context

The environmental context refers to an inclusive overview of the operator's external and internal context, including all personal, organisational and environmental factors that influence his/her intention and behaviour. The environmental context is conceptualised as the greater vassal with the factors of weather, day/night, facilities and the landscape or terrain form; beyond these factors, it engulfs the organisational and the operator's local rationality context. As such, it holds specific attributes and shared attributes with the other two contexts. The connection among the internal contexts comprises communication channels specific to each function (i.e. telecommunications, visual/auditory communication). Additional factors which may disrupt the harmonic flow of processes and communication are, for example, the compatibility of production and safety goals, operating pressures, ambient noise and vibration, temperature, lighting and the availability of protective equipment and clothing, and the corporate safety culture (ICAO, 2013). Moreover, environmental factors may influence risk perception and communication from the point where the operator weighs or communicates preventive measures, such as weather (Chang C.-T. , 2017), time of day when the operations take place (Morris, 2018), the facilities' supportive quality (ICAO, 2018), and the operating landscape, airframe, type of operation and aircraft (Schagaev & Kirk, 2018).

Figure 1-2: Contexts as Variables Influencing Risk Perception and Communication



1.6. Research Aim and Objectives

1.6.1. The aim of the Study

The research aim of this project is to plan a holistic intervention to modify risk behaviour on the assumption that risk perception and risk communication are the basic factors. The product of this thesis will be a model destined to intervene in risk perception and risk communication factors and influence them towards maximum effectiveness. A central argument for this thesis is that risk communication and risk perception act in a compelling manner towards risk intention-behaviour. The further research objective is deeper exploitation of the results from this study, in the form of a set of training toolsets, by safety agents within the aviation context to enhance risk perception, risk communication, and ultimately safety culture by disseminating its findings widely.

1.6.2. Objectives of the Study

To achieve the research aim, first, there is a need to discriminate among the existing safety methods which cover risk perception and risk communication to determine the intervention's material. Second, there is a need to investigate the variations of risk perception and risk communication through a given period to process which safety model directly or modified could produce suggestions-preventive actions against the extent of risk perception and risk communication dimensions. Third, it is needed to assess the available behavioural intervention models to apply and define the connection among risk perception, risk communication and risk behaviour to suggest intervention steps. Under these three set investigations, multiple objectives and hypotheses were formed. The objectives were:

a) To determine a set of risk perception factors that can be associated with risk behaviour.

b) To determine a set of risk communication factors that can be associated with risk behaviour.

c) To generate a model that can be applied in the aviation context to influence risk perception and risk communication.

1.6.3. Research Hypothesis

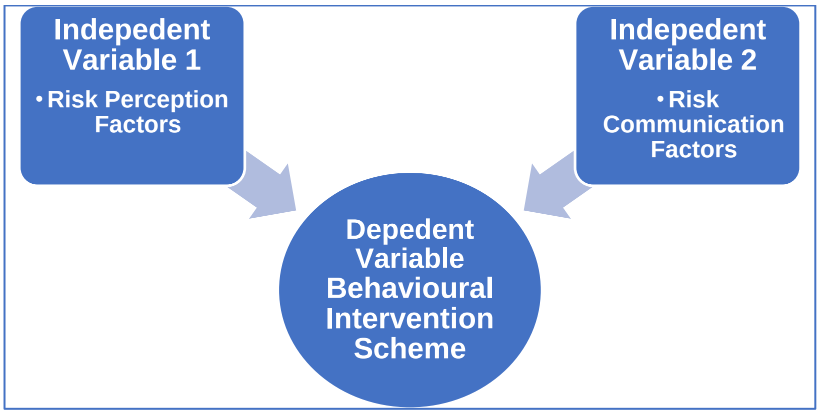
The anticipated risk perception and communication factors are expected to be aggregated groups of minor factors that may influence decision-making and communication in everyday and critical situations. The variables in this research are expected to generate non-numerical data (i.e. qualitative data derived from interviews) and numerical data (i.e. quantitative data derived from questionnaires and database queries). The hypotheses emerging for this body of research are as follows (Figure 1-3):

1. Risk perception may be limited to specific factors such as the operators' fear, fatigue, self-confidence, and the gravity of possible injuries.

2. Risk communication may be limited to specific factors such as the operators' fear, stress and fatigue, self-confidence, the gravity of damages and possible injuries.

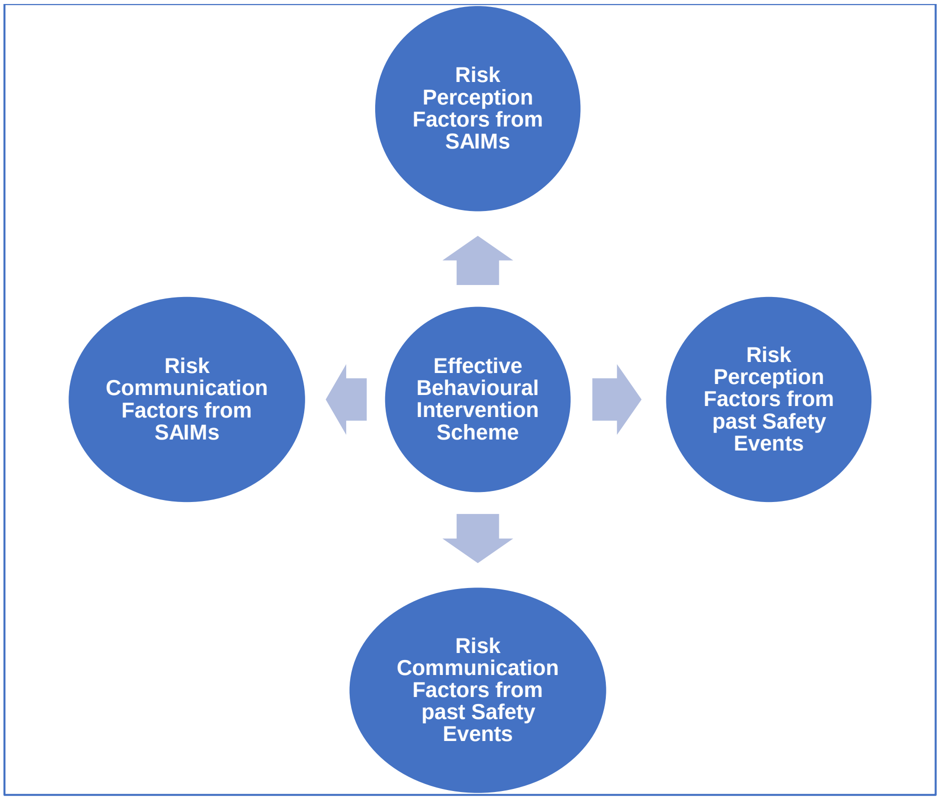
3. An integrated behavioural intervention model strategy can be proposed for application in the aviation safety human factors context.

Figure 1-3: Proposed Research Hypotheses



To construct an all-encompassing behavioural intervention scheme addressing the enhancement of aviation operators' risk perception and communication, the focus should rely on the determination of the factors associated with risk perception and communication in aviation. Consequently, the achievement of drawing an effective intervention depends on the consensus of risk perception and communication factors as they emerge from past designed Safety Accident and Investigation Methods (SAIMs) and past safety events. This course is further visualised in Figure 1-4.

Figure 1-4: Detailed Research Focus and Hypothesis



Therefore, the body of this research has been set into two areas of investigation, as depicted in Figure 1-4. These two sources of data are predestined to counterpart each other towards the choice and re-design, the latter if needed, of the final behavioural intervention scheme.

1.6.4. Research Questions

The research questions deriving from the objectives can be presented as follows:

1. Which are the risk perception factors that can influence aviation operators' risk behaviour?

2. Which are the risk communication factors that can influence aviation operators' risk behaviour?

3. Which behavioural intervention model(s) can be applied to influence the enhancement of aviation operators’ risk perception and communication factors?

1.7. Assumptions/limitations

This research aims to develop a comprehensive model of understanding and enhancing erroneous risk perception/communication to be regulated through a behavioural approach. Furthermore, producing a specified safety method to promote safety culture efficiently would be essential to a safer aviation world. The ultimate goal is to promote aviation safety and provide more solutions for downsizing accidents or incidents with dreadful ‘rewards’.

1.8. Benefits of the Research

The aviation industry is constantly growing every year. The need for aviation personnel and the erection of new facilities can be viewed in relevant statistic reports (ICAO, 2011; Garcia, 2018). Even so, the field is supposed to grow in safety as well. Therefore, deeper investigations in risk management are imperative. As such, this thesis investigation into risk perception and risk communication to manufacturing a behavioural intervention to enhance them constitutes a promising contribution to the field.

To enhance risk perception and communication among aviation personnel, there is a need to identify and comprehend the factors influencing these attributes towards riskier decisions and behaviours. Based on this notion, safety practitioners and safety policymakers will be able to conceptualise further risk factors’ implications, manage risk more effectively, and implement practical solutions. The main benefit of this research is that it will highlight the specific risk perception and communication factors, which influence aviation operators’ decision-making towards riskier behaviours, it will develop a conceptual framework of the latter’s implications to unsafe behaviour, and it will provide a scheme for a behaviour intervention to apply and test in future research.

Also, risk perception and risk communication, no matter how secondary they might seem due to their qualitative reach, are parts of decision-making during risk management, leading to antecedent behaviour, which in turn lead to (un)safe behaviour. Risk management can be reactive (i.e. address risks after an event), proactive (i.e. address risks before an event), and predictive (i.e. plan ahead for potential risk based on operational data) (SKYbrary, 2016). The road to being proactive and predictive is a continuous effort for regulators and safety investigation organisations (SKYbrary, 2016). Towards the goal of eliminating risk, this thesis aims to provide safety professionals and individuals from all levels with the tools based on a generated model.

1.9. Organisation of the Thesis

This thesis has been planned sequentially to enable the reader to follow the conceptualisation of the contents to achieve the research aims and objectives.

The direction of processes for the thesis is as follows:

a. Multiple literature sources from various fields related to human factors principles and processes are reviewed to assist the author in gaining a broad range view and a better understanding of the research problem. The aim is to form a solid foundation to formulate working hypotheses leading to successful and applicable results of the research;

b. Throughout the literature review, an overview and critique of relevant empirical investigations and various theoretical approaches laid by other researchers constituted the foundation upon this research can be evaluated;

c. Before the main data collection, a set of sub-studies were conducted to gain insight into the investigated variables and context. The first sub-study highlights the importance of risk perception and communication factors among Safety Aviation Investigation Methods (SAIMs) while also offering an initial indication of which factors are related to the two constructs. The second sub-study aims at clarifying which risk perception and communication factors may influence an operator towards a safety event in a consistent manner, as shown from multiple accident/incident reports. The third sub-study aims at scoping the current literature to tackle the issue of using or integrating a new behavioural intervention model. The fourth sub-study aims to compare and contrast SMEs and the general aviation workforce input while mapping the layout for a strategic communications approach.

d. The primary data will be collected through questionnaires and interviews in the forms of quantitative and qualitative data to examine and test the hypotheses.

The thesis is organised into six chapters and sub-sections wherever necessary. Chapter one is a general introduction to the thesis, providing basic guidance for the reader concerning an initial familiarisation with the investigated variables and the structure of the following chapters. Chapter two consists of the literature review mandated to investigate all factors and parameters of this thesis. Historical assets of human factors research and all necessary terminology and accompanied research across multiple related fields will be presented. This will lead the reader to gain knowledge of the field and the investigated hypotheses. Chapter three presents the research methodology. This chapter presents the procedures followed for the three sub-studies as per the methods for data collection and tools for measuring the dependent and independent variables, the justification of approaches. This chapter also describes the research paradigms, sample segmentation, collected data, and statistical methods. Chapter four illustrates the results of all sub-studies towards formulating the behavioural intervention model for enhancing risk perception and communication, and a relevant discussion of theories and previous research related to the investigated variables, factors, and context. Chapter five discusses the results. This chapter will provide the reader with a general summary of the findings. Chapter constitutes the conclusion of this research while indicating the generated model and its applicability value. Furthermore, the conclusion recommends consecutive relative research that will assist in further investigating the applicability of the drafted model on a broad population sample and other recommendations for future research in the area of risk in human factors.

1.10. Summary

The purpose of this chapter was to provide an initial insight into the current study. The chapter discussed the extent to which a behavioural intervention scheme aiming to enhance risk perception and communication is required. Based on theoretical approaches on risk and indicative safety events from the aviation context (i.e. general/commercial/military aviation). The investigation of hazard and risk identification is a continuous effort of safety and human factors research. Relevant research and events have demonstrated the importance and the contribution of risk perception and communication in aviation safety. The importance is being highlighted by all significant bodies of aviation authorities, stressing that effective risk management is of paramount importance (Maragakis, et al., 2009; ICAO, 2013).

There is no widely accepted framework for a behavioural intervention to enhance risk perception and risk communication and minimise the danger for aviation operators. Furthermore, evidence suggests that the existing risk management training methods tend to focus more on a shallow approach on risk perception and communication rather than delving deeper into the factors that may predetermine risk behaviour (Chionis & Karanikas, 2018). Lastly, developing an intervention scheme to enhance risk perception and communication will be an important step in a systematic way to clear the uncertainty surrounding training and intervention ventures in aviation safety.

The following chapter will present an overview of the human factors field considering risk perception and communication, the implications from the operators' perspective, and a review of the applicable intervention methods in influencing safe behaviour.

2. Chapter 2: Literature review

2.1. Introduction

In this chapter, a review of the literature concerning risk perception and risk communication will be presented. This review will lead to acceptable descriptions of the investigated variables, the involved operators' contribution, and the research gap for the present study. The chapter will also grant background on the importance and relevance of the human factors research field as well as the factors that determined the approach taken in this research.

The chapter will also review the involvement of cognition, cognitive biases/heuristics and other factors on risk perception and communication. It has long been perfidious the contribution of several contextual factors, which yet could not be generalizable. Risk perception and risk communication have always been essential in decision-making for safe air and ground operations. However, it would appear that this omnipotent presence has been grouped and underrepresented within the scope of risk management research and has not been matched by research.

2.2. Deeper in the Field of Human Factors Research

The first landmark in safety research and human factors took place in Hawthorne of the USA between 1924 and 1930 (Roethlisberger & Dickson, 1939; Mayo, 1946; Mayo, The Social Problems of an Industrial Civilisation, 1975; Gillispie, 1991) (Roethlisberger & Dickson, 1939; Mayo, The Human Problems of an Industrial Civilisation, 1946; Mayo, 1975; Gillispie, 1991). It was there that the "Hawthorne Effect" declared that job performance might be influenced by psychological factors, independent of the context involved. The next landmark was the recognition of the need for human factors training. This training took place for the first time in 1971 as a two-week seminar in the United Kingdom introducing to aviators the gas laws most relevant to aviation human factors to increase their understanding of the effects of the human body gaining altitude during the flight (Green, Muir, James, & Grandwell, 1996).

Koonce and Debons (2010) suggest a definition of human factors in the aviation field of study. The authors defined the Human factors in the aviation field as a framework of research that rests on the notion of the various ways human's capabilities, behaviour, human-machine interface and the accumulated knowledge needed to integrate into a system with the primary purpose of enhancing safety first for the operator, then for the equipment, and finally for the organization.

The absence of a definitive framework with clarity and universal acceptance could create problems regarding comprehension of the work produced by the professionals in the field. As Wogalter et al. (1998) suggested, human factors face problems in understanding from various audiences. Therefore it remains difficult for the broad workforce or the average layman to define and perceive the exact area of human factors study. Their respective study investigated the terms most frequently used to describe Human Factors/Ergonomics field. Their ultimate intention was to build a list of terms used as a basis for developing definitions destined for lay or field–related audiences. As for the differences between Human Factors versus Ergonomicslso stated that both “refer essentially to a common body of knowledge” (p. 671). As a fundamental principle, which is also considered throughout this whole thesis, the definition should be perceivable from lay-public and subject matter experts (SMEs) and among the spectrum of front-line to back-line operators. This last statement has to do with effective communication.

Additionally, Wogalter et al. (1998) suggested that ergonomics as a term also has minor issues. According to their initial contributory research, ergonomics is a synthesis of ‘Ergon’ and ‘Nomos’, both Hellenic words. ‘Ergon’ means work or action, and ‘Nomos’ means law or rule. Rule-based skills are a determinant factor for this framework. Their study's results provided a list of words of definitions SMEs gave. The reason for making such a reference to this list is none else but the case of communication and understanding of the human factors field.

Until this point, the reader of this thesis has become familiar with an attempt to define human factors field, the problem of defining such a field, and the importance of using a definition that is easily communicated evenly to laypersons or Subject Matter Experts (SMEs). Laypersons or passengers and aviation professionals are supposed to communicate risks effectively. An everyday example is the cabin crew's demonstration about the use of seatbelts. However, the question about why trifle into human factors in aviation remained; until now. The aviation field is an excellent field of human activity, including multiple posts, specialities, regulations, and most importantly, requires the highest caution. As another example, front-line operators should be able to communicate effectively to their safety managers. One more reason to uphold the aviation field is that it is a means of transportation. Statistics show that passenger, freight and mail air transport have evolved into a central theme of human activity (Eurostat, 2016). The Greek air passenger transportation landscape (Figure 2-5) depicts a steady rise since 2012 in air carriers as a means of transportation.

Figure 2-5: Greece's Air Passenger Transport 2006-2016 (as constructed by a manual query from Eurostat database)

Supposedly, for the Hellenic State, aviation safety is an emerging, rising factor that should be considered. Furthermore, the Hellenic Aviation Industry field and General Aviation field are considerable, as shown in the statistics, and not to be neglected on matters of safety from those involved in these fields; pilots, air traffic controllers (ATCs), engineers/ engineers/technicians and airport handling personnel.

2.3. Human Factors and Safety

The technological progress, the rise in the use of air commute and the target ‘zero’ for safety have necessitated continuous research practices and constant innovation (EASA, 2018; EUROSTAT, 2019). The transition in new technological advancements puts into question the effective and safe performance of aviation personnel. Whereas the target of safety culture remains the same, namely ‘zero accidents', research from cross-sectional fields such as Human Factors reveals a need for constantly upgrading safety training (ICAO, 2013; Collins, 2015; Graeber, 2017). Safety training focuses on many aspects related to human-computer interaction (HCI) field of study context, the social context and cognitive context. HCI grasps the reciprocate relation between machine and operator. The social context involves social skills, organisational issues, and the connection among crew members or a larger organisation. The cognitive context insinuates decision making and all assessment processes, such as risk assessment. More effective safety training could mean higher probabilities of reaching the ‘zero accidents’ target.

Advancing to a more explicit explanation of the Human Factors field, a definition of human factors may be the study and profound realisation of the multiple ways interact with machines, systems, automation, procedures, and other humans (Balog & Gibbs, 2017). Licht et al. (1989) attempted to produce a standardised definition of human factors through content-analysing 400 definitions from a variety of sources, resulting in a 90 definitions index. The results showed that the construction of a single unifying definition requires consideration of the differences among human factors, human factors engineering, and ergonomics and that the field has evolved in global manufacturing and consumer-oriented environment. Following the above, Licht et al. concur with Balog and Gibbs (2017) that Human Factors in Aviation is the application of principles, concepts, constructs, and ideas of human factors to the aviation and aerospace field.

Due to its interdisciplinary nature, Aviation Human Factors include professionals from the fields of engineering and psychology. The American Psychological Association (APA) defines Human Factors Psychology as a “branch of psychology that studies the role of human factors in operating systems, with the aim of redesigning environments, equipment, and processes to fit human abilities and characteristics related to Human Engineering” (2015, p. 506). Furthermore, in an attempt to define the professional who studies behaviour in the aviation context, an Aviation Psychologist is the professional psychologist who studies the role of aviation human factors in the aviation context to redesign processes, equipment and environments to fit human limits and abilities related to Human Engineering and Psychology.

Balog and Gibbs (2017) suggested that the purpose of Aviation Human Factors is to improve the efficiency, effectiveness, and safety of aviation and aerospace operations. As far as Human Factors professionals are concerned, the author suggested that they accomplish their mission by taking advantage of human performance strengths and capabilities while avoiding human performance limitations and error. Another suggestion is that ‘human factors’ is an ‘umbrella’ term comprised of numerous sub-fields such as human cognition, ergonomics, biomechanics, physiology, kinesthetics, human performance, human error, risk management, and so much more. Additionally, the authors define separate fields of application for human factors; Standard Operating Procedures (SOPs) and systems engineering areas. Regarding the SOPs, the authors listed various operational areas such as flight operations procedures, maintenance operations procedures, Air-Traffic-Control (ATC) operations procedures, airfield operation procedures, and management operation procedures. As far as Systems

Engineering Areas of Aviation are concerned, Balog and Gibbs (2017) suggested that human factors may be applied in cockpit design and integration, avionics systems design, maintenance systems design, ATC systems design, airfield operations systems design, human-machine interaction (HMI), and automation.

HMI is a common context for the modern industrial world; from seemingly harmless micro-electronics to heavy machinery, HMI and digitisation are a continuous trend (Kun, 2018). According to Spitsberg et al. (2015), whose work has introduced a framework for identifying and developing technology-based business opportunities in new areas to help companies move into new markets, an innovative technological approach that offers the potential to augment internal capabilities can be an enabler in evolving market challenges. However, Spitsberg et al. (2015) do not account for the safety of business innovation for the end-user, but the risk in new business opportunities.

Nowadays, industrial policies often adjust to new rising hazards (Beg, Sekur, & Smolic, 2018). However, this was not always the case. In the 1980s, the pursuit of a “zero-risk” society was perceived as a threat to political and economic stability (Slovic, Fischhoff, & Lichtenstein, 1982). The definition of risk was yet inconsistent even among experts. Slovic et al. (1982) attempted to accumulate a clear definition of risk perception. This definition would include what is and what is not “risky”, a model explaining how individuals respond to new hazards, and techniques for assessing risk perception. This early work suggested that risk perception is quantifiable. Thus far, there was not still a definition of risk due to differences among groups of experts. However, risk tends to be measured more accurately when analysed through its traits or dimensions, such as knowledge and controllability (Chionis & Karanikas, 2018). This also constitutes a reason for these traits to be sometimes highly correlated.

Moreover, risk traits or factors should be standardised before measurement of risk perception is to be estimated, if the case refers to quantifiable metrics. Risk as a construct and a factor, with aggregated traits or sub-factors, interacts with end-users during operations. The end-users' capacity to filter and decide upon quantifiable risks may indicate a deeper link between hazards and their risk perception.

According to Slovic et al. (2000), their study confirmed risk perception's quantifiability and predictability, among others. This study replicated that knowledge of a situation's judged dread and severity is a valid predictor of perceived risk. To this fold fell also perceived benefit. "Any attempt to control accidents must be guided by assessments of their probability and severity" (p. 149). The same study implies the importance of experience in a context to judge the viricidal dread of a hazardous situation.

On the contrary, cognitive limitations, biases, misleading experience, accumulated anxiety influence risk perception and risk acceptability (Slovic, Fischhoff, & Lichtenstein, 2000). More importantly, Slovic et al. (2000) noted that the social impact of *N* losses cannot be depicted in a single weighting function. They support that this notion derives from the fact that individuals have multidimensional relationships in and across contexts. Nonetheless, by striving to quantify risk, Slovic and other researchers many times minorly neglected that risk can be highly subjective, biased positively (i.e. reporting no risk when there is) or negatively (i.e. reporting high risk when there is low), and easily influenced by quantitative variables such as emotion.

2.3.1. Safety Analysis and Investigation Methods

In the aviation industry and other high industries (i.e. nuclear energy production), the organisations use safety analysis and investigation methods (SAIMs). SAIMs aim to provide courses of action to maintain goals by avoiding adverse consequences on humans, equipment, facilities, and the environment. In this manner, SAIMs contribute to safe operations by facilitating effective management of risks and communication from the front-line to the highest managerial level. SAIMs examine causal factors and systemic functions and may produce early warnings of incoming hazards, enable risk assessment, and suggest countermeasures and remedies after a safety event (i.e. accident/incident). Therefore, every SAIM condenses risk perception as a highly influential factor that enables a probabilistic analysis or a factor that interfered within a safety event, and mandates an assessment of the consequences of a hazard and risk communication.

Every SAIM views operations and safety events under a lens of causality (i.e. safety model), which guides the approach of analysts, safety managers and safety investigators to unveil the ways risks and safety events arise. Kaspers et al. (2016), concluded in their literature review what has been commonly accepted by other authors of the field concerning the categorisation of safety models in three major categories (Hollnagel, 2012; Aurisicchio, Bracewell, & Hooey, 2016):

- Single or Root Cause Models: They suggest that safety events happen due to a chain of other cases, clearly distinguishable and set on a timeline. The root cause is a default baseline for the timeline, and, from that base, a chain-of-events sprout leads to a safety event. By managing the root cause, all other cases can be prevented.

- Epidemiological Models: They consider proximal and distinguishable hazards, as well as probable causes, present before the chain-of-events, lead to the safety event. These causes include a broad recollection of factors, such as organisational flaws, training shortcomings, and poor supervision (i.e. latent failures).

- Systemic Models: They extend their prospect by going beyond the former two categories to address interactions and dependencies amongst systemic components and effects of their performance inconsistency over time and under different contexts.

Under the emerge of new developments such as the increasing growth of air travel and social network systems (e.g., social media), the safety field has been complicated by absorbing new variants of systemic risks into sociotechnical systems (Waterson, Jenkins, Salmon, & Underwood, 2017). Sociotechnical systems contribute by highlighting the equilibrium between individuals (i.e. the social system) and tools, technologies and techniques (i.e. the technical system) (Waterson, et al., 2015). Lately developed SAIMs can locate these imbalances, such as Systems-Theoretic Accident Model (STAMP) (Leveson, Engineering a Safer World, 2012). However, the feedback from the industrial practice showed that a majority of SAIMs could be confusing for safety practitioners, highly difficult to manage for inexperienced specialists and non-experts, narrow-sighted to include a wide variety of safety events, and frustrating to navigate (Waterson, et al., 2015).

2.3.2. The Reach of Risk Perception and Risk Communication Factors in Safety Events

It has been common knowledge that accidents and incidents or safety events in the aviation industry have been studied for many years and various reasons. The main reason for studying and analysing past errors with detrimental consequences is to produce preventive measures. Post-accident/incident safety recommendations aim to prevent the reoccurrence of the same accident/incident. Given that the human factor is the most often causal factor of air transportation, there is a need to focus on the relevant post-accident/incident data (Rankin, 2007). Moreover, although there are a few definitions of the term “accident”, the majority converge in describing the accident as a hazard materialising in an unexpected, probabilistic occasion with adverse consequences (Hovden, Albrechtsen, & Herrera, 2010). Also, according to Kjellen (2000), there are four categories of accidents:

1. Damage: Injuries, fatalities, organisational losses.
2. Incident: Dependent on Type (Act) and Agency (Mean)
3. Hazardous Condition: Defective means, unsafe designs.

4. Unsafe Act: Errors and Omissions.

Furthermore, SAIMs, as has been mentioned earlier, aim to propose ways to accomplish tolerable organisational results and evade unfavourable consequences on individuals, equipment, facilities, and the environment. The contemplation of risk perception and communication within a SAIM is essential to explain the decisions and actions made during a safety event or defend the ones planned for future interventions based on a risk assessment process. Additionally, to the author's knowledge, risk perception and communication factors have not been investigated in a uniform representative way, but rather they have been dedicated in each speciality or sub-context. The groups of interest in the aviation safety risk management field and the groups of interest for this thesis are pilots, Air Traffic Controllers (ATCs), and Maintenance Personnel (MP).

As a common principle within aviation safety, a hazard is a mandatory prerequisite for a safety event (FAA, 2006). For example, a hazard can be any potential condition that may lead to injury, death, loss of equipment or facilities. Moreover, hazards can be grouped according to their source as natural (e.g., weather-related) and technological hazards (e.g., hardware and software failures). Hazards or risk sources are elements that have the potential to raise risk (British Standards Institution, 2018). For that reason, risk management stands out as a tool with specific stages to set a tolerable situation for the end-user's safety and fulfilment of his/her mission (British Standards Institution, 2018). The stages of risk management have been set through various standards.

The risk management process from ISO 3100:2018 indicates that it is a loop process beginning with monitoring, adjacent is context establishment, following is risk assessment with partial semi-stages (risk identification, risk analysis, risk evaluation), next is risk treatment, and finally, review and monitoring. Communication and consultation with stakeholders is applicable and mandated, throughout the process and semi-stages (Yoe, Risk Communication, 2012). Preceding external publics and stakeholders, internal risk communication is more than just reiterating the story of the risk management process and the risk assessment between managers and operators. Risk communication can be envisaged as the interactive exchange of information throughout risk assessment among risk assessors and risk managers (Yoe, Risk Communication, 2012). In other words, the way risk is apprehended and communicated among the risk managers constitutes an omnipresent process during risk management. Also, the psychometric paradigm of investigating risk has repetitively indicated that the multitude of dimensions addressing hazards can be aggregated into factors, and an ample portion of risk can be explained by combinations of these factors (Chauvin, Hermand, & Mullet, 2007).

2.3.3. Managing Safety and Risks

Safety risk management is a process that aims to assess and mitigate safety risks; to achieve that, risk management assesses risks deriving from identified hazards, develops and applies mitigations (ICAO, 2013). In the modern age, risk assessment and management have been parts of the scientific risk field for the past 40 years. Their development could be attributed to the growth of high-risk industries (e.g., aviation) or policy-making due to technological innovation. As such, risk assessments and risk management study the risk of specific activities and support risk research and development, methods, models, and approaches (Aven, 2016).

A significant contribution of risk management to operations is narrowing the planned (Work as Imagined – WaI) versus executed operations (Work as Done – WaD) gap. According to Aven (2016), the risk field has two main tasks; (a), to use the risk management and risk assessments to study and treat the risk of specific activities (e.g., flying in adverse weather conditions), and (b), to perform generic risk research and development, which provides the tools to be used in the specific assessment and management issues of (a). Markedly, he suggests that the risk discipline (e.g., risk educational programmes, journals, papers) differs from the risk field covering the knowledge generation of (a) and (b). This constitutes a novel view that depicts that Risk-as-Imagined (RaI) differs from Risk-as-Deployed (RaD) as a parallel depiction of WaI and WaD difference. Continuing into this path, in the RaI perspective, the generation of knowledge fosters the scientific analysis of risk management and risk assessments. In the RaD perspective, the generation of knowledge derives from real practice to update operational practice further.

Based on this path of RaI vs RaD, an argument could be settled that various specialities of safety practitioners may differ among each other, such as end-users, safety investigators, and safety managers. From a first approach, a detailed and informed process of evaluating even the rarest occurrence of eventualities requires a deeper understanding of the available sources, evidence, and specific knowledge over the studied phenomena. For example, in a group of safety investigators, not all of them may be specialised in assessing weather data and conditions. Similarly, some safety managers may have received specialised training in human resources while others may have special training in operations, such as dangerous materials transportation. Nonetheless, end-users working in the first line of operations may have gained enough experience and respect among different levels within an organisation. Their opinions matter as if they were experts in the conventional way (i.e. special training). It would be no surprise that the estimations of these 'first-liners' to be even highly appreciated during time-pressuring operations, such as a turn-around.

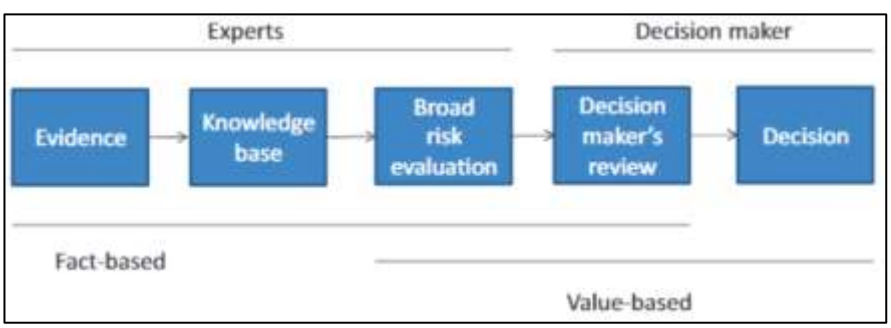
Real practice work issues may differ from the actual designed standard operating processes. This gap expresses a difference between the work-as-done (WaD) and the work-as-imagined (WaI). More explicitly, the WaI depicts processes and the notions, the unwritten rules and in general, every aspect of a task before it is conveyed. As Hollnagel (2017) clearly explained, WaI refers to the various assumptions, explicit or implicit, that people have about how their or others' work should be done. Also, he described the WaD as the manner which refers to how a task is conveyed, either in a specific case or routinely (Hollnagel, 2017). The solution he suggests to narrow the gap between WaI and WaD is to attempt a comprehensive approach towards the elemental ways a task is done and elaborate on effective paths to manage the variability of WaD within acceptable limits.

From the risk perception and risk communication perspective, thinking about a hazard's risk implications and designing how to communicate them is the WaI part. The WaD is explained by the risk behaviour, for risk perception, and by effective risk communication, for risk communication. However, Hollnagel (2017) warns that it is impossible in practice and, in principle, exactly to prescribe how a task should be done. This warning is going to be challenged in this investigation—risk behaviour and ineffective risk communication sound to have a negative attitudinal notion. However, by explaining the connection of these constructs' suggestions could be provided to avoid-trap-mitigate key elements or actions leading to unsafe behaviour.

What is more, Hollnagel (2017) indicates that the Safety-I perspective assumes that a task can be analysed entirely and prescribed so that WaI will correspond to WaD. Hollnagel also uses the Zero Accident Vision (ZAV), which was elaborated in a previous section. ZAV is not totally achievable whatsoever; it is based on the belief that all accidents are preventable (Hollnagel, 2017). However, this creates a gap; ZAV is based on rigid and straightforward standards which supposedly guarantee a perfect processed task (Zwetsloot, et al., 2013). However, the distance of practice from these rigid rules is being depicted by human error rates. This is the reason Hollnagel also argues that the models and methods that comprise the mainstream of safety engineering, human factors, and ergonomics are being challenged.

Hansson and Aven (2014) argued that risk analysis could be placed within the scientific field when two prerequisites are met. First, it should be consistent about risk-related phenomena, processes, events. Second, it should be comprised of an instrumental part including concepts, theories, frameworks, approaches, principles, methods and models to understand, assess, characterise, communicate, and manage risk, in general, and for specific applications. Based on the points of Hansson and Aven (2014), which of the two previous groups can be more credible for risk analysts? This question could be probable but also a very simplistic approach on the matter. During operations, data and information are gathered from practitioners at all levels, not only first-liners. This recollection of claims may include epistemic and non-epistemic entries. This constitutes a knowledge base that feeds the evaluation step. Therefore, the evaluation step has to funnel all data into an epistemic filter. Beyond that, the decision-maker of the risk analysis has to include additional sources and considerations, such as policy-making. This path is depicted in Figure 2-6. According to Hansson's and Aven's (2014) conclusions, the scientific foundations of risk assessment and risk management remain divergent on theoretical and practical perspectives, which may misguide decision-makers, such as the definition of risk itself. Moreover, integrative research on risk is suggested to provide a solid foundation for developing the field. Lastly, they recognise that modern societal changes and technological reforms challenge the field. From another point of view, instead of keeping a logistical approach of enlisting risks, there is the question if risks could be predetermined alternatively, including what Hansson and Aven (2014) suggested.

Figure 2-6: Risk-Informed Decision-Making (Hansson & Aven, 2014)



2.4. Risk Perception

Risk perception is frequently understood as a multifactorial construct based on uncertainty and adverse consequences (Renn, 1998). The importance of risk perception in the aviation industry does not deviate from its general importance in everyday life. The primary link is that the same individual takes decisions in different contexts. For example, an unrealistic attitude regarding consequences can take place in ordinary life and during working conditions. Risk perception is affected by multiple factors, which can be discriminated as cognitive (Von der Heyde, 2015) and emotional (Dobbie & Brown, 2014). This connection with cognition declares that risk perception is also an indispensable part of the decision-making process as well (Proctor & Chen, 2015).

What is more, risk also inherits a kind of action or inaction based on its definition. As such, risk perception can also be influenced by a prohibition of actions or passive style management (Smith, Eldridge, & DeJoy, 2016), a disregard of stimuli, for example, spatial misperception (Serences & Wixted, 2018), or lack of effective communication (Vieira, dos Santos, & de Morais, 2014). Risk has been defined in various qualitative ways, such as (Aven, 2016):

a. The possibility of an unfortunate occurrence.

b. The potential for realisation of unwanted, negative consequences of an event.

c. Exposure to a proposition of which one is uncertain.

d. The consequences of the activity and associated uncertainties.

e. Uncertainty about and severity of the consequences of activity concerning something that humans value.

f. The occurrences of some specified consequences of the activity and associated uncertainties.

g. The deviation from a reference value and associated uncertainties.

From a general perspective, basic risk conceptualisation may be influenced by human information processing or decision-making (Aven, 2016). Human Information Processing (HIP) is an approach that considers human cognition as an information processing system. The HIP has been addressed as an approach that explains the flow of information during behaviour responses, indicating response times, error rates and types (Proctor & Vu, 2016). An example of the connection of risk perception and HIP is through Human-Computer Interaction (HCI), as highlighted (Proctor & Vu, 2015). The source of interlinks like the former is that risk perception is part of decision-making. A study on gamblers' risk perception suggests that it possesses an adaptive or maladaptive influence on decision-making and behaviour (Spurrier, Blaszczynski, & Rhodes, 2015). Gamblers represent end-users of majorly dealing constantly with risk decisions, regardless of the effects' magnitude. Since literature does not support risk perception in the aviation context, additional contexts are considered where constant and/or high risk is met. Nonetheless, risk perception is a construct that has explained behaviour that results in safety events for aviation operators and operators from other contexts (e.g., drivers) (Hunter, 2006). Even though the former study of Spurrier et al. (2015) investigated how experts envisage the gamblers' risk perception, it produced valuable results that listed eight core functional components of risk perception content and processes that are nested with additional points from literature, as follows:

1. Estimation and Expectancy of Outcome: The assessments about how a system (i.e. gambling) operates and generates outcomes combine with the perception of the benefit or cost of expected or possible event outcomes. This is confirmed by the tendency of adults to view themselves as relatively susceptible to the detrimental consequences of risk-taking behaviour (Todesco & Hillman, 1999).

2. Meaning and Motivation: The perception of the outcome's meaning and its consequences is associated with the individual's goal setting and motivation drives. An individual may disregard the factors which influence his/her behaviour. Nonetheless, they

never fail to model their interactions as not possessing a cognitive vacuum (Woods & Hollnagel, 2006).

3. Strategic Planning: The end-user may comprehend and adapt to rules and strategies to prioritise and assimilate them into internal goals. Long-term or short-term planning adapts to the system properties (i.e. VFR to IFR), integrating risk perception factors, such as mission requirements, prior experience with mishaps, and/or additional specified training (Stimpson, Tucker, Ono, Steffy, & Cummings, 2017).

4. Reinforcement, Learning and Experience: An end-user is exposed to operative reinforcement schedules and resultant cognitive changes. The end-user may evaluate risky options under repeated sampling following classical reinforcement models where impressions are constantly renewed, highlighting recent events over distant ones (Weber, 2006). Additionally, when end-users decide based on experience, rare events tend to have less impact than they should according to the objective probabilities (Hertwig & Erev, 2009).

5. Decisional Context and Available Choice: Risk perception may be influenced by availability, salience and sensitivity to internal and external cues. Individuals tend to adjust their perception due to the availability heuristic when the occurrences of an event are recent and/or constant (Tversky & Kahneman, 1973). The salience of the event affects the availability due to the specificity of the local context in which the risk is assessed (Bordalo, Gennaioli, & Shleifer, 2012).

6. Implicit versus Explicit Cognition: An operator may conduct comparative application and exercise control of implicit versus explicit cognitive processes. The concept of cognition, in general, may partially adhere to the attributes of social cognition. Under this lens, implicit versus explicit cognitive processes are distinct, sometimes complementary and sometimes oppositional (Frith & Frith, 2008). Perception is one of the implicit influences on an individual's behaviour (Reingold & Ray, 2006). The value of this component lies on the premise that possible behavioural regulation intervention effects can be understood by investigating implicit versus explicit concordance (Berry, Rodgers, Markland, & Hall, 2016).

7. Ambivalence and Manipulation of Risk Data: Risk Data may be implicitly/explicitly suppressed or amplified towards positive and negative ends. Risk-averse advice from an expert may influence risky decisions, as it proved based on neurobiological differences in adolescents and adults (Engelmann, Moore, Capra, & Berns, 2012). Moreover, risk perception may be diversified to match the risk ratings of older others, thus being socially and peer-influenced (Knoll, Magis-Weinberg, Speekenbrink, & Blakemore, 2015).

8. Innate and Developmental Individual Differences: Each operator is unique, regardless of conformity due to policies or peer influence. As such, personal experience will be placed most often as a link or barrier among individuals. For example, during a stressful situation, an individual may miscalculate risk due to prediction bias, that is, the tendency to misperceive the prospect that (un)pleasant events will occur in one's future (Borkenau & Mauer, 2006). The perseverance of each end-user may be unique in extreme conditions of risk. Personality issues and motivation are also important. From the driving safety context, there is the risk homeostasis principle (Wilde, 1994), where the end-user compares the actual risk of the situation with the degree of risk they are willing to tolerate. The tolerant degree of risk is called target value, and the end-operator is supposed to regulate his/her behaviour to match that degree constantly. Tests like the "Vienna Risk-Taking Test - Traffic" aim at identifying potentially risk operators who require restraints on specific aspects of their behaviour (Hergovich, Arendasy, Sommer, & Bognar, 2007). The specific test supports Wilde's assumption about the generalisability of the latent personality trait target-risk value (Hergovich, Arendasy, Sommer, & Bognar, 2007).

Additionally, risk perception can be influenced by complacency. The concept of complacency is generic and does not specify objectively any underlying psychological mechanisms but instead encapsulates risk perception, attention, decision making, and information acquisition (Dekker & Hollnagel, 2004). Additionally, the term "complacency" may predispose investigators to blame the end-user rather than other systemic causes (Innes-Jones, 2012).

Innes-Jones (2012) explicitly suggested that complacency should be re-framed under the mantle of risk perception and risk tolerance since these two concepts are readily understood, more grounded in theory, and may facilitate individual and collective strategies of mitigation. As such, strategies of mitigation may be reiterated, conceptualised, and applied as safety interventions. For that matter, Innes-Jones (2012) proposed clearly that if an organisation wishes to reduce the likelihood of risky behaviour, it should focus on improving risk perception and improving the individual's perception of the capability to confront consequences. Empirically, an end-user may attain familiarity and success by completing a task multiple times and tend to ignore blind spots to potential hazards, entering a complacency due to automation. Though relieving to the information processing, the rise of automation tools within the aviation context may endanger the operator due to misleading calculations, navigation or issue diagnosing, a phenomenon described as automation bias (Mosier, Skitka, Heers, & Burdick, 1998). In more detail, risk perception, complacency, and automation bias are linked through errors of omission and commission (Parasuraman & Manzey, 2010).

Self-confidence also plays an important role. Self-confidence may rise when confirmation bias (Nickerson R. S., 1998) influences the awareness of control over one's abilities and the situation and may also lead to underestimating risks. The disproportioned or improbable size of self-confidence may be called overconfidence (Ehrlinger, Mitchum, & Dweck, 2016). Empirically, overconfidence may occur due to cases of disproportionate trust in the tool-equipment-procedure that it will perform as it is designed to do. Iterated from another perspective, individuals tend to underestimate the contribution of additional environmental factors (Kahneman, 2011). Equally, individuals implicitly tend to underestimate judgement and prediction concerning the variance of factors (Herdener, Wickens, Clegg, & Smith, 2016).

2.4.1. SAIMs and Risk Perception

Among the high-risk industries context, safety has been attributed to a utilitarian perspective, translated into the minimisation of risk, lessening the exposure to hazard and probability of harm (National Research Counsil, 1989). Consequently, risk perception has been considered as a subjective assessment during an action plan while considering the probability of adverse results along with the extent of their respective consequences (Sjoberg, Moen, & Rundmo, 2004). Furthermore, risk perception is primarily included as a mediator when investigating the effects of independent variables on risk behaviours (Simon, Houghton, & Aquino, 1999).

Various authors have analysed risk perception into smaller chunks to focus on the experience of the consequences of a risk event (e.g., degree of familiarity) and the magnitude of consequences (e.g., common dread) (Slovic, Fischhoff, & Lichetenstein, 1985; Fischhoff, Hayakawa, & Fischbech, 2000). Other taxonomies of risk perception factors have emphasised the differences among groups' cognitive factors (e.g., the centrality of an event or crew coordination), emotional influences (e.g., overconfidence), physiological effects (e.g., fatigue), environmental factors (e.g., night operations) as well as differences in risk perception amongst individuals and teams (Thomson, Onkal, Avcioglu, & Goodwin, 2004; Chionis & Karanikas, 2018). Moreover, emotions and cognition have been seen as influential in prioritising risks (Houghton, Simon, Aquino, & Goldberg, 2000; Thomson, Onkal, Avcioglu, & Goodwin, 2004; Dobbie & Brown, 2014). Research suggests that risk perception is affected by cognition, emotional attitudes, and social projections (Drinkwater & Molesworth, 2010; Dobbie & Brown, 2014). Chionis and Karanikas (2018), following a review of the risk perception types available in the literature, concluded to list eleven risk perception factors to assess respective differences among experts and trainees in the aviation maintenance domain. The particular study revealed messages that the consideration of risk perception as a single entity could have concealed.

As mentioned previously, risk perception has been deemed as subjective by nature (Vasvári, 2015). Variant perception of risk may lead to varied risk assessment results, and consequently, different safety-related interventions, even for the same set of hazards or identical cases evaluated through the same technique and instrument. Certainly, the reliability and validity of risk assessments might also be negatively affected by the tools used. This was shown by Karanikas and Kaspers (2016), who examined the inter-rater agreement amongst ten experts of a single company when using a typical risk matrix for the same events. Nonetheless, cognitive biases can negatively affect the unilateral accuracy of risk perception (i.e. imbalance of risk cues), even under the usage of a reliable risk assessment tool, which may lead to successful assessment and avoidance of unfavourable occurrences (Simon, Houghton, & Aquino, 1999; Houghton, Simon, Aquino, & Goldberg, 2000).

Furthermore, cognitive biases can create a malleable reflection of reality, setting barriers in noticing and interpreting information (Simon, Houghton, & Aquino, 1999; Houghton, Simon, Aquino, & Goldberg, 2000). The barriers set by cognitive biases, such as personal traits and socio-cultural parameters, influence risk perception and risk assessment (Michalsen, 2003). Risk assessments are vulnerable to challenging cognitive claims, values and interpretations from multiple level end-users with various experiences (Renn, 1998; Williams & Noyes, 2007).

According to the psychometric paradigm, the risk of an activity is the most vital variable to examine during a safety investigation (Sjoberg, Moen, & Rundmo, 2004). Succeeding, the psychometric paradigm describes the interpersonal differences concerning the causes behind the choices of groups or individuals to act or perceive the situation around them (Siegrist, Keller, & Kiers, 2005; Ho, Looi, Chuah, Leong, & Pang, 2018; Cardoso, 2018; Pu, et al., 2019). Furthermore, the points of interest for risk perception have emerged as dimensions or sub-categories similarly to other mental processes (Slovic, Fischhoff, & Lichetenstein, 1985; Slovic, 1992). Consequently, the psychometric paradigm concerning interpersonal differences focuses on the causality of various psychological dimensions that influence risk factors such as the voluntariness of risk, the control over the risk, or the severity of the consequences. From a different perspective, the psychometric paradigm assumes the subjective definition of risk, possibly influenced by various psychological, social, institutional, and cultural factors (Sjoberg, Moen, & Rundmo, 2004). During a safety investigation, these factors should be considered as part of examining how the possible effects of hazards were evaluated, hence allowing investigators to provide targeted recommendations for the prevention of future safety eventualities (UK HSE, 2001; ICAO, 2015; Directorate of Defence Aviation and Air Force Safety, 2017). Additionally, risk perception may be a significant, influential factor during the risk assessment and control analyses executed as part of the Integrated Safety Investigation Methodology (ISIM) (SKYbrary, 2017).

Consequently, the literature suggests that risk perception and its associated factors must be considered when evaluating risks during risk assessment or normal operations and investigating safety events. To summarise, according to the cited literature, risk perception can be influenced by:

1. Emotional factors (PEMF) that correspond to sentimental attitudes and naturalistic decision making;

2. Cognitive factors (PCOF) which are linked to the rational processing of information;

3. Physiological factors (PPHF) that are connected with the body states of the actor;

4. Wider environmental factors (PENF) are associated with the overall physical, technical, organisational, and social conditions external to the risk assessor.

2.4.2. Risk Perception as a Subject of Research

Originally, risk perception research stemmed from judgement and decision-making studies (Mosteller & Nogee, 1951; Edwards W. , 1953; Edwards W. , 1954; Savage, 1954). Initially, decision theory aims at providing the right decisions under risk or uncertainty, while theories of decision-making under risk are maximisation theory and bounded rationality theory (Slovic, Kunreuther, & White, 2000). From the first point of view, maximisation theory or utility theory represents the course of action when an individual estimates the results of his/her action according to the consequences, depending on events and the subjective probabilities of the outcome of that action (Bernoulli, 1954; Savage, 1954). Next, bounded rationality theory assumes that the limits of decision-making possibilities of the decision-maker force an adjusted view of the context (Simon H. A., 1956; Simon H. A., 1959). The major difference between these two theories is the set of limits due to the cognitive limitations of the decision-maker. Although this work was intended for understanding the risk of natural hazards, Slovic et al. (2000) suggested a range of phenomena be examined in the field:

1. The law of Small Numbers. The phenomenon of the law of small numbers iterates an analogy where extreme results are more likely to be found in smaller samples than larger ones (Kahneman, 2011). Research supports that people value weight more than numbers of data, even though these weighted pieces of data may contain additional noise, driving them to ignore actual patterns of evidence (Williams, Lombrozo, & Rehder, 2013; Yarritu, Matute, & Luque, 2015; Sanchez & Dunning, 2018).

2. Judgements of causality and correlation. Trivial overestimations may involve beliefs about causal relationships among unrelated events (Kelley, 1972). Taking examples from cognitive illusions, there is the illusion of control implying that an individual's action (potential cause) provokes the desired outcome; there is the cue interaction illusion where two potential causes are presented to the desired goal with two sub-conditions: (a) the blocking effect (Kamin, 1968), when a previous belief supports only the first potential cause;

(b) super-conditioning (Rescorla, 1971), when a previous belief supports only the second potential cause (Yarritu, Matute, & Luque, 2015).

3. Availability. Decision-making biases include availability bias, confirmation bias, and framing effects (Hudlicka, 2010). In an attempt to answer the above questions, since availability bias exploits the most readily available evidence, the primacy of a memory related to a hazard will probably affect risk perception. Adjacent, since confirmation bias drives seeking evidence to support one's expectations, experience may dominate a new hazard cue. Finally, framing might influence risk perception if the wording of risk communication is misleading or inappropriate.

4. Anchoring and insufficient adjustment. Drawing answers from a literature review on flight crews signifying a beneficial expansion of pilot training on heuristic thinking (Tuccio, 2011), anchoring indeed falsify decision-making. The aviation context describes the phenomenon where one fixates on a specific cue, with minor or insufficient adjustments (get-there-itis). Typical examples are continuing into instrument flight rules (IFR) from visual flight rules (VFR) occasion, continuing to controlled flight into terrain (CFIT) occasion, or continuing into adverse weather situations.

5. Information processing shortcuts. Mere examples of information processing shortcuts are authority bias (Milgram, 1963), halo effect (Baron, 1994), time-saving bias (Peer, 2011), self-consistency bias (Schacter, 2002), hyperbolic discounting (Laibson, 1997). Authority bias can be met in a conforming student pilot when he/she obeys the trainer. The halo effect may be responsible for diverting seemingly good weather conditions from different flights, while adverse weather conditions are building up next for the latter. Time-saving bias can be met when a pilot is heading to land, underestimating the time that could be saved when increasing from a relatively low speed, resulting in a short landing, or overestimating the time that could be saved when increasing from a relatively high speed, resulting in long-landing. Self-consistency bias can be met as bragging among experts during a casual conversation about having the same attitudes, beliefs, and feelings through time.

From a moral-psychological analysis of risk-related decision-making processes perspective conducted within functional safety (Johnsen, Crnkovic, Lundqvist, Hanninen, & Pettersson, 2017), functional safety utilises the absence of intolerable or unreasonable risk according to the societal moral concepts. Extending to ethics, these moral concepts employ the “do no harm” principle. Unreliable reasoning accepting residual risk may include tendencies for unethical conduct. The review also suggests that to promote an effective safety culture, an organisation needs to apply a ‘vision zero’ principle and focus more on functional safety standards, such as not compliance alone but more in-depth understanding.

To be concise, research of risk derives from a path where decision-making is the main focused principle. In the boundaries of this perspective, risk has been regarded as part of a utility equation and as a weight factor indicating reasonable cognitive capacity during decision-making. However, risk itself may be more than that. As indicated, a set of biases or heuristics may represent a measure of difference among individuals. Also, these differences may even point to differences in a moral framework.

From a broader perspective, decision-making functions with mental representations of the physical plain. Mental representations allow the decision-maker to think, evaluate, argue, visualise and judge physical objects or situations as if they were present. The critical element for this process is the ability to encode the received information through perceptual experience (Wallis & Bulthoff, 1999). Precisely, when a mental representation is matched with the contents of perceptual experience, recognition can be considered successful (Christou & Bulthoff, 2000). This matching process requires two-way flexibility; either the representation has to be adjusted to the perceptual encoding, or the perceptual encoding has to be adjusted to match the representation (Christou & Bulthoff, 2000). In this notion, a hazardous situation’s representation includes the probability of known or unknown consequences. Adjacent, supposedly, this hazardous situation's mental representation resides at least on the lack of known consequences for an individual. The individual’s risk perception will either regulate the mental representation leading to an effective recognition or subjugate to it, and the individual will miscalculate the hazard and its consequences. Alternatively, recognition is used to distinguish choices valued according to familiarity, accessibility, fluency, or availability (Marewski, Pohl, & Vitouch, 2010).

Besides the cognitive character of constructs of decision-making, the affective content of mental representations is also essential. It has been reported that affect heuristic as a function of trust in risk communication determines reliance on risk management institutions (Wu, Lin, Chang, Wang, & Liu, 2016). Mainly, reliance on affect was higher among decision-makers with a high level of trust in risk management institutions for the same study. Risk as sentiment argues upon instinctive and intuitive reactions to the supposed danger, while risk as a cognitively analyzed construct relies on logic and reason (Slovic & Peters, Risk Perception and Affect, 2006). Affect heuristic has been used to characterize reliance on feeling state with or without consciousness and a stimulus' sentiment (positive vs negative) (Slovic & Peters, 2006). Affect has been found to amplify risk perception and participation to tackle risks when used to enhance information (Guo & Li, 2018). Affect has also been referred to as "the positive or negative valence of an experienced feeling" (p. 2), which can influence risk perception (Lacasse, 2017). Consequently, the level of affect regarding the subject of risk is not influencing risk perception more than the existence of a salient subject that could influence risk perception in total. The positive or negative additional trait that salient subject may interfere in the interaction with other risk perception factors, such as prior knowledge.

2.4.3. Risk Perception and Heuristics/Biases

In everyday life, professionals and non-experts are subject to personal 'paths' of decision-making. These 'paths' may divert from common sense or a set of standard operating procedures (SOPs). In many settings, these incidents can be relatively harmless. However, this is not valid for those who operate in high-risk industries. These small cut-throughs may elope errors leading to grave consequences. Whether they are 'biases' or 'heuristics', the author of this thesis strongly supports that the probabilities of harm remain, regardless of their natural propensity. The human experience is dependant on its conscious sensory experience (Goldstein E. B., 2010), which derives from perceiving an ideal 'enough' amount of sensory inputs. As such, this 'ideal amount' of sensory inputs and how it is perceived depends on the accuracy and timeliness that the inputs are filtered through risk perception and decision-making. In a case of a high-risk situation, an improperly fixated notion guided by cognitive bias may be fatal.

Heuristics simplify judgemental rules that focus on reducing the difficulty of tasks (Tversky & Kahneman, 1974). Certainly, heuristics may be constructive, but there are cases where they can become perilous. The availability heuristic is the mental process where an event is judged as likely possible if occurrences are easily imagined or recalled or the recalled information has a disproportionate influence on the outcomes (Nazlan, Tanford, & Montgomery, 2018). Another critical limitation is that "memorability and imaginability may pose a barrier to open, objective discussions of risk" (Slovic, Fischhoff, & Lichtenstein, 2000, p. 107). Similarly, complacency may also result from the availability heuristic (Fischhoff, Slovic, & Lichtenstein, 1978). Slovic et al. (2000) suggest that an essential trait of heuristics is that people confidently support their judgments. The authors suggest that this confidence derives from the validity of the availability heuristic. Being overconfident in the high-risk industry may be extremely perilous. Experts in high-risk industries may be overconfident similar to less experienced professionals or trainees and lay people. Slovic et al. (2000) indicate that conventional processing of risk may include:

(a) "Failure to consider the ways in which human errors can affect technological Systems" (Rating the Risks, p. 110).

(b) Overconfidence in current scientific breakthroughs.

(c) Ignorance about Human-Machine-Interaction traits.

(d) “Failure to anticipate human response to safety measures” (Rating the Risks, p. 110)

(e) Uncertainty denial, sourcing from anxiety-reducing search.

In the aviation context, there is no fixed list of biases/heuristics that apply in a definite manner. However, in an attempt to give some indicating examples from an extensive list of cognitive biases, some specific cases follow:

(a) **Ambiguity effect** (Baron, 1994): This case represents the choice of a riskier option over a choice that engulfs uncertainty. This bias/heuristic may explain cases where approaching landing with questionable weather conditions in a known area is preferred over a diversion to an alternative airport. A similar case was that of ERA11LA330, where the pilot, even if he was aware of the less significant weather to the northeast and south well before the encounter with bad weather and of the clear weather through which he had just flown, continued to fly toward his destination, and toward the significant weather, which resulted in the aeroplane's encounter with the turbulence (National Transportation Safety Board, 2011a).

(b) **Anchoring bias** (Kahneman, 2011): This case represents a situation where individuals base their decisions on a provided reference, regardless of the situation’s needs. This may explain situations where errors of missing steps in SOPs occur or where unbalanced compensations occur. In the case of WPR11LA175, the pilot, although he had noted that the wind was close to extreme limits for his aircraft, decided to depart for local takeoff-and-landing practice. During his first landing, the aeroplane bounced, he lost control of it, and it departed the left side of the runway (National Transportation Safety Board, 2011b).

(c) **Attentional bias** (MacLeod, Mathews, & Tata, 1986): Attention may be diverted due to emotional value. During flight operations, this may lead to ignoring the risk of severe weather conditions over a low fuel threat or ignoring in-flight fuel conditions while checking paperwork. In the case of WPR16LA008, the pilot was distracted with some paperwork during the flight and “failed to switch tanks” as planned, he experienced a high workload during the descent due to weather reports and other traffic, and he did not use the descent checklist, which included a task to “manage fuel” (National Transportation Safety Board, 2016a).

(d) **Attentional tunnelling** (Wickens & Alexander, Attentional Tunneling and Task Management in Synthetic Vision Displays, 2009): This construct has been defined as the allocation of attention to a particular channel of sensory information, a product of decision-making, or mission objective, for a duration longer than optimal, given the mandated attention to other channels, other decisions, or other mission objectives. In the case of CEN11CA015, during an after-landing taxi, the pilot diverted his attention to a flickering landing gear indicator light, and the aeroplane exited the taxiway falling into a drainage ditch (National Transportation Safety Board, 2011c).

(e) **Automaticity and Expectation bias** (Pascual, Mills, & Henderson, 2001): Expectation bias may lead one to assume that a checklist function is correctly configured without actually being cognitively in sync with the task itself. The accident of Airbus A330 Air-France on Monday 1st June 2009 is a notable example where the pilots failed to diagnose the stall situation due to inconsistent feedback from the autopilot (BEA, 2015). As such, it was evident that end-users necessitate direct perceptual clues to handle unexpected situations and that perception is central in recovery from an orienting response (Wit & Cruz, 2019). An orienting response is a reaction to a novel or important but non-aversive stimulus (Schell & Dawson, 2001).

(f) **Confirmation bias** (Nickerson R. S., 1998): This bias/heuristic describes a situation when an individual will neglect inputs that do not conform to their preconditioned mental models and beliefs. In the case of WPR09IA065, the de-icing crew perceived no objection from the aircrew to begin de-icing as a confirmation to begin the de-icing process (National Transportation Safety Board, 2009a).

(g) **Optimism bias** (Chandler, Greening, Robison, & Stoppelbein, 1999): This bias/heuristic describes a situation where an individual is overly optimistic about the outcomes of his/her actions. For the author of this thesis, this case resembles cases of complacency due to desensitisation to urgent and hazardous situations. For example, in the case of CEN09LA145, the fixed base operator line personnel fueled the aeroplane based on non-standard fueling practices, on the assumption that they could avoid using a modified fuel filler opening, resulting in a loss of engine power mid-air and an emergency landing on a field (National Transportation Safety Board, 2009b).

(h) **Selective perception** (Massad, Hubbard, & Newtson, 1979): This case represents the bonds of an individual belief system. Although the resemblance to expectation bias, their difference relies on the fact that selective perception filters the perception of information, while the latter focuses on situational awareness for future events and the interrelated expectations. In the case of WPR15MA243B, the local controller had incomplete situational awareness due to the high workload. As a result, he never visually confirmed the patterns of the two airplanes there put on a collision course (National Transportation Safety Board, 2016b).

(i) **Recognition Heuristic** (Goldstein & Gigerenzer, 2002): Recognition heuristic (RH) has been subject to much debate. First is an example of what is called “Fast-and-frugal Heuristics”. “Fast and frugal heuristics are composed of simple building blocks that specify how information is searched for (search rule) when information search will be stopped (stopping rule), and how the processed information is integrated into a decision (decision rule)” (Reimer & Rieskamp, 2007, σ. 347). A significant reason for debating over RH structural role in decision-making. A decision-maker should be able to detect in which situation a heuristic may be effective or not (Gigerenzer & Goldstein, 2011). The value of this awareness level rests on the need for being adaptive to situations to survive. Due to that value, there are different approaches to this heuristic. Recognition and evaluation are considered two processes guiding the RH’s adaptive course (Gigerenzer & Goldstein, 2011;

Newell, 2011). For example, an ATCO may question "Do I recognise one IFF signal and not the other?" as a recognition probe, and "If so, is it reasonable to rely on which IFF I recognise?". In this example, a cue's familiarity, such as an IFF in the ATCO's area of responsibility, poses as a valid inference interpreted as cue weighting (Gigerenzer & Goldstein, 2011). Additionally, in terms of binary recognition, there is no clear set of when a cue becomes information and information becomes knowledge (Newell, 2011). In other words, it is hard to say when the ecological rationality criterion is satisfied. An excellent observation is that RH represents the benefits of ignorance (Newell, 2011).

(j) **Affect Heuristic** (Finucane, Alhakami, Slovic, & Johnson, 2000): The affect heuristic has to do with representations deriving from an "affective pool" of positive versus negative attitudes, interconnecting experience and future judgements solely under the criterion of positive/negative polarity, consciously or unconsciously (Finucane, Alhakami, Slovic, & Johnson, 2000). According to Finucane et al. (2000), the value, effect, and distinct role of affect heuristic over risk perception have been proven during time pressure situations. According to the same study, praising or accusing the results of a hazard influences risk perception due to positive or negative affect towards the consequences. Although there is a similarity with optimism bias, the affect heuristic differs from utilising both positive and negative labels, while optimism bias considers only positive labels.

Although the heuristics/biases influence on decision-making concerning risk perception as a denominator can be at large shown in the previous examples, there has been no focused and detailed investigation on the matter. A small contribution to this context has been delivered, though; the heuristics and, more importantly, the meta-heuristics have gained the spotlight in research for airside operations at least (Ng, Lee, Chan, & Lv, 2018). The meta-heuristics approach came as an evolved step of solution search to solve the issue of local optimum through various control points (i.e. parallelism, control and memories) (Vidal, Crainic, Gendreau, & Prins, 2013). Moreover, a literature review had focused on the heuristic cognitive strategies as they are used only by flight crews through 19 airline accidents (Tuccio, 2011). Therefore, Tuccio (2011) suggested that incorporating vivid re-enactments of decision-making scenarios using heuristics in pilots' training will improve pilot performance. However, after a thorough search in the literature, there was no citation confirming results from his program for improvement.

2.4.4. Risk Perception and the Technological Hazard

A common question among professionals about risk management is an expression of "How much safety is enough?". This concern may take the form of multiple concerns, for example, about either safety regulations, or safety culture, or training. These concerns raise the issue of determining or generating a clear framework where safety standards could be appointed. According to Fischhoff et al. (1979), four approaches assess this issue. These approaches are cost-benefit analysis, revealed preferences, expressed preferences and natural standards. Cost-benefit analysis weighs the benefits of a plan of action over the cost (Choy, 2018). Revealed preferences approach considers risk tolerated preferences to weigh the benefit, while expressed preferences approach expresses the people's general declared acceptance of risk (McDaniels, 1988; Polisson, Quah, & Renou, 2015; Lanier, Miao, Quah, & Zhong, 2018). The natural standards approach regards risks as acceptable, comparing them with human development (Fischhoff, Slovic, & Lichtenstein, 1979).

In either of these approaches, the decision-maker should compare and value risk standards to declare his/her intentions. Indeed, it is not a matter of superiority of one risk assessment process over another. According to Fischhoff et al. (1978), the social context is a factor in exploiting each approach's contributions to risk acceptability. This argument aims to highlight the lack of precision, which accompanies the real world. Not only that, but this argument also aims to motivate research iterating risk acceptability. To summarise, risk acceptability is a complicated process, with many approaches, which draws from the study of hazards in the real world. To accept risks is to consider multiple contexts and actors, and weigh standards and norms, personally or socially accepted.

When it comes to hazards, the aviation industry is involved primarily with hazards coming from technology (i.e. modern aircraft automation), as the other high-risk industries. High-risk industries, such as aviation, confirm their notorious perspective through the consequences over stakeholders and operators, to the very least through illness or even death (Hohenemser, Kates, & Slovic, 2000). However, beyond that grim persespective, there are always remedies; for the technological hazards in aviation classification, which may ease and simplify their management (Hohenemser, Kates, & Slovic, 2000). Towards this effort, Hohenemser et al. (2000) stated the need to distinguish the terms hazard and risk. “Hazards are threats to humans and what they value, whereas risks are quantitative measures of hazard consequences that can be expressed as conditional probabilities of experiencing harm” (p. 169). This statement will be the distinguishment between the terms of hazard and risk for this thesis.

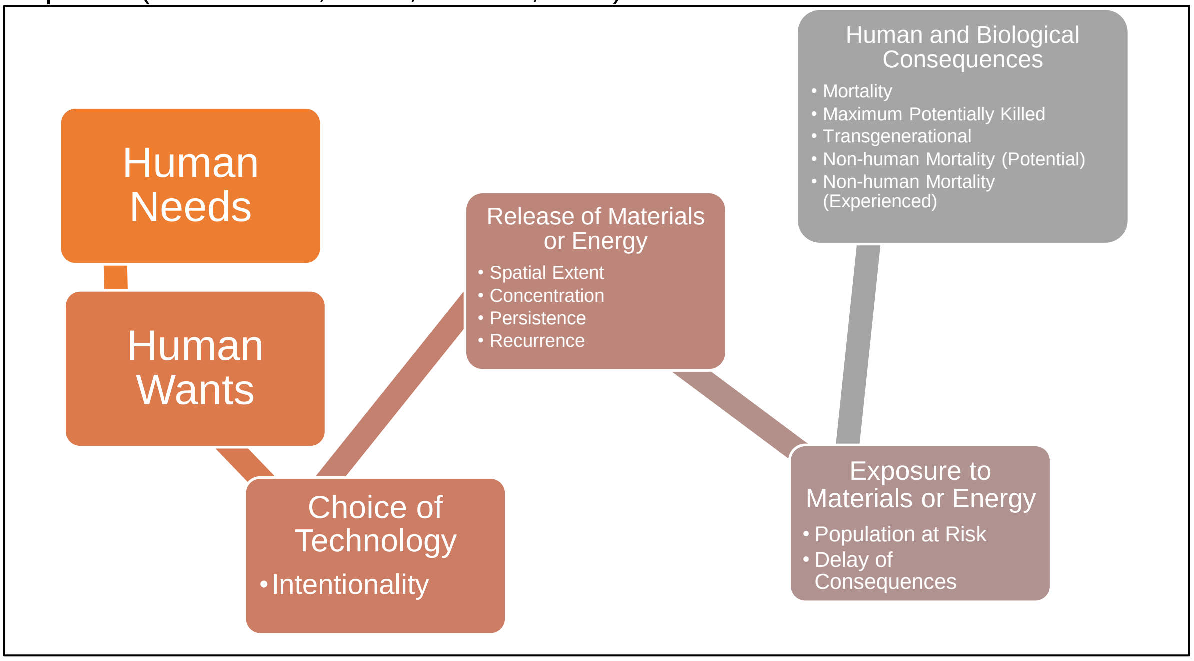
The general approach of understanding technological hazards is causality sourcing from Human-Machine-Interaction (HMI) (Hohenemser, Kates, & Slovic, 2000; Marquez, Riley, & Schutte, 2018; Wit & Cruz, 2019). The traits of the simplified causal analysis suggested by Hohenemser et al. (2000) are depicted as descriptors in Table 2-1, aimed to produce a simplified analysis of 93 various technological hazards. Their methodology included quantitative measurement of hazards classified. Their conclusive results after coding numerous categories of hazards indicated a severe issue. A successful hazard classification “must describe the essential elements that make specific hazards threatening to humans and what they value, reflect the concerns of society and offer new tools for managing hazards” (Hohenemser, Kates, & Slovic, 2000, p. 176)

Additionally, they warn that bias, regardless of the experience level or stature of the decision-maker, may be a significant disadvantage in future methodological designs about risk perceptions comparisons. However, although it is not mentioned, the causality sequence depends on scales that have a social extension. For example, scales including harm for an individual or the whole population of a context, like ‘mortality’, is a piece of information that would influence social norms and opinions (Basting, Towey, & Rose, 2016). On this premise lies the link between risks and hazards, according to the definition stated earlier in this section. In other words, risk perception obtains the hazard itself and its measurable conditional and probable consequences.

Table 2-1: Hazard Descriptor Scales

Hazard Descriptor Scales	
Intentionality	Measures the degree to which technology is intended to harm
Spatial Extent	Measures the maximum distance over which a single event has a significant impact
Concentration	Measures the concentration of released energy or materials relative to natural background
Persistence	Measures the time over which a release remains a significant threat to humans
Recurrence	Measures the mean time interval between releases above a minimum significant level
Population at Risk	Measures the number of people in the US potentially exposed to the hazard
Delay of Consequences	Measures the delay time between exposure to the hazard release and the occurrence of consequences
Mortality	Measures average annual deaths due to the hazard for the population at risk
Maximum Potentially Killed	Measures the maximum credible number of deaths in a single event for the population at risk
Transgenerational	Measures the number of future generations at risk from the hazard
Non-human Mortality (Potential)	Measures the maximum potential of nonhuman mortality
Non-human Mortality (Experienced)	Measures non-human mortality that has actually been experienced

Figure 2-7: Causal structure of technological hazards illustrated by a simplified causal sequence (Hohenemser, Kates, & Slovic, 2000)



2.4.5. Risk Perception and Trust

Trust is a complex construct that represents an aspect of the bond among members of a team. Trust in layman's terms is about reliance or confidence in someone. Regarding trust and risk perception, three basic debates can be located (Slovic, 2000); (a) overestimation of hazards vs perceived risk, (b) disputability of risk assessment and management versus the perceived risk, and (c) build of trust/distrust vs perceived risk. The first debate expresses the frequency of occurrences of ignorance due to reasons of inefficient education on the matter or rarity of detrimental events. According to Slovic (2000), a large period of more than 20 years and the absence of serious incidents made the American public more concerned about risk. Regardless of technological progress, the public perceives itself as increasingly vulnerable to hazards.

The second debate expresses an environment of polarised views. The literature on risk perception research reveals many diverging views (Slovic, 2000; Ropeik, 2012; Kaufman, Persoskie, Twesten, & Bromberg, 2018). For example, risk perception may be measured using questionnaires targeting the total effect of safety culture with tools like the CANSO Safety Culture Development Questionnaire or EUROCONTROL Safety Culture Measurement Toolkit (Mearns, Kirwan, & Kennedy, 2009; Heese, 2012; Schwarz & Kallus, 2015; Schwarz, Kallus, & Gaisbachgrabner, 2016). The usual practice among these efforts is that risk perception is matched with an SMS's maturity level from the use of documentation and practice of proactive and predictive methods to inform an organisation about risk levels. Another view presents risk assessment as part of "nontechnical skills" (NTSs). According to Mavin et al. (2013, p. 53), NTSs include "human-human and human-machine coordination, communication, problem-solving, management of crew member tasks, and problem escalation".

Additionally, Heese (2012) argued that a non-effective risk perception consists of lacking risk awareness and poor mitigation strategies, while on the opposite case, risk perception reflects an organisation's shared risk perception and mitigation strategies. An additional concept is the social aspect of risk perception (Slovic, 2000). According to IBM theory (Montano & Kasprzyk, 2008), many constructs define intention related to an individual's social environment. Additionally, the importance of social values in risk perception is that ignorance or irrationality concerns are only two probable attributions. Risk assessments have been indifferent to qualitative variables like uncertainty and aversion to exposure (Slovic, 2000). Summarising the examples for the disputability of risk assessment and management vs perceived risk, the risk is being measured qualitatively through broad documentation and quantitatively through specific structured tools. Also, risk perception consists of NTSs deriving from the organisational and social context.

As far as the third debate of trust/distrust versus the perceived risk is concerned, trust among humans is an incontrovertible composite for their social nature. This might be the reason for becoming too familiar; thus, neglected as a concept in the technological environment. Slovic

(2000, p. 317) highlights the “lack of trust as a critical factor underlying the divisive controversies surrounding the management of technological hazards”. Slovic (Perceived Risk, Trust and Democracy, 2000) also suggested that the importance of trust could be appreciated through an exciting comparison. The suggested comparison prompts to compare the accepted risks to those who were rejected. Another trait of trust is that it is fragile. Trust builds up slowly but may ‘shatter’ like a glass instantly.

On the other hand, distrust is much easier to build and more difficult to destroy. Slovic (2000) instructs a few reasons for this phenomenon:

(a) Trust-destroying events are more noticeable than trust-building events. Trust-destroying events are mostly definite incidents by nature, like accidents or erroneous situations.

(b) Trust-destroying events ‘weigh’ more, primarily due to rarity and complexity. In a complicated situation where there is a fear of damaging relationships, a strong trust connection may foster silence in a hazardous situation (Bienefeld & Grote, 2012).

(c) Sources of trust-destroying news tend to be more credible than sources of trust-building news.

(d) Distrust builds more distrust. First, due to distrust, people tend to avoid experiencing the truth about a situation. Second, the initial prejudice reinforces prior beliefs.

An additional construct related to trust is ‘worldviews’. “Worldviews are general social, cultural and political attitudes that appear to have an influence over people’s judgments about complex issues” (Slovic, 2000, p. 402). An approximate list of worldviews is provided below (Slovic, 2000; Ropeik, 2012):

1. Fatalism. Fatalists tend to believe in destiny.
2. Hierarchy. Hierarchists tend to demand a top-bottom organised society, embodied with obedience and conformity.

3. Individualism. Individualists express the free and unhindered nature of the individual.

4. Egalitarianism. Egalitarians demand power and wealth evenly distributed among members of society.

5. Technological enthusiasm. Society's progress depends on technological progress.

Worldviews, in general, may serve as orienting mechanisms (Slovic, 2000). An additional orienting mechanism suggested by Slovic is affection. He accepts that affective reactions may serve as orienting dispositions if affection is characterised by primacy and automaticity. Figure 2-8 illustrates what Slovic suggested as "people's perceptions of risk, their acceptance of risk and their trust in risk management are based on knowledge and experience" (2000, p. 404). Furthermore, the model implies that worldviews and affection influence risk evaluations.

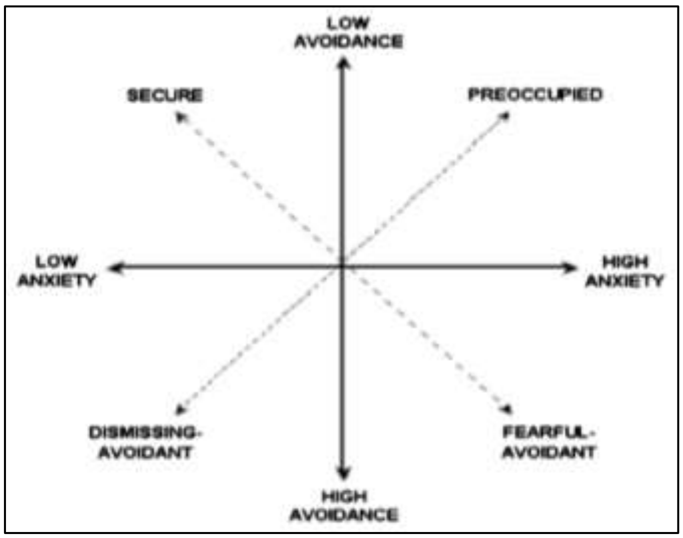
Figure 2-8: Schematic model of worldviews and affect as orienting dispositions (Slovic, 2000).

Trust among aviation consumer audiences is related to the pilots' different configurations (Rice & Winter, 2015). Also, according to the CANSO safety model, trust is an underlying dimension of safety culture described as one of the emergent properties (Figure 2-9) (Heese, 2012). According to Heese (2012), trust reflects accountability, responsibility, and blame attribution under the scope of just culture. Furthermore, trust is also an essential factor during in-flight operations. According to de Boer and Hurts (2017), too much trust in the suitable operation of systems and complacency are two among the factors which may cause an automation surprise.

Figure 2-9: CANSO Safety Model (Heese, 2012)

An additionally study related to the construct of distrust is worth mentioning due to its aviation relevant sample. Shrivastava and Burianova (2014) studied the relationships between attachment styles, proximity, and relational satisfaction among flying crews and non-flying crews. Attempting to fill the gap where few studies have explored the effects of romantic attachment patterns and how people successfully cope with separation episodes, the authors used a two-dimensional model of adult attachment by R. C. Fraley and P. R. Shaver (Figure 2-10).

Figure 2-10: Two-Dimensional Model of Adult Attachment by R. C. Fraley and P. R. Shaver (Shrivastava & Burianova, 2014).



According to the model depicted in Figure 2-10, distrust of intimacy and feeling of unworthiness distinguish fearful-avoidant individuals experiencing high anxiety levels (Shrivastava & Burianova, 2014). Their results confirmed that “individuals with higher levels of avoidance generally do not trust others, they do not display a great deal of support, concern, or validation for their partner, and feel discomfort when addressing emotional disclosure or relational conflicts” (p. 110). Their results also confirmed that “these behaviours may further lead to conflict escalation and subsequent reduction of positive outcomes in relationships” (p. 110). The above arguments imply that social and even organisational traits which involve high levels of anxiety may not enable a safety culture orientated communication to be effective. On the other hand, the two-dimensional model of an adult attachment may further apply to cases of overestimating trust of complacency involving low anxiety levels.

2.4.6. Risk Perception Short Summary

To summarise, risk perception is an indispensable part of risk management during everyday practice in aviation. Risk perception reflects the ways individuals or organisations perceive current and latent information inducing uncertainty or implying adverse consequences. Although SAIMs are supposed to counter adversities and systemic failures, risk perception has been left aside due to its high frailty induced by subjectivity. Nonetheless, safety events continuous sustainment has pointed out that a strict positivistic and logistic approach, although it may suffer traces of subjectivity, could also play a crucial role in effective analysis and preventive measure suggestion. Adjacent, risk perception research showed that it is deeply rooted in cognitive research, which also explains its strong ties with heuristics/biases. Indeed, this connection highlights the possibility that risk perception may be both qualitative and quantitative by nature, which is also reinforced by its ties with technological hazards. Finally, risk perception is highly influenced by trust based on the concept that the risk assessor may overestimate risk or mistrust risk assessments made by other individuals or even over-trust an appreciated individual’s risk assessment.

2.5. Risk Communication

Risk communication is based on communication theory by principle. As such, it could be described in various conceptual frameworks, depending on the context. To serve the scope of this thesis, the variety of frameworks could be narrowed down to four based on the principle of the participants and the traits of what is transferred (Table 2-2). Moreover, communication in the aviation context goes beyond the confinement of communication among humans to the pluralistic context of human-machine interaction (HMI). Beyond the HMI context, the new addition to human interaction in the industrial area is the Industry 4.0 concept.

Table 2-2: Risk Communication Perspectives (Beytekin & Arslan, 2013)

Perspectives	Description: "*Communications as a…*"
Mechanistic	Transmission process of information from one point to another.
Psychological	Loop transmission process of information aggregating thoughts and feelings of the sender to the recipient and vice versa.
Interpretive-symbolic or Social	Loop transmission process of information used by individuals to shape their social reality through communicating, highlighting the transmission content.
Systemic	Process of producing reflecting sequential behaviour.

The course of industrial progress drives through remarkable transformations, going through the generation of steam (Industry 1.0), the introduction of electricity (Industry 2.0), the addition of automation (Industry 3.0), to recent additions of "smart" systems (Badri, Boudreau-Trudel, & Saâdeddine Souissid, 2018). "Smart" systems or Cyber-Physical Systems (CPS) have been defined as "co-engineered interacting networks of physical and computational components" (Griffor, 2017, p. 1). CPS enhance the communication process by integrating additional capabilities narrowing the distances among actors in the operational environment (Wang, Törngren, & Onori, 2015). Real-time communication is considered a non-negligible asset for organisations that face high competition and seek to expand productivity while reducing costs (Badri, Boudreau-Trudel, & Saâdeddine Souissid, 2018). Effective risk communication may highly contribute to avert costs by facilitating compliance to safety measures. According to ISO 45001 (ISO 45001:2018, 2018), there is a significant need to communicate hazards and risks to increase awareness as part of a Safety Management System (SMS). Based on ISO 45001 (ISO 45001:2018, 2018), an organisation may apply a hierarchy of controls to reduce risks. As part of these controls, risk communication reflects the administrative layer of controls (e.g., warnings, safety signs, instructions, and training). Industry 4.0 has already impacted the aviation industry as well, indicating new benefits (i.e. increased fuel efficiency, enhanced tools, preventive maintenance) and needs (i.e. development of new skill-sets, updated training (Bonneau, Copigneaux, Probst, Pedersen, &

Lonkeu, 2017). Implementing Industry 4.0 means that the aviation industry will have to integrate more human-machine control interfaces and new ways of communicating complex operations (Badri, Boudreau-Trudel, & Saâdeddine Souissid, 2018). Progressive technologies are contemplated in delivering new potential risks, mainly focused on HMI (Brocal & Sebastián, 2015).

Similarly to risk perception, risk communication has not been explicitly addressed as per its contribution to safety events. However, risk communication is a functional component of an effective risk analysis. It has been defined from multiple sources either as an effort to supply end-users with the information they need to make informed decisions about risk (Morgan, Fischhoff, Bostrom, & Atman, 2002) or as an interactive exchange of information about risks among risk assessors, managers, news media, interested groups, and the general public (Muralikrishna & Manickam, 2017). Moreover, although these two definitions came from the health context and the environmental management context, further research revealed more definitions with minor variations among them (CDC, 2014; Gamhewage, 2014; Qiu, Rutherford, Chu, Mao, & Hou, 2016; Farjam, Nikolaychuk, & Bravo, 2018). In principle, a communication network is first established as the foundation for communicating risks (Null, 1991). A set of core principles for risk communication include the following (Yoe, Risk Communication, 2012; CDC, 2014):

1. An interactive exchange of information and opinion takes place. According to the systems theory, communication is an interactive and communicative understanding with continuous input, throughput and output (Vieira, dos Santos, & de Morais, 2014). Based on the complexity of the aviation context, effective communication is at least mandatory to manage risks.

2. It is undertaken throughout the risk analysis process. As Yoe (2012, p. 128) highlighted, "risk communication improves understanding of the risk and risk management

options (RMOs)". The RMOs remain critical as the key to communicating the costs and benefits of a chosen course of action to manage risk.

3. It concerns risk, risk-related factors, and risk perceptions. The primary role of risk communication is to frame the risk to the end-user as a sufficient situational awareness.

4. It involves risk assessors and risk managers as well as affected groups and individuals and interested parties. During a pre-flight passenger cabin preparation, a safety demonstration sets a common language and understanding of hazard indicators and safe behaviours.

5. It includes an explanation of the risk, possibly an explanation of the risk assessment, and the basis for the risk management decision. By explaining the reasons behind the choice of a specific RMO, all communicating sides declare honesty and trust among them.

Beyond the core values of risk perception, a broad set of guidelines has been demonstrated early enough by Covello et al. (1989). Even though risk communication is described in detail per its philosophy, planning and process, it has remained a generic principle, mainly related to crisis management in terms of being a precedent in terms of relating it with the human factors in the aviation context (Dickmann, Biedenkopf, Keeping, Eickmann, & Becker, 2014; Drennan, McConnell, & Stark, 2014). Previous research has shown that risk communication aims at the individual's cognitive processing and emotional state (e.g., fear, anger) (Johnson B. B., 2005; Van der Linden, 2014). Nonetheless, as Kim and Choi (2017) remark, risk perception varies by individual, risk communication should account for each separate interaction of risk message, conveyed matching traits between the sender and the recipient. As Kim and Choi (2017) discussed, message appeal and coping style are two factors enabling the effectiveness of risk communication. The process of framing an event is clearly stated to influence risk perception while appealing to the recipient's emotion enhances it (i.e. better memory recall) more than logical appeals (Tversky & Kahneman, 1981; Johnson B. B., 1993; Kim & Choi, 2017). An essential aspect of risk communication literature is that every study concerning risk communication has been conducted from an originating source of experts compared to the end-users. An example of expressing that argument, in other words, is that aviation safety experts are not necessarily still pilots, engineers or ATCs working in the field, and neither are the recipients of risk communication equally matching them in terms of experience or academic stature.

In terms of managing risk communication, involved stakeholders, end-users, and managers are prompt to re-assess cues, hazards, and scenarios they already know. Practically, pilots are aware of hazard alerts, ATCs know the sound of a TCAS when they hear it, MP knows what a 'crack' means, and passengers understand the 'no-smoking' and 'fasten your seatbelt' signs. However, risk communicators have the difficult task to assess all these means of communication and many more. Morgan et al. (2002) presented a conceptual framework to overcome these problems in five steps:

1. Create an Expert Model: Demonstration of the risk's nature and with an influence diagram[2] depicting involved factors, actors, and processes.
2. Conduct Mental Models Interviews: Based on the influence diagram, a comparison-processing of open-ended interviews eliciting subjective data about the hazard.
3. Conduct structured initial interviews: Distribution of a confirmatory questionnaire whose items capture the beliefs expressed in the open-ended interviews and the expert model to a large sample.
4. Draft Risk Communication: Communicate on the incorrect beliefs and knowledge gaps as observed from the interviews, questionnaires, and past decisions.
5. Evaluate Communication: Test and refine using multiple methods (i.e. interviews, focus groups, closed-form questionnaires, or problem-solving tasks).

[2] Influence diagrams are graphical representations of information considered during decision-making, with arrows (influences) connecting pieces of information (nodes) (Morgan, Fischhoff, Bostrom, & Atman, 2002).

Safe behaviours are enabled when the communication elements (i.e. source, message, receiver) are supported in a context-dependent channel (Williams & Noyes, 2007). Based on the mentioned attributes of communication in general and specifically of risk communication, the risk communication factors are:

1. Emotional State of Sender and Receiver.
2. Cognitive State of Sender and Receiver.
3. Physical State of Sender and Receiver, including non-human operators.
4. Local State of the system, which refers to environmental influence (i.e. organisational culture).
5. Timeliness of communication, which refers to the harmonisation of the communication process to magnitude and latitude as it is needed.
6. Medium of communication type, which refers to the channel of communication (i.e. visual, verbal, haptic, auditory).

Furthermore, risk communication is a process based on the audience perception of risk and scientific principles of effective communications in high concern situations (Walaski, 2011). Risk is supported as a trendsetter in social decision making about technologies (Kasperson, et al., 2000). Kasperson et al. (2000, p. 233) argued explicitly that “because the resolution of social conflict requires the use of factual evidence for assessing the validity and fairness of rival claims, the quantity and quality of risk are major points of contention among participating social groups. As risk analysis incorporates a variety of methods to identify and evaluate risks, various groups present competing evidence based on their perceptions and social agenda. The scientific aura surrounding risk analysis promotes the allocation of a substantial effort to convince official decision-makers and the public that the risk assessment performed by one group is superior in quality and scientific validity to that of others”. Therefore, policy-making cannot be supported efficiently only by a technical approach to risk.

2.5.1. Risk Communication and Crisis Communication

Risk communication is closely related by definition to crisis communication. Risk communicators may employ crisis communication when the hazard is high or a critical event is imminent or ongoing (Walaski, 2011). However, no matter how close the relationship between risk and crisis communication are, they possess differences that have practical implications that separate the depth of intervention a safety professional has to take (Table 2-3).

Table 2-3: Differences between Risk and Crisis Communication (Walaski, 2011)

Risk Communication	Crisis Communication
Event that is the focus of the communications is in the future.	Event that is the focus of the communications is about to occur or is already occurring.
Ongoing process between communicator and audience is time-consuming.	Shorter process between organisation and audience due to the immediacy of the crisis event.
Focus of efforts is on the dialogue generated between the two parties.	Focus of the efforts is the delivery of messages to the audience.
Most communications are two-way events.	Most communications are one-way events.
Goal is to reach a consensus with audience regarding activities and solutions to present a hazard.	Goal is to inform and compel the audience to action intended to keep them safe.
Safety Health Executive (SHE) professional functions include assisting in the risk assessment process to qualify and quantify the risks and assisting in the development of the messages in some organisations, the SHE professional will also deliver the messages, typically to the workforce.	SHE professional functions include assisting in the understanding of the severity of the crisis and assisting in the development of the messages; in some organisations, the SHE professional will also deliver the messages, typically to the workforce.

The most crucial reason for referring to crisis communication in this thesis is that a professional with Health and Safety duties will be often required to communicate risk information or even run a safety communication campaign. As Walaski (2011) points out, a safety professional may be asked to deliver the message(s) at formal settings or organisational meetings. During a crisis, a Health and Safety professional employs risk communication with various audiences, but the time he/she may have at his/her disposal is critically little (Walaski, 2011). The types of risk communication related to safety reveal that the effectiveness depends mainly on the communicator's skills and risk perception (Table 2-4).

Table 2-4: Examples of Risk Communication

Oral Risk Communication	Multimedia Risk Communication
Verbal Message	Lecture Video
Press Conference	Audio Conference
Briefing	Podcast
Safety Meeting	Social Media
Safety Training	Press Release
Individual Exercise	Newsletter
Group Exercise	e-mail
Tailgate Meeting	Blogging
Toolbox Talk	Brochures

One of the essential communication skills is building trust. A rule of thumb suggested by Walaski (2011) is the asymmetry principle. Briefly, the asymmetry principle is noted as the phenomenon when one communicator tries to create trust in an audience for an organisation's or a concepts interests. Once it is created, positive information about the organisation will tend to reinforce the audience's trust level strongly. Nevertheless, on the other hand, when there is no or a weak level of trust, negative information may create mistrust.

Furthermore, Walaski (2011) notes the importance of personal control over a specific risk regarding trust. If an audience has no personal control over risk, trust is a major facilitating factor over the complete acceptance of the communicated message. Additionally, Walaski (2011) agrees with Kasperson et al. (2000) in terms of modelling the perception of trust at the layers of the reflection of the communicator on the audience, the absence of bias, and caring and commitment.

Covello (2007) suggested the risk perception model of risk communication to enable risk communicators' effectiveness. This model aims to to utilise a list of factors that influence an audience's perception of risk. Also, this model measures the magnitude of the perception through audience analysis in the alignment of 15 factors. In this manner, the messages will be more precise and affect changing behaviours (Table 2-5).

Table 2-5: Covello's 15 Risk Perception Factors (Walaski, 2011)

Risk Factor	Applicability
Voluntariness	If the audience members perceive the risk to be voluntary, they are more likely to accept it because they understand their role in experiencing the implications of the risk.
Controllability	If the audience members perceive that they have control over the risk, they are more likely to accept its implications.
Familiarity	If the audience members have some previous knowledge of the risk or experience with it, they are more likely to accept its implications because of the increased level of knowing what might or might not happen.
Equity	If the audience members perceive the implications and consequences of the risk to be equally shared among audience members, they are more likely to accept its implications.
Benefits	If the audience members perceive the ultimate benefits of the risk to be positive, they are more likely to accept the potential negative implications of experiencing it.
Understanding	If the audience members possess a basic understanding of the risk, they are more likely to accept its implications. The greater the level of understanding, the higher the acceptance.
Uncertainty	If the audience members perceive the risks have a degree of certainty in various dimensions and the scientific information available, they are more likely to accept its implications.
Dread	If the audience members' emotions about risk are less intense and fearful, the more likely they are to accept its implications.
Trust in institutions	If the audience members perceive the institutions more significantly involved in the risk as trustworthy and credible, they are more likely to accept its implications.
Reversibility	If the audience members perceive the risk to have reversible adverse effects, they are more likely to accept its implications.
Personal stake	If the audience members perceive the risk to be limited in its personal implications and consequences, they are more likely to accept

Risk Factor	Applicability
	the implications of the risk.
Ethical/moral nature	If the audience members perceive the risk to be morally or ethically acceptable, they are more likely to accept its implications.
Human vs natural origin	If the audience members perceive that the origin of the risk is naturally occurring, they are more likely to accept its implications.
Catastrophic Potential	If the audience members perceive that the number of fatalities, injuries, and illnesses from risk is minimal, they are more likely to accept its implications.

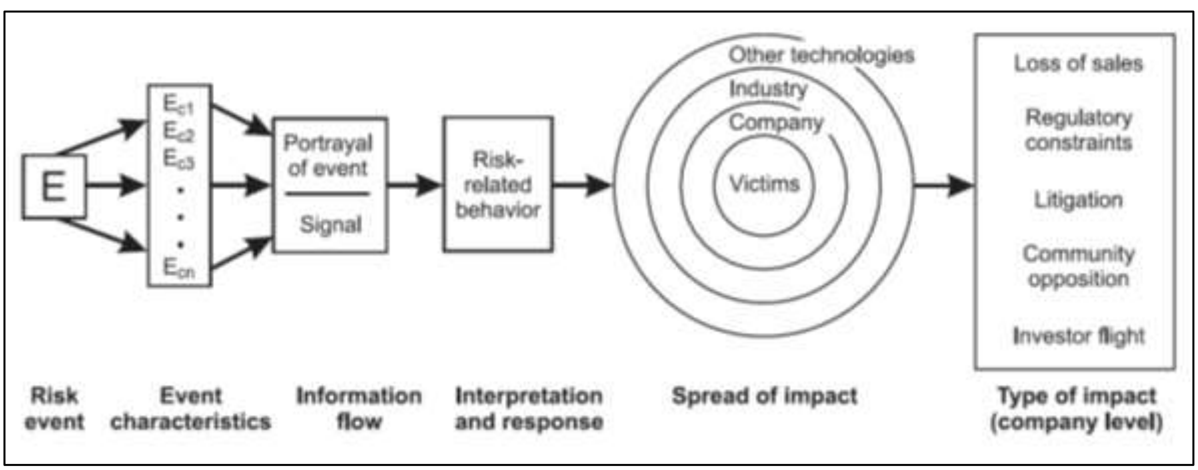
Covello's theoretical approach is supported by the notion that a unique risk or critical situation has a unique combination of the 15 factors. From a qualitative aspect, some combinations of factors or factors will be salient in relevance to the situation. Additionally, the audience analysis results may indicate that more than one sub-group should be treated differently. Lastly, during a crisis, an audience's perceptions of the combinations of factors or some individual factors may vary, resulting in ineffective communication. This model's structure implies that a particular course of handling a risk event is nearly impossible, but as Walaski (2011) suggested, the factors should be acknowledged more as a reference point allowing for fluctuations. Nonetheless, trust within the aspects of practice in the aviation context and as a prerequisite of effective communication is barely explored (Chatzi, Martin, Bates, & Murray, 2019).

2.5.2. Risk Communication and the Social Impact

According to Kasperson et al. (2000), primary processes, such as psychological, social and cultural processes, interacting with risk events heighten or attenuate risk perception and behaviour in public. Furthermore, primary processes trigger secondary processes, such as organisational policy-making and proactive/protecting measures. As such, Kasperson et al. (2000), named this triggering effect and the resulting chain reaction as *social amplification of risk* (SOAR). SOAR aspect is included in this thesis due to the holistic approach on the aviation personnel. An individual sustains, replicates and communicates issues and behaviours inward and outward the aviation context. This poses a great concern; contextual factors within the aviation context and generic societal contextual factors may influence the same individual. Therefore, SOAR may highlight the part of the individual's social identity in the aviation context. Indeed, SOAR has been reported to facilitate risk perception as a corrective mechanism, combining the technical assessment of risk with a complete determination of risk (Kasperson, et al., 2000).

SOAR may be paralleled with the concepts of communication signal amplification from the traditional theories of communication. Therefore, a transmitter may amplify or attenuate signal reception. However, SOAR “denotes the phenomenon by which information processes, institutional structures, social-group behaviour and individual responses shape the social experience of risk, thereby contributing to risk consequences” (Figure 2-11) (Kasperson, et al., 2000, p. 237). SOAR draws from the individual and public experience without discriminating absolute risk or socially determined risk (Kasperson, et al., 2000).

Figure 2-11: Social Amplification of Risk and Potential Impacts (Kasperson, et al., 2000)



Sources of probable risk amplification in the aviation context may be the following:

- Safety Personnel (e.g., Emergency Responders, Safety Managers)
- Safety Management Systems (SMSs)
- Social groups (e.g., peer-groups consisting of an airport’s personnel)

- Opinion Leaders (e.g., Union Leaders)
- Key Communicators (e.g., Safety Managers)
- Peer-to-peer references (e.g., word-of-mouth after a safety event)
- Federal organisation (e.g., EASA)

SOAR stirring points may transmit information through traditional organisational communication channels and non-organisational as organisational channels are meant safety-policy based methods, such as hazard reports. As non-organisational are insinuated means meant for safety but include a new perspective, such as a Social Media post informing for an incident and prompting for lessons-learned. The important part consists of the individual's later participation. It consists of social value attached to the information, cultural and peer-to-peer interaction, behavioural intention formulation to risk tolerance levels, and individual or peer-to-peer engagement to ignore, accept or adjust the risk (Kasperson, et al., 2000). Additionally, Kasperson et al. (2000) suggest that further investigation on SOAR should explain the reason for amplification or attenuation of specific risks and risks events.

Following, SOAR mandates that behavioural responses will provoke secondary impacts. According to Kasperson et al. (2000), secondary impacts have the following effects:

- Enduring attitudes and perceptions (e.g., alienation from the physical properties of the context, social apathy, stigmatisation)
- Impact on economic activity (e.g., a drop in passenger traffic)
- Cultural pressure (e.g., stigmatisation)
- Changes in the physical nature of the risk (e.g., overestimation of hazardous cues and signals)
- Changes in the training of operating and emergency-response personnel (e.g., reactive rise of the frequency of exercises)
- Social disorder (e.g., word-of-mouth generating distress during after-work hours)

- Changes in risk monitoring and regulation (e.g., increased reactive policy making)
- Increased liability costs (e.g., reactive hiring of external safety consultants)
- Effects on other technologies and social institutions (e.g., stigmatisation of events and overgeneralisation)

The importance of noting the secondary effects of SOAR is to supply further indication for third or N-order implications. SOAR uses the analogy of dropping a stone into a pond to illustrate the spread of SOAR (Figure 2-12). Thus, SOAR facilitates the transfer of the risk cue and societal response mechanisms. In other words, SOAR provides the service of facilitating direct or indirect experience about risk events. What matters most, however, is indirect experience, especially during proactive interventions or safety training. The shared information and its attributes regulate responses. Kasperson et al. (2000) suggested information attributes that may influence SOAR are volume, degree of dispute, the extent of dramatisation and the symbolic connotations used.

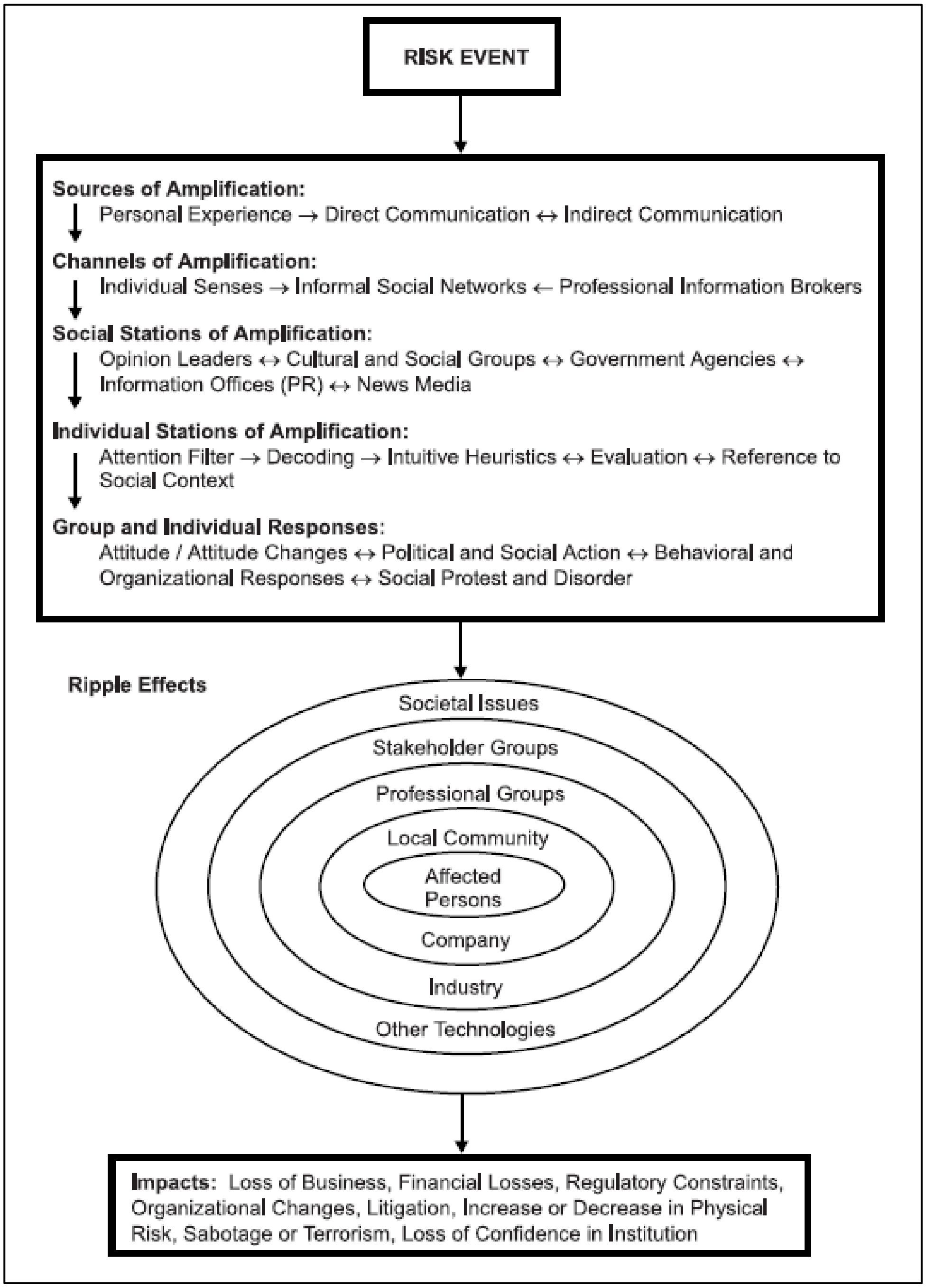
The volume of information may serve as a risk amplifier. “High volumes of information also mobilize latent fears about a particular risk and enhance the recollection of previous accidents or management failures or enlarge the extent to which particular failures, events or consequences can be imagined” (p. 242-241; Kasperson, et al., 2000). For example, on August 14, 2013, in United Parcel Service (UPS) flight 1354, an Airbus A300-600 crashed short of runway 18 during a localizer nonprecision approach to runway 18 at Birmingham-Shuttlesworth International Airport (BHM), Birmingham, Alabama. According to the accident report (NTSB, 2015), the flight crew failed to monitor the aircraft's altitude during the approach, which led to an inadvertent descent below the minimum approach altitude and subsequently into terrain. What is more, the flight crew failed to communicate the required information about attaining the needed vertical profile. The captain’s fatigue, distraction, or even confusion, including an additional volume of information, drove him to focus on trying to break out the clouds. Reiterating Kasperson et al., the captain of flight 1354 probably sustained high volumes of information, leading to his incapacitation by enlarging the risk of being out of schedule and not landing quickly enough. The information workload from the environment was due to instrument meteorological conditions (IMC) north of the airport on the approach course at the time of the accident.

Following, the degree of dispute of information over facts may raise debates focused on the veracity and credibility of information. Furthermore, dramatization is a powerful risk amplifier. For example, after the Air France 447 Flight relatives of the deceased disputed the human error finding in the official report, a separate judicial report attributed the event to pilot error and malfunctioning speed sensors (National Post, 2012). Another example is the Ethiopian Airlines crash on 10 March 2019. Boeing's new 737 Max model crash in Ethiopia triggered a dispute and drama which has inflicted significant damage on the company's image itself, since the aircraft entered commercial service on 22 May 2017 (i.e. reports claimed that the pilot was untrained, Boeing was sued in Chicago court) (Topham, 2019; Ducharme, 2019; Africanews, 2019).

Ultimately, Kasperson et al. (2000) suggest four probable response mechanisms of social amplification. To do that, they were based on three sub-contexts; social, institutional, and cultural. The mechanisms are heuristics, social group relationships, signal value, and stigmatisation (Kasperson, et al., 2000). Heuristics are mainly used as a means of simplifying a considerable volume of information. However, there is always the danger of errors due to biases. Social groups' relationship depicts the social alignments of managers or supervisors towards the risk-management process. Following, the signal value is directly related to risk perception depicting a risk event's same seriousness and impacts. Furthermore, stigmatisation is associated with negative imagery biases about risk events.

Additionally, Kasperson et al. (2000) argue that social processes may inflict positive feedback to the physical risk itself. For example, if an aeroplane accident with hazardous materials were to occur close to an inhabited area near the end destination, protests about the removal of the airfield could result. This, in turn, could initiate a sequence where hazardous materials should be redirected in a non-qualified airfield, increasing the probability of future accidents with more consequences.

Figure 2-12: The Framework of Social Amplification of Risk



2.5.3. SAIMs and Risk Communication

Regardless of the context, communication activities aim to inform or/and influence (Fischhoff, 2012). Concerning risk communication, the informing aim is attributed to the sender who targets to increase the receivers' awareness of existing or imminent risks in their environment (e.g., awareness campaigns, warning signals and posts, sharing of safety information). Regarding the influential aim, the sender aims at (re)shaping the receiver's risk perception (e.g., dedicated training sessions, procedures for risk assessment). Risk communication interrelates emotional, social, and cultural processes while interacting with hazards and risk events, the actors involved, and their risk perception, and is driven by organisational policy-making and proactive measures (Kasperson, et al., 2000; Williams & Noyes, 2007). As mentioned earlier, according to the theory of Social Amplification of Risk (SOAR), a risk event may be amplified based on the source, the channel, and the receiver through ripple effects or interferences; and all these components disperse the message to primary, secondary or unintended recipients (Kasperson, et al., 2000; Fellenor, et al., 2018; Coombs, Holladay, & Tachkova, 2019).

To facilitate safe behaviours, the communication mentioned above elements need to be considered in a context-dependent channel (Williams & Noyes, 2007). It is expected that risk communication is facilitated towards most SAIMs since the unclear lines of communication have been notoriously one of the leading causes of accidents (UK HSE, 2004; Molesworth & Estival, 2015). Moreover, communication needs to be provided timely and support mutual comprehension and coordinated activities (Fiske, 1990; Macrae, 2007; Yanmaz, Yahyanejad, Rinner, Hellwagner, & Bettstetter, 2018; Downey & Bedard, 2019). Unsuitable mediums of communication, poor timing, low literacy of the communicators, and adverse social/organisational features, such as inadequate and unclear policies and Standard Operating Procedures (SOPs), are factors that can lead to communication failures (Ford, Henderson, & O'Hare, 2013).

Based on the mentioned literature and the premise that risk communication should contribute to the development of desired risk perceptions, the factors influencing each risk communication direction can be grouped as:

1. Emotional (CEMF), Cognitive (CCOF) and Physical (CPHF) for the senders and receivers;

2. Broad environmental (CENF) which are external to the senders and receivers;

3. Temporal (CTIF) that are linked to the timeliness of communication;

4. Channel-related (CCHF) refers to parameters such as the medium's suitability, the reliability of the channel, and external interferences.

2.5.4. Risk Communication: Educating about Risk

At the epicentre of the daily practice of risk management lies training. Risk awareness is extremely precious from all stakeholders in a context. Slovic (2000) stressed in his research that informing about risk issues may be extremely difficult. He pointed out that risk communicators have a heavy burden to be effective. Risk communicators are needed to overcome biases and research limitations. Their role is to present complicated procedures and policies of technical nature through comprehensible ways of overcoming uncertainty (Slovic, 2000). The importance of the role of the risk communicator lies in the fact that the awareness they bring enhances safety procedures.

According to Slovic (2000), risk communicators should consider some basic guidelines to be practical; (a) the limitations of risk assessment, (b) the limitations of the stakeholders' understanding, (c) the placing of risks in perspective, and (d) the means of communication. Slovic (2000) suggests that risk communicators have to be aware of various risk assessment practices. It is vital for Slovic (2000) that these processes and their theoretical background may be inaccurate. Additionally, the risk communicator should be well aware of any criticism about risk assessment processes; although criticism may bring uncertainty, this does not imply chaos (Slovic, 2000).

Adjacent, risk communicators are strongly recommended to assess the stakeholders' understanding (Slovic, 2000). Finally, Slovic (2000) suggests that risk communicators may always bear in mind the causes of understanding limitations:

(a) Risk perception is often inaccurate. Inaccuracy derives from faulty risk communication, which enhances the subjectivity of the hazardous situation.

(b) Risk information may frighten and frustrate. "Whereas mere mention and refutation of potential risks raise concerns, the use of conservative assumptions and worst-case scenarios in risk assessment creates extreme negative reactions in people because of the difficulty of appreciating the improbability of such extreme but imaginable consequences" (pp. 184-185).

(c) Strong beliefs are hard to modify.

(d) Naïve views are easily manipulated by presentation format. In the absence of pre-existing dogmatic attitudes, communicated information depends vastly on its presentation.

For Slovic (2000), placing risks in perspective means choosing risk measures and exploiting statistical presentations. In other words, risk communicators are recommended to focus on assessing risk measures initially. This may include categorising hazards, consequences measurement, consequences report, and determining a unit of observation (Fischhoff, Lichtenstein, Slovic, Derby, & Keeney, 1981). Where Slovic (2000) and Fischhoff et al. (1981) agree is on the importance of setting the suitable material for an effective presentation. One aspect of a resourceful presentation is supported by Fischhoff et al. (1981), through statistics. However, statistics is one technique in the blur context of risk communication.

For this reason, Slovic (2000) suggests the psychometric paradigm approach. In this way, there will be more meaning in representations of risk attitudes and perceptions. This is explained by the exploitation of self-reporting data to construct risk perception descriptors in the paradigm.

What is more, Slovic (2000, p. 190) argues that "risk perceptions and risk-taking behaviours appear to be determined not only by accident probabilities, annual mortality rates or mean losses of life expectancy but also by numerous other characteristics of hazards such as uncertainty, controllability, catastrophic potential, equity and threat to future generations". Indeed, each hazard may be unique to different stakeholders. Additionally, the set time of the hazardous situation is also unparalleled. In this notion, when a researcher studies risk perception is therefore recommended to communicate the broader conception of risk under various dimensions. Furthermore, Slovic (Informing and Educating the Public about Risk, 2000) warns that sometimes, the risk may be a surrogate rationale for issues grasping social issues.

Another critical issue for the risk communicator is the means of communication. Slovic (2000, p. 196) argues that stakeholders' "cognitive representation of risk dictates the sorts of information they will find necessary for participating in risk-management decisions". The principal characteristic of risk communication, as implied earlier, is participation. Extending this argument, participation in risk-management decisions may employ attitudes, norms, knowledge, and in general, whatever constitutes the identity of an involved individual or group. As Slovic (2000) support, the risk may derive from a general societal issue. In the case of the aviation industry, this may refer to the organisational culture as a context.

2.5.5. Risk Communication: Interacting about Risk

Through communication, individuals influence each other to the point that it may also affect their identity and self-identification. In the notion of human sciences, the individual is the moderator of his/her behaviour and the underlying source of expertise for an organisation (Swanson & Holton, 2001). Specifically, the Human Resource Development (HRD) context considers individuals as the main cause of an organisation's performance, and an organisation depends on expertise and performance (Korte, 2007). Korte (2007) also notes that while the individual's importance is debatable, its form of satisfaction, loyalty and commitment is likely to affect performance. Additionally, Korte (2007) deducted that internal organisational groups and their way of operation affect organisational performance and that any organisation is a social entity comprised of interacting groups. Korte (2007) argued that social identity is a basic moderating factor influencing individual behaviour in groups and that therefore is a critical factor influencing learning in organisations.

The concept of social identity is defined by psychology as a cognitive construct answering the simple question "Who am I?". Based on this structure, there is a major division between personal identity and social identity. Personal identity refers to behaviour met by the individual as a person, while social identity regards the individual as a member of a group (Korte, 2007; Hogg, Abrams, & Brewer, 2017). The self is regarded as the bridge concept between the individual and the group, assumed as an implicit schema. The self's core concepts represent the personality and peripheral concepts that demonstrate an individual's adaptation skills (Hogg, Abrams, & Brewer, 2017). According to Hogg et al. (1995), social identity theory focuses on group membership and behaviour. Based on the notion supported earlier, social theory is part of social cognition and is destined to investigate how any individual is self-aware and situationally aware in any social context. The peripheral adaptation skills of self-identity reflect upon the group membership and the group's interactions in any social context, mainly depending on the influence of the group's salience due to its size (quantitative criterion) and its cultural traits, organisational prestige, contextual prestige, nationality, sex (qualitative criteria) (Hogg & Terry, 2000; Korte, 2007).

Historically, Henri Tajfel (1982) recognised that cognition might be divided into two components; (a) cognitive elements, (b) cognitive processes. In this way, he proposed his theory of social identity eloquently. Adjacent, Turner (1981) added the complementary theory of self-categorisation. These theories are complementary because social identity theory explains the elements of self and their development process. According to Turner (1981), a social identity is developed through a process of self-categorisation. Social identity theory assumes that the individual and the group coexist in a reciprocal relationship. This relationship is expressed with a constant exchange of experiences and interactions (Jenkins R. , 2004). Combining Turner's (1981) suggestion, the resulting identity is dependent on in-group and external categorisations. This dynamic relationship constructs social identity.

Social identity theory explains the work motivation framework proposing a cultural approach towards work-related identities (Shamir, 1991; Van Knippenberg, 2000; Illgen & Sheppard, 2001; Kleinbeck, Wegge, & Schmidt, 2001; Watson, 2003; Ellemers, De Gilder, & Haslam, 2004; Haslam, 2017). According to Shamir (1991), Illgen and Sheppard (2001) and Kleinbeck et al. (2001), the individual has the benefit of a work context where values and even moral obligations are related to increasing self-worth concepts. Van Knippenberg (2000) suggests that a clear organisational identity is positively related to work motivation, task performance, and contextual performance as far as it matches the social identity and the performance is in the group's or organisation's interest. Watson (2003, p. 275) adds that "Organisations are often experienced as if they are 'things' which exist outside and prior to human activity but what are really being experienced are institutional processes. Moreover, the human actor is always implicated in those processes rather than existing merely as a passive object upon which the process works". In other words, in an organisational culture where common traits are shared reciprocatively with the members of the organisation and the organisation itself, the individual draws specific behaviour and intention sets to apply in his/her context. Ellemers et al. (2004) argue that social identity theory may contribute to further understanding work motivation. Haslam (2017), describes the process of integrating social identity theory concepts into a training context.

Furthermore, Korte (2007) suggests additional group concepts related to social identity. The group's norms and expected behaviour may be as well regarded as the ideal identity. This prototype identity may be assumed as the basic criterion for an individual's allowance into the group and his/her progress within the group. This evolving process represents the same esoteric procedure that social identity theory describes self-categorisation. Additionally, the reasons for attempting to enter a group vary. An individual may wish to develop a social identity for the sake of pride, the sense of belonging, acquisition of power and social status, and materialistic rewards and benefits (Abrams & Hogg, 1990; Hogg & Grieve, Social identity theory and the crisis of confidence in social psychology: a commentary, and some research on uncertainty reduction, 1999). Comparison with other groups provides evidence of a strong tendency to receive appraisal through discrimination (Tajfel, 1982). According to social identity theory (Abrams & Hogg, 1990; Hogg & Grieve, 1999), groups tend to praise the similarities among their member while diminishing differences. On the opposite side, groups tend to exaggerate the differences with other groups to achieve certainty and positive self-evaluation (Korte, 2007). Consequently, stereotyping and prejudice result from social identity and self-categorisation (Tajfel, Social psychology of intergroup relations, 1982). In turn, stereotyping may lighten the cognitive workload providing predispositions, which may lead to a vicious cycle.

What is more, an individual having difficulties in adopting the group's social identity may end up being a "scapegoat". As stated earlier, internal group discriminations are a tool for strengthening the group's core by achieving conformity. Due to factors such as groupthink (Janis, 1982), they may be eligible to create black ships or scapegoats to maintain ingroup and outgroup integrity. In exchange for becoming a scapegoat, the individual assumes the group identity based on trust, relinquishing control of power to the group and resulting in behavioural changes (Dyckman & Cutler, 2003; Tanis & Postmes, 2005). In return, the individual receives a kind of empowerment, while the group identity fills the gap of the relinquished identity (Drury, Cocking, Beale, Hanson, & Rapley, 2005).

However, there is a debate about the limitations of social identity theory and the concept of identity. First, there is an issue about the definition of identity, the location and its importance. The definition issue is an issue of semantics (Korte, 2007). The argument resides within the details of its construction from the fields of anthropology, sociology and psychology. Specifically, anthropology regards identity as a result of culture, sociology accepts identity as the set of social roles, and psychology defines identity as a set of norms (Stets & Burke, 2000). The second issue about location refers to the dynamic process and relationship of the individual and group. There is no agreement in approaches considering group-level phenomena. There is a tendency to either locate social identity in the individual or into the group identity (Jenkins R. , 2004). However, the important fact is the interaction between the individual and the group (Wenger, 1998). The third issue of importance resides in the problems predicting future behaviour and its use as a lens to examine social, organisational phenomena. On the one hand, social identity theory explains past individual behaviour in social settings but not in a satisfactory manner to provide chances to predict future behaviour (Hogg & McGarthy, 1990). On the other hand, the concept of social identity is used in many different disciplines and too broadly to set limits (Pratt, 2003).

What is of interest to this thesis is that Korte (2007, p. 172) discussed implications about training in an organisation based on social identity theory. “Groups are not only instrumental in executing organisational functions and processes, they are influential at enabling and constraining the motivations and commitments of individual members […] The importance of social identity theory for training in organisations stems from the insights about individual behaviour in groups and the group dynamics that affect individual learning and performance in organisations”. The insights provided from his work are that (a) social identity theory may explain the change in the training process, (b) social identity demonstrates the influence of the individual's workgroup, (c) social identity constitute a lens through which individuals perceive the reality of the organisational context. Finally, he suggests that any intervention aiming at an organisational or individual level should focus its attention on the group level to avoid failure.

Beyond the group and individualistic prospects, safety events pose as an ultimate price the loss of human life. Furthermore, the aviation environment is comprised of a variety of crew and teams, which indicates that many aspects of social behaviour are present. The basic concern linked with high-risk industries is the individual mortality on his/her sense of self and social behaviour (Arndt & Vess, 2008). The actors in safety events, such as first-line operators, first responders and emergency personnel, are supposed to manage the detrimental consequences at hand and carry out all their tasks. Terror Management Theory (TMT) explains this management process by highlighting the actions of individuals when serious consequences become salient and generate fear (Becker, 1973; Greenberg & Arndt, 2012). When an individual comprehends mortality as inevitable, any cognitive or social schemas reach an impasse as nature's constraint becomes evident. However, this pressure of awareness affects how one may manage risk and communicate it since he/she engages in anxiety-buffering actions to repress that knowledge and pursuit escape and meaning (Mann & Wolfe, 2016).

A practical example of the reason TMT is related to risk communication is that individuals may communicate information in a variety of ways, either misinforming or disinforming themselves or others, by ignoring or omitting hazardous cues and signals, especially when they try to manage their fears in the face of salient mortality (Martin & Kamins, 2010). Taken altogether, it is evident that some individuals may find refuge either by creating a personal worldview where distress of mortality can be alleviated temporarily during a safety event through rationalisation or by structuring reality as stable to satisfy the need for structure, nevertheless remaining unambiguous (Arndt & Vess, 2008). The related concepts to TMT, which may affect risk communication, are as follows (Rodriguez, Avtgis, & Liberman, 2016):

1. Self-Efficacy is responsible for low levels of distress caused by high-risk situations.

2. Self-Esteem is responsible for rationalising fear generated by the possibility of death.

3. One's Worldview is responsible for grouping the individual's perception of the rules set by the groups he/she identifies with.

2.5.6. Risk Communication Short Summary

The risk communication field may hold insurmountable difficulties. However, to educate stakeholders about risks, an initial approach is to apply a grounded training methodology (Chatzi, Martin, Bates, & Murray, 2019). Undoubtedly, people differ in the way they view the world no matter the level of experience—however, commonalities, as broad as they can, always exist. For the sake of risk communication, the risk communicator has to be able to counter more adversities than just people's bias. For this cause, risk research may amplify the results with further quantitative and qualitative results. Cultivating trust, deepening risk perspectives, and contributing by discussing experience may further amplify risk communication results. Crisis communication may aid risk communication since they share the common context of imminent or ongoing safety event by offering insight and practical solutions, such as key factors that affect risk perception and communication. Adjacent, communication has an additional social facet since the operator is also influenced by his/her outside-work social life. This issue diversifies the ways of communication among the contexts the operator socialises. Nevertheless, the current SAIMs provide basic guidelines to manage risk communication, with ambivalent effectiveness. Finally, interacting about risk and trying to communicate an imminent hazard has to do with the operator's social identity and the self-cope mechanisms of mortality.

2.6. The Risk from the Operators' Perspective

Above and beyond procedures, models, conceptual frameworks and policies, lies the human element. The approach of this thesis has the human operator or end-user at its core. Human-made systems are unique structures that represent the wisdom and care of their creators (Makridakis, 2017). Based on that logic, the creation reflects the virtues and flaws of its manufacturer, which extends to the end-user as well. As an exception, Artificial Intelligence (AI) could stand out in conceptual framework as it is more than a mere reflection of its programmer, but also a self-learning actor or regulator in some instances (Mariarosaria & Floridi, 2018). As such, risk perception and risk communication from the operator's perspective is equally important to the other systemic elements as a point of examination.

It is a fact that 70-80% of accidents are due to human factors (Wolfe, 1979; Reid, 2000). This indicates the importance of the operator (e.g., pilot, cabin crew, air traffic controller, land crew). Both authors with 20 years of difference, Wolfe (1979) and Reid (2000), focus on a specific personality type that may be safe "enough". The American Psychological Association (2015) defines personality as the "enduring configuration of characteristics and behaviour that comprises an individual's unique adjustment to life, including major traits, interests, drives, values, self-concept, abilities, and emotional patterns". Personality is envisaged as a complex, dynamic integration or totality shaped by many forces, including hereditary and constitutional tendencies; physical maturation; early training; identification with significant individuals and groups; culturally conditioned values and roles; and critical experiences and relationships. Various theories explain the structure and development of personality in different ways, but all agree that personality helps determine behaviour" (American Psychological Association, 2015, p. 782).

Throughout the history of psychology, there have been many diverse approaches to personality. The primary approaches in personality theories are the psychodynamic approach, the trait approach, the learning approach, the humanistic approach, the cognitive approach, and the biological approach (Corr & Matthews, 2009) (Table 2-6). The value of personality for the aviation context is depicted from hiring and maintaining the appropriate personnel. According to Stabile (2002), who studied the benefit of using personality tests as hiring tools, personality tests relate to job performance by predicting it. However, Stabile (2002) stresses that much of their use may be irregular or irrelevant to their original purpose. For example, Stabile (2002) suggested that the Minnesota Multiphasic Personality Inventory – 2 (MMPI – 2), which Hellenic Aeromedical Centre uses for the mental evaluation of new pilots, ATCs, is initially purposed for clinical psychologists to test for personality disorders. Nonetheless, the MMPI and later version MMPI – 2 have been established for personnel selection in contexts that involve high levels of stress and responsibility (Butcher, 1994; Stabile, 2002).

Table 2-6: Major Approaches Personality Theories (Corr & Matthews, 2009)

Major Approaches to personality		
Approach	Major concepts	Contributors
Biological	temperament, evolution, adaptation, altruism, sexual jealousy, heredity, neurotransmitter pathways, cerebral hemisphere function	D. Buss, Eysenck, J. A. Gray, C. R. Cloninger, Kagan
Cognitive	expectancy, self-efficacy, outcome expectation, schema, cognitive person variable, personal construct, reciprocal determinism, modelling, constructive alternativism, life narrative	Mischel, Bandura, Kelly, Beck
Humanistic	self-actualisation, creativity, flow, spirituality, personal responsibility, freedom, choice, openness to experience, unconditional positive regard, acceptance, empathy, real self, the	Maslow, Rogers, Seligman, Csikszentmihalyi

Major Approaches to personality		
Approach	Major concepts	Contributors
	hierarchy of needs, peak experience, positive psychology	
Learning	reinforcement, punishment, stimulus, response, conditioning, extinction, shaping, discrimination learning, generalisation, situation, act frequency, basic behavioural repertoire, labelling, gradients of approach and avoidance	Skinner, Staats, Dollard and Miller
Psychodynamic	libido, conflict, id, ego, superego, defence mechanisms, Oedipal conflict, fixation, repression, attachment, object-relations	Freud, Jung, Adler, Erikson, Horney, Klein, Sullivan, Chodorow, Westen, Kohut, Kernberg
Trait	trait, type, facet, factors, Neuroticism/ Emotional Stability, Extraversion	Allport, Cattell, McCrae and Costa

Another approach to personality is that of the 'Big Five' model. The 'Big 5 model' can be traced in the work of Costa and McCrae (1985), who created it from Cattell's (1979) 16 principal factors. It consists of the dimensions of neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness. Neuroticism reflects negative behaviours, such as anxiety or hostility. Extraversion represents the quantity and intensity of interpersonal interactions. Agreeableness expresses one's spectrum from empathy to hostility. Finally, conscientiousness is described as the continuous drive towards goal-directed behaviours. For example, according to Fitzgibbons et al. (2000), the NEO-PI-R personality inventory, based on the 'Big Five' model, provided a pilot personality profile. After a qualitative analysis of the trends noticed after 93 filled NEO-PI-R tests by pilots, the authors suggested a mosaic of traits describing pilot personality as emotionally stable, low in anxiety, vulnerability, hostility, impulsiveness, depression, highly conscientious, trusting and straightforward, with a high level of assertiveness.

Additionally, Stabile (2002) stressed all possible disadvantages that personality tests might have. First, she questioned their effectiveness because personality tests target job performance traits, while this is a situational-specific context. This assumption is based on the notion that personality tendencies are not transferable from one environment to another (Black K. R., 1994). Additionally, motivation cannot be situationally depicted (Stephen & Zimmerer, 1988). A second concern Stabile suggests is that administration may depend on the researcher or clinician supervising the administration. A third argument she stated is that personality tests may be cheated. Fourth, "to the extent that personality inventories are looking for mainstream personality types, essentially testing for conformity, creative persons who may potentially become leaders and do extraordinary things for an employer may be weeded out" (p. 297).

The debate about the ability to predict behaviour from personality derives from the work of Walter Mischel (1968). After examining the relationships among personality traits and actual behaviour in specific situations, he found an average correlation of r=.30 - .40. Hence, he argued that a single personality trait accounts for 9 – 16% of the variance in behaviour within specific situations, while the behaviour may cause an ovary over personal dispositions in complex real-world situations. However, his reasoning assumes a simplistic model of personality, where a single personality trait is used to predict a specific behaviour in a specific situation. The prospect of studying personality traits is to predict a sum of one's behavioural tendencies in multiple situations across time.

Additionally, although situations may dictate behaviour, people maintain a degree of consistency. Also, the value of r=.30 - .40 rates from 'weak' to 'moderate' (Owen, 2017), is not unimportant, as Mischel argued. According to Fleeson's (2004) and Funder's (2009) reviews, the debate of persons, behaviours, and situations is essentially over, and personality psychology should move on empirically testing behaviour in the same research paradigm. All sides are partially right, traits are not dictating a strict behavioural pattern, but they preserve a congruence through long time intervals, explaining individual differences.

In general, personality theories and personality testing are an indispensable part of aviation history due to their high risk and high stress-inducing nature (Butcher, 1994). Since the beginning of aviation, pilots were discriminately the most investigated group within this context. However, there are very few references to personality studies. Dunlap (1918), first studied the United States Air Force (USAF) pilots' personalities. For Dunlap, a successful pilot is impulsive to match his/her reaction in a highly changing environment. Another interesting trait of that study is that he refers to assessment processes assessing cognitive performance, stimuli reaction time, and coordination. Next year, Anderson (1919) referred to pilots a having a special flying temperament, absence of fear, and great overcompensation skills. Birley (1920) focused on cognitive processes, and especially on decision making speed. Many years later, Reinhardt (1970), highlighted excellence because of high self-esteem, great wish for challenges, limited scope for self-examination, and wish to keep an emotional distance from others. Later, Novello and Youssef (1974) studied men and women of the US Navy Airforce and found low levels of diversity in personality traits. Retzlaff and Gilbertini (1987) examined 350 USAF pilots undergoing Undergraduate Pilot Training with the Personality Research Form (PRF) and the Millon Clinical Multiaxial Inventory (MCMI) within the first four weeks of training. Cluster analyses suggested that there are three personality types; (a) achievement-oriented (58%), (b) fighter representative type (21%), and (c) fighter non-representative type (21%).

Type A pilots were focused on problem solving and companionship. Type B pilots were aggressive, impulsive, resilient in combat, and pompous. Type C pilots had mostly compulsive traits and were too careful. Reinhardt (1966) believed that Type C would be the best pilots, given they are intelligent, reliable, and safety-oriented. However, Strongin (1987) warned that type C aviation personnel might be susceptible to performance anxiety and procrastination. This was confirmed by Jenkins and Baggett (1992), arguing that type C personnel may create issues in-flight safety. Jenkins and Baggett (1992) study is a case report of a male naval aviator who demonstrated a compulsive personality trait that adversely affected his duties as a pilot trainee and, later, as a naval flight officer. After reviewing DSM-III-R's terminologies of personality disorder and anxiety disorder as sub-categories of obsessive-compulsive, this study suggested that both are incompatible with safety behaviour.

Additionally, it is noted that obsessive-compulsive personality describes a set of behaviours where useful, adaptive compulsive traits may become abnormally exaggerated and maladaptive, thus interfering with the aviator's usual routine, occupational functioning, relationships with others, and aviation safety. However, the three pilot clusters failed to prove criterion validity concerning training success and duration of actual fighting service in a ten-year follow-up (Retzlaff, King, & Callister, 1995). Regardless of the efforts of psychometric tools in the acquisition of personnel, there is not a tool specifying and measuring risk perception and risk communication per se, but a spherical and generic approach based on unstandardized approaches, since not all organisations and authorities use the same psychometric tools and assessment processes.

2.6.1. Pilots

Concerning pilots, effective risk perception may calibrate effective decision making while averting risk behaviour (Reason, 2016, p. 73). For pilots, two primary sources of misperception are to be constantly managed, human-environmental limitations and subjectivity. The term 'limitation' aims at configuring all these situations and contexts where either the human physiology exceeds its limits, or the environmental cues are highly variant. Cases of human limitations can be illusions, the gravity effect or sensory outage (Previc & Ercoline, 2000; Gibb, Ercoline, & Scharff, 2011; Moriarty, 2015). The management of these sources is distributed to acquire reliable data from flight instruments and external data sources such as other crewmembers, ATC, and official documents (i.e. checklists) (Moriarty, 2015). During the manual flight, pilots follow perceptions instinctively, based on previous learning, similarly to most operators in the context of operation (Lindsay & Norman, 2013). Second, pilots may tolerate risk based on subjective data either because they account that the consequences are irrelevant to them (Hunter, 2002), or due to the propensity to exploit the opportunity for gain or avoid loss (Pauley, O' Hare, & Wiggins, 2008). Third, a pilot's training sets the standard baseline on which previous knowledge and risk tolerance will be regulated as per taught experience, learning style, and program orientation (Hong, Lee, Seol, & Young, 2016).

2.6.2. Maintenance Personnel (MP)

Concerning MP, errors of perception, in general, are defined as a failure to detect a critical item that the operator should have been capable of perceiving (Hobbs, 2008). For the present sub-context of maintenance, the critical item may be a worn part, a crack on a structure, moving heavy parts and hazardous materials (Kim & Song, 2016). Moreover, since risk perception is based on the operator's or organization's assumption for a given situation, this may lead MP to tolerate risk due to a wrong understanding of the situation falsely, time pressure, lack of communication, and fatigue (Hobbs, 2008; Kim & Song, 2016; Chionis & Karanikas, 2018). Additional factors are complacency, lack of knowledge and teamwork, stress, and distraction (Transport Canada, 2017). It is worth highlighting that the mentions found in literature concerning risk perception are through erratic behaviour and not normative behaviour for the particular group. '(In)Correct' actions have been related to the accuracy of risk perception (Reason, 2016, p. 73). This perspective may lead to a vicious cycle when studying risk perception since, according to probabilistic risk management, human error is considered one of the risks (Latorella & Prabhu, 2000).

2.6.3. Air Traffic Controllers (ATCs)

The role of ATCs is unprecedently rivalled with daily high-risk situations and a workload dedicated to gradually increasing (ICAO, 2018). For this reason, risk management is one of the highest priorities. Like other operators of the aviation context, ATCs confront multiple risk factors that may add to their high workload, such as monitoring under time pressure and being in an inadequate psychophysiological state (Averty, Collet, Dittmar, Athènes, & Vernet-Maury, 2004). These factors are highlighted due to the implications to decision-making under pressure which may detriment the ATCs' risk perception, such as adequately judging air-traffic conflicts in terms of detection and resolution (Fothergill & Neal, 2008; Mulder, 2010). A recollection of these factors can be grouped as clusters of fatigue sourcing, environmental sourcing, and personality sourcing. From a comprehensive approach, the fatigue cluster includes the cases of working after inadequate sleep, trying to work against the circadian biological clock, and the duty period duration and workload (Gander, 2001). One of the first examples of fatigues influence are attention and memory failures (Shorrock, 2007).

Following, the environmental cluster includes organisational and broad environmental situations affecting ATCs' risk perception. Specifically, the communication field in Air Traffic Management (ATM) is quite condensed. The airspace is organized in the Upper Space (ACC-Area Control Centre), and the Lower Space (TMA - Terminal Maneuvering Area, APP - Approach Control, TWR - Tower Control) and communication should be available to coordinate traffic, the equipment should be capable of bearing the workload, and the established policies should facilitate safe functionality (Mulder, 2010). Finally, the personality cluster has been concerned about personality traits that affect performance. Research on ATC's personality has been attributed to the unified theoretical concept that the 'Big Five' taxonomy provided (Luuk, Luuk, & Aluoja, 2009). According to Luuk et al. (2009), the emotional facets of the Extroversion dimension from the NEO-PI (Costa & McCrae, 2008) is a valid and valuable negative predictor for performance over and above cognitive ability level. However, as the previous study warns, these results might vary among countries, workload size, and unique traits of each ATC. These results have also been confirmed and enriched recently. A unified model of personality, workload and theories about affection revealed that the difficulties of ATM directly influence cognitive workload and self-reported mood independently, while the Neuroticism dimension of NEO-PI affected both mood and performance (Truschzinski, Betella, Brunnett, & Verschure, 2018).

2.6.4. Cabin Crew (CC)

The CC service is considered one of the factors of the level-of-service/comfort in air transportation and a significant factor in deciding among flight alternatives (Wen & Lai, 2010). CC or flight attendants have been understudied in multiple facets, although they are sustaining exposure to ionising radiation, circadian rhythm disruptions, poor air quality, hypoxia, high levels of noise and vibrations, and even verbal and sexual harassment (McNeely, Mordukhovich, Tideman, Gale, & Coull, 2018). The main focus of investigation regarding CC has been concerned with health adverse related factors (Griffiths & Powell, 2012; Damos, Boyett, & Gibbs, 2013). The CC's safety duties include all the actions necessary for the passengers' safety (e.g., passengers are seated and fastened, service items are appropriately stowed, in the case of injury or illness, the CC will act as a first responder) (USA Department of Labor: Bureau of Labor Statistics, 2018). Based on the above and the lack of specific literature, the assumption is that CC's risk perception is mainly concerned about their interactions with passengers, the flight crew, and the cabin environment. This conceptualised interactive context represents an indication that their risk perception is majorly based on risk communication.

2.6.5. Artificial Intelligence Operators

Concerning non-humane operators, earlier it was mentioned that Industry 4.0 had entailed an era where AI and automation interact with human operators more than ever. As a result, new demands for communication have emerged and potential risks (Brocal & Sebastián, 2015; Badri, Boudreau-Trudel, & Saâdeddine Souissid, 2018). AI has already been applied as in automation used in flight management systems (FMS) and autopilot (Moir & Seabridge, 2003;

Sherry, Fennell, Feary, & Polson, 2006). Nonetheless, AI has to demonstrate interoperability and coordinate to support a human-centric system (Billings, 2018). The issue arises when late AI performs by imitating complex human behaviours through overcomplications (i.e. 'on-off' cognitive components) (Ramachandran, 2012, p. 127). Predominantly, controlled flight into terrain (CFIT) and loss of control are attributed to human factors (Kharoufah, Murray, Baxter, & Wild, 2018). One answer to these problems has been to exchange human operators in sensitive positions, since automaticity may excel in performing an error-free operation, regardless of the operation context (Haight & Caringi, 2007; Woods, Dekker, Cook, Johannesen, & Sarter, 2017).

Still, the limits of choosing between best performers (i.e. AI vs Human Operators) are stranded on a thin line for the modern flight deck design and other operational frameworks (Kaber D. B., 2018). Based on the principle that AI is yet evolving before becoming independent (Lu, Li, Chen, Kim, & Serikawa, 2018), the remaining interactions are a matter of communication among the operator and the system. According to a study on Unmanned Aviation Systems (UAVs), AI's capacity is predetermined to fit the initially designed system it will operate into, defining its perceptive capabilities into monitoring capability (MC) and flight capability (FC) (Schirmer, Torens, Nikodem, & Dauer, 2018). Not to mention, there is a highly positive connection between operators' complacency to automation (Brown, 2016). Moreover, the evolution of AI among generations has shown that it has reached from rule-driven reasoning (Ertel, 2018), to Big Data learning (Ossai, 2017; Syeda-Mahmood, 2018), to Analytical Awareness (Huang & Rust, 2018), until Contextual Awareness (Cavaliere, Senatore, & Loia, 2018) in multiple fields which in practice mandate close enough to the aviation context, requirements from their operators. In terms of aviation software and hardware, the contribution of AI began with autopilot systems during the '30s (Scheck, 2017), GPS navigation software (Houston, 2018), continued to analysis and prediction of passenger behaviour (Chen, Huang, Chen, Zhong, & Cheng, 2017), to haul damage detection

(Dworakowski, Dragan, & Stepinski, 2016), until self-flying planes and autonomous in-flight services until outer space missions (Milligan, et al., 2018).

From an additional point of view, AI's capacity for risk perception and communication is not at all negligible. In terms of perceived risk, AI is yet limited to a single frame or type of problem according to its algorithm restrictions (Liu, Yang, Zio, & Chen, 2018). Similarly, AI cannot associate symbols with their meanings (Burgess, 2018). Nonetheless, AI can generate text representing voice sequences with meaning (LeCun, Bengio, & Hinton, 2015). Next, although AI depends on bulk numerical data and presumably lacks the human association capacity, AI is also rooted in deep learning and reinforcement learning (Hassabis, Kumaran, Summerfield, & Botvinick, 2017). Moreover, speech recognition is an emerging trend and aims to transcribe human communication and convert it into an appropriate format for AI to understand and vice versa (Felix, Kumar, & Veeramuthu, 2018). Finally, the critical role of AI is depicted in its involvement in the industry; for example, the most common association of AI is with virtual/augmented reality applications and devices used in 3D simulations, customer service, and generic operational support (i.e. customers, end-users, management-level operators) (Bellamy, 2017; Pal, 2018; Abed, 2018; Apple Inc., 2018). Furthermore, along with the developments in the information communication technology, AI-based methods (i.e. decision trees, neural network) contribute to the total spectrum of decision making, with the same possible implications on risk perception as well (Lin, Lin, & Yang, 2017; Camilli-Gay, 2018).

2.7. Strategic Communication

Strategic Communication (StratCom) is the holistic and purposeful use of communication for an organisation to fulfil its mission; thus, as strategic is considered the communication when it is vital for the organisation's development and survival (Thomas & Stephens, 2015; Zerfass, Verčič, Nothhaft, & Werder, 2018). Also, StratCom are formatively analysed and put into practice through evaluation models, that show the targeted result for which audience, and what/whose interests that assists (Macnamara, 2018). In addition, StratCom is more than public relations, marketing, public affairs or crisis management, but it rather is a strategic approach to legitimately communicate to internal and external stakeholders an organisation's mission, such as environmental legitimacy (Allen, 2016).

Furthermore, StratCom means to instrumentalise communication channels and interventions to promote or transform organisational culture (Thornton, Mansi, Carramenha, & Cappellano, 2019). StratCom choices are based on the organisational context, the communicators' and their recipients' perceptions; thus, an intervention bringing change for an organisation must be meaningful, use a viable communication network, and process effective communication (Lewis, 2019). In this vein, although StratCom is being criticized as episodic in nature, antecedent regulatory moves are need for a long-term effect (Maor, 2020). For example, today's information-inflated digital environment demands polyphony to address multiple audiences within a single communication, reaching even at the micro-level (Palmieri & Mazzali-Lurati, 2021). Therefore, the notion of "strategic corporal" is inherently implemented, as the individual expected to be technically proficient and command responsible, regardless the organisational level due to today's pervasiveness of communication media (Liddy, 2004). Nonetheless, to the author's knowledge there is rather limited research and explicit integration of StratCom into safety research.

2.8. Interventions

The improvement of safety behaviours in the aviation industry depends on evidence-based practices. The practice of safety during operations is inflicted from the generic situation of an evolving work paradigm, sustaining, for example, more significant fragmentation of work and isolation of end-users from each other, limited social contact among operations in different levels, reduced union representation and involvement, less worker participation in work-places, greater managerial control of operation processes, and fewer resources for inspectorates to visit first-line operators (Glendon, Clarke, & McKenna, 2006). As such, behavioural approaches aiming at change can also be repurposed as behavioural interventions favouring safety. Organisational behaviour management (OBM) has evolved as the applied branch of behavioural science to individuals and groups in the industry, including many sub-disciplines such as Behaviour-based safety (BBS) (Wilder, Austin, & Casella, 2009). BBS and its derivative safety behaviour interventions aim to reduce erroneous or risk intolerable behaviour patterns, which may result in injuries while reinforcing safe performance (Wilder, Austin, & Casella, 2009). These patterns are materialised either through actions of smaller or larger significance (e.g. errors of omission and abuse of drugs during working hours). Interventions are delivered through regular, deliberate training, practice, and example, promoting the optimal application of standard operating procedures (SOPs). Evidence of these behavioural modifications can be measured through the progress of inexperienced personnel on their duties. However, due to multiple factors, these interventions are not always entirely or at all successful.

The procedure of applying a behavioural modification or intervention to inexperienced and experienced adolescent personnel differs. The multiplication of individuality of heightened sensitivity to feelings of status and respect is one probable causes an intervention might fail (Yeager, Dahl, & Dweck, 2017). For example, an intervention may aim to change pilots' attitudes towards the factors they consider when calculating weather limitations. To this end, the application of this intervention may lead to the deduction that a focus groups intervention is the most appropriate. On the other hand, one may take a stricter approach and impose financial penalties or even fire a pilot under inappropriate behaviours. It is not uncommon for a supervisor to intervene individually or in a group based on his/her experience, his/her communication competence, and common-sense behavioural models (Michie, Fixsen, Grimshaw, & Eccles, 2009).

Additionally, applying one or more models may not be proven sufficient since the full spectrum of variables cannot be assessed. As an example, the most often used Theory of Planned Behaviour may not include variables such as impulsivity, habit, self-control, associative learning, and emotional processing (Michie, van Stralen, & West, 2011). Glendon et al. (2006) represent an excellent generic source for those who want to get a holistic view on human safety and risk management, nonetheless this thesis supports that a behavioural intervention (i.e. behavioural safety program) can cause changes in aviation organisations of various sizes in favour of safety and that the generation of a model based on a mixed-methods approach and a pragmatist paradigm can go beyond the dilemmas posed by the psychometric and the pragmatist paradigms (quantitative versus qualitative approaches). The real issue resides with the variability of cultures and organisations, effects of technology and policy-making, and the gaps of WaI/RaI vs WaD/RaD[3], which goes beyond a simplistic and blur statement of 'fixing the safety culture'.

Safety researchers and practitioners who aim to apply and preserve a safety culture can face several challenges, as described in more detail in the next section:

i. A massive set of theories deriving from multiple fields. Some of these theories and fields may also compete with each other, making knowledge highly fragmented.

ii. A high demand for diverse strategies of application due to environmental, organisational and specific case related inputs.

iii. A highly integrated and collective academic background is also built with practical knowledge.

iv. A constant demand for being capable of delivering safety suggestions, which will be able to interpret socio-cognitive systems' operations.

Safety culture has a unifying meaning among individuals' collective organisational and interorganisational practices, which in turn, aim at protecting both individuals and their

[3] WaI: Work as Imagined, WaD: Work as Done, RaI: Risk as Imagined, RaD: Risk as Deployed

environment (Gherardi & Nicolini, 2000). From a behavioural approach, safety culture could also be defined as a set of conditioned behaviours that aim (in)directly to safety (Reason, 2016). However, there is an abundance of other sub-cultures within an organisational culture, which could be menacing towards safety culture. For example, learned helplessness describes situations when individuals accept that their attempts to change a condition are vain and they give in, while anxiety-avoidance dictates an organisation to repeat a diffusion practice regardless of its actual effectiveness (Reason, 2016). Indeed, learned helplessness is a barrier against pro-environmental concerns, and most importantly, against pro-environmental actions (Landry, Gifford, Milfont, Weeks, & Arnocky, 2018). Concerning anxiety-avoidance behaviours, behaviours are either motivated by appetitive or aversive stimuli, where the latter may lead to pure avoidance and escape or behavioural inhibition brought by the uncovering of goal conflict (Corr, 2013). Consequently, safety behavioural sets may shape the organisational culture by either urging for (in)action or inhibiting action while preserving temporal motivation.

Moreover, safety culture comprises five elements (Reason, 2016), which dictate the aforementioned behavioural sets. First, the managerial and operational level of the organisation is needed to have updated knowledge about the human, technical, organisational and environmental factors determining the total safety, meaning an ***informed*** culture. Second, an informed culture is based on a ***reporting*** culture in which all personnel are eager to report errors and near-misses. Third, personnel should trust the organisation to foster a reporting system based on a pre-set boundary between error and violation, meaning a ***just*** culture. Fourth, an organisation needs to possess flexibility and adaptability during a crisis, as expressed by the bilateral exchange of mode of operation (e.g., bureaucratic hierarchy to a group of experts and vice versa), meaning a ***flexible*** culture. Lastly, an organisation should adapt and reform based on lessons learned; to possess a *learning* culture. Since accidents happen during systemic malfunctions and are not only due to human error (Patterson & Deutsch, 2015), these elements of safety culture can also be culpable. For example, a definitive perception that an organisation's risk management is robust enough may lead to higher risk tolerance or an overestimation of capabilities, similar to the situation where inaccurate risk perception may lead to inaccurate risk tolerance (Hunter, 2002).

From a general perspective, OBM dictates a certain series of basic steps that each practitioner should follow, regardless of problem, setting and intervention (Austin & Mawhinney, 2005). Nevertheless, high-risk industries such as aviation include many specific additional features which may deem that omnipotent trait of OBM somewhat inapplicable. For that specific reason, other fields commemorate the application of aviation safety as exemplary for them to follow. For example, although health care has a constantly higher level of accidents leans towards having a rather reactive culture than systematic management of patient risks (Hudson, 2003). The main background of an OBM case is depicted thoroughly by Wilder et al. (2009) as follows:

1. The researcher and the stakeholders decide and determine the key results.
2. In collaboration with the stakeholders, the researcher determines the important behaviour and intermediate results ("pinpoints") required to reach the key results.
3. The researcher should provide a measurement system to assess the baseline and the change of behaviour from it during the intervention.
4. The researcher diagnoses the issues through the stakeholders' observations concerning potential causes for the issues.
5. The researcher develops and implements a solution responding to the identified deficiencies.
6. The researcher evaluates the effects by applying measurements before, during, and after implementation. This step aims at retrieving at least behaviour change results, intervention acceptability, and cost-benefit results.

Within the context of an aviation organisation, change of behaviour can be succeeded in many ways. One way is through managerial means such as punishment or rewards. It has been conceded that behaviour-based safety programs' effectiveness depends on goal commitment, punishment, and monetary incentive (Guo, Goh, & Wong, 2018). Goal commitment has been set in a theoretical framework where five key drivers should be pursued during the goal-setting process (Liccione, 2009):

1. Measurability (M): Goals are measured by their clarity of meeting the expectations of individuals and groups of individuals at various levels. They can either exceed expectations, match them, or fall short of them. Clarity does not represent numeric values per se. In other words, measurable targets are reflected by reliable and presentable evidence. An example of exacting measurability is the "SMART" framework. Goal-setting with SMART is meant to be ***S***pecific, ***M***easurable, ***A***ttainable, ***R***ealistic, and ***T***ime-bound. SMART is a multidisciplinary framework with a wide application (Li, Tancredi, Co, & West, 2010; Bounds, et al., 2013; Webb, et al., 2014). SMART as a framework has also been reported to have been extended to "SMARTER", further including ***E***thical and ***R***esearch-based (Wade, 2009).

2. Performance Range (PR): The range of performance includes the target performance according to the minimax criteria of the job description, the tolerable failures, and the optimum achievable level of performance. Formal and informal relationships may influence employee performance from all organisational levels through employee interaction and diffusion of (non)work-related information (Cai, Wang, Cui, & Stanley, 2018). From another perspective, organisations are responsible for adjusting their measurement of the performance range, which may result in improved employee engagement and performance (Smith & Bititci, 2017). Additionally, performance management is the application of organisational routines on the performance measurement system to manage performance (Bititci, 2015). In that aspect, the performance range possesses a technical dimension (measurement) and a social dimension (management) (Smith & Bititci, 2017). Additionally,

performance is mediated by vigour and moderated by self-efficacy (Hador, 2016). As vigour can be defined as the feeling of possessing intensified physical, emotional and cognitive aptitude (van den Broeck, de Cuyper, de Witte, & Vansteenkiste, 2010), where vigour has been associated with increased performance (Carmeli, Hador, Waldman, & Rupp, 2009). Self-efficacy has been defined as an individual's evaluation of personal capacity to be motivated, to mobilise cognitive resources, and actions mandated to cope with situational demands (Bandura, 1986). Moreover, self-efficacy has been linked with anxiety-mitigating effects, which in turn generates adequate performance at the extent of tolerable behaviours (de Clercq, Haq, & Azeem, 2018). It may be enhanced by assigning more prominent roles or enlarging existing ones, and providing coaching and training (Parker, 1998).

3. Consistency with Job Responsibilities (C): The goals are shared between employer and employee, crew leader and members of the crew in the sense that the latter may be held accountable for a tasked goal they have a veridical impact. The workplace relationship and its accompanying knowledge and resources constitute an interactive framework among teams of the same and different levels (Uen, Chien, & Yen, 2009). The psychological contract perspective also reflects consistency. The psychological contract includes a holistic perspective of the individuals' beliefs shaped by the interaction between individuals and their organisations (Rousseau, 1995; Persson & Wasieleski, 2015). In other words, the psychological contract can explain the consistency with job responsibilities by analysing how cognitive, emotional, and relational processes affect employee engagement (Persson & Wasieleski, 2015). Additionally, the consistency of goals may be influenced by job satisfaction since the latter mediates the learning goal orientation occupational withdrawal intentions and behaviours (Sims & Boytell, 2015). By definition, consistency with job responsibilities refers to a driver of employee engagement framed as the complex expression of a job description (Kahn, 1990; Ruban, 2018).

4. Attainability (A): The manner the employers and employees envisage and account for their capacity (e.g., knowledge, skills, and abilities) towards the goal regulates their

willingness to accomplish the goal. Their mode of thinking about the envisaged goal and its perceived feasibility will also affect goal commitment (Oettingen, 2000). It is suggested that range goals foster goal commitment because they are more attainable and more challenging than specific goals (Scott & Nowlis, 2013). Goals should be set high enough, aiming at the most effective performance, but they should be achievable to avoid losing motivation, dishonesty, and rule shortcuts (Monahan, 2018). The goal's attainability limit is regulated by the individual's capacity to respond, accompanying capabilities, and self-efficacy (Lunenburg, 2011).

5. Concept Clarity (CL): The complexity of the link between incentive awards and performance must be defined as straightforward as possible to ensure that employees will understand and commit to the behaviour expected of them. Clarity on goal-setting provides better results than encouragement, enhanced effort, enhanced persistence, and stimulated learning, although slightly related to biases such as tunnel vision (Anderson & Stritch, 2015). Goal clarity affects team performance positively alongside self-management (van der Hoek, Groeneveld, & Kuipers, 2016).

Moreover, since goal-commitment is framed by self-efficacy beliefs (Oettingen, Sevincer, & Gollwitzer, 2008), cultural differences can influence goal-commitment. Cultural differences may be differentiated as per a continuum of dimensions (individualism/collectivism, large/small power differential, strong/weak uncertainty avoidance) (Hofstede, 2001). For example, individuals descending from collectivist cultures value conformity and mutual commitment to their group, while individualist cultures emphasise personal success, distinctiveness, and control (Kim & Markus, 1999; Oyserman, Coon, & Kemmelmeier, 2002; Triandis, 2018). As such, low efficacy beliefs are associated with the upper levels of the continuum (collectivism, large power differential, strong uncertainty avoidance), indicating a more substantial influence on authorities' performance evaluations. In contrast, the opposite stands for the lower levels of the continuum (Oettingen, Sevincer, & Gollwitzer, 2008). Based on an analogy, goal commitment can be swayed by an authority’s intrusiveness of performance evaluations and an organisation's personnel's acceptance of that behaviour.

Punishment can be a means of communication with vague and grave consequences regarding safety culture. Concerning the application of behaviour-based safety programs, the reality is no different since punishment links preferably on focusing on individuals to attribute blame. For example, behaviour-based safety programs [e.g., DuPont’s STOP (DuPont Sustainable Solutions, 2018) aim at promoting safe behaviour to the point where there can be associations with management’s punitive actions (Hopkins, 2006). These punitive actions mainly derive from isolating individuals with repeatedly reported unsafe behaviour (Hopkins, 2006). From the aspect of reporting culture, punishment instead leads to inhibition and disclosure of valuable information, which could prevent an accident (Hale & Borys, 2013).

Additionally, organisational life and safety research contrasts since the first rely on power issues, while the latter rests upon a harmonic organisational reality (Antonsen, 2009). Even the notion of the Safety-II perspective (Patterson & Deutsch, 2015), although focusing on systemic success and failures, does not yet cohere the organisational anomalies from the perspective of power and authority. Punishment falls into coercive power (Lukes, 1974), while it is applied to supplement compliance as an alternative to rewards (Antonsen, 2009).

Incentives and rewards constitute courses of action for organisations to compensate for the gap of personal goals of their personnel and corporate goals. According to Maslen and Hopkins (2014), incentive schemes are one way that organisations pursue aligning their personnel's personal interests with organisational goals. There are numerous examples of safety-related incentive schemes (Atkinson, 2004; ITA Group, 2018). Their main aim is to induce or improve preventive measures, such as preventing risks at their source or providing more elaborate training (Elsler, Heyer, Kuhl, & Eeckelaert). Some of these schemes may be one-off prizes, monthly gift vouchers, or even specific risk insurance premiums (Elsler, Heyer, Kuhl, & Eeckelaert; UK HSE, 2012). An early literature review about the feasibility and effectiveness of incentive schemes (Elsler, et al., 2010), has revealed through a narrative case review data coming from the European Agency for Safety and Health at Work that insurance premium and subsidy based schemes can be cost-effective (e.g., positive pay-out ratio), feasible for organisations, and in need for research regarding their qualitative efficiency.

Moreover, incentive schemes are related to accidents from the perspective of value-added activities versus non-value-added activities (Argilés-Bosch, Martí, Monllau, Garcia-Blandón, & Urgell, 2014). The concept of value in economics has been long-claimed as a ratio of exchange between two goods, quantitatively specified (Clark, 1915). From the author's empirical point of view, this exchange should be motivating enough for an individual to pay for. That leads to the fact that the value-added activities of a safety program should address the personnel's desired characteristics and functions. On the other hand, non-value-added activities may consume resources while not contributing to a safety program. In other words, should they have been omitted, no one would notice, and there would also be some benefit. Concerning safety, incentive programs can be rate-based, rewarding operators with the least injuries or illnesses during a pre-set period, and can also be behaviour-based, rewarding operators for reporting near-misses or making safety recommendations (Koczur, et al., 2016). Behaviour-based Safety Incentive Programs (SIPs) should abide by the following minimum requirements (Koczur, et al., 2016):

1. The SIP should be structured in multiple ways to allow individual or group accomplishment recognition, and awards should be flexible.
2. Employee involvement is encouraged in the development of similar programs.
3. Fund obligation should be consistent with financial management and delegations of authority.
4. Justification for awards must be clearly documented.

5. The SIP cannot conflict or violate other regulations.

6. The SIP must be clearly communicated to all employees.

7. Non-monetary awards cannot be costly; they should communicate the organisation's name, logo, values, and mission when appropriate.

8. The SIP must not result in suppressed reporting of incidents, injuries, or illnesses or retaliation for employees reporting.

Moreover, Koczur et al. (2016) provide a list of elements, similar to OBS general instructions, upon which a tailored approach should be designed. The first element is continuous employee (managers, supervisors, operators) participation in all aspects of the SIP through safety committees. The second element is that the SIP must be behaviour-based to actively encourage participants to engage in safety-related activities. The third element is flexibility. Regular adaptation to unique and often changing demands of the employees is mandatory for effectiveness. The fourth element is compliance with the ruling-policy system. Policy changes should be interpreted frequently and openly, so the SIP is up-to-date with the current policies. The fifth element is timeliness to achieve a behavioural association between the aimed behaviour or action and the reward. The sixth element is for the SIP's goals to be SMART, as referred to earlier about goal-setting. Lastly, the seventh element is the freedom of choice of the reward from a pre-set variety to increase employee motivation. Compared to the OBS guidelines, one could suggest that SIPs indeed are an extension or sub-setting of OBS programs since the former follows the same basic structure with the additions of more detailed planning concerning the approach to the targeted audiences, thus the operators.

Another way is through the organisation's evolution and adjustment to new reality and policies. This way includes both change and reform. Through policy change, existing structures make fundamental shifts, or new policies are applied (Bennett & Howlett, 1992). Through policy reform, an attempt is made to improve the performance of existing systems, promising their future efficiency (Berman P. , 1995). However, since policy reform is imbalanced unsure, this review will not delve into that course.

On the contrary, policy change models have a lot to show for. For example, the model of path dependence suggests that an organisation may be institutionalised so that only great cost change could have been applied to preserve policy continuity (Pierson, 2000). Another example is the disruptive innovation model where first, a more beneficial agent to the existing one is introduced, which leads to a less expensive upgrade of the final product (Christensen, Horn, & Johnson, 2008).

What is more, the consistent notion that all the arguments, as mentioned earlier, refer to the individualistic level alone would be inaccurate. The safety approach taken can be pretty confusing in terms of referencing the levels of analysis since it includes all operators from all organisational levels and across disciplines (Tholén, Pousette, & Törner, 2013; Erickson, 2016). Traditionally, the levels of analysis are being used to indicate a research target similar to a lens used in a microscope (Bouvier, 2011). In psychology, there are three levels of analysis; the biological level, the cognitive level, and the sociocultural level (Valsiner & Rosa, 2007; Eysenck & Keane, 2010; Kalat, 2016). In general, levels of analysis in social sciences include even more layers such as the micro-level (i.e. person, family, neighbourhood), the Meso-level (i.e. community, organisation), and the macro-level (i.e. society, global interactions) (Blalock, 1979). Based on the premise that safety is a general consideration during an effectively functioning aviation organisation, the two levels of analysis mentioned earlier, taxonomies overlap in several cases. Practically, this argument explains that whenever there is a reference to the ‘end-user’ or ‘operator’, it marks the last individual to produce an output in the organisation’s functions. For example, an individual belonging to the managerial level is the end-user for producing significant policies for the organisation.

However, the worst-case scenario is for an organisation to change the behaviours of its employees due to a detrimental safety event where human casualty took place (Yoe, 2012). Also, it is not recommended to base policy changes on worst-case scenarios during risk management since it may focus on an unrealistic scenario, where an even worse one can always be imagined while leading to waste of resources and lead to fixation and confirmation bias (Yoe, 2012). In each of these general directions, an aviation organisation has to apply policies and take measures that will change the conditions which create a stagnant situation leading possibly to hazards. As an important observation, it has been indicated that behavioural models differ from general theories of change (van der Linden, 2013).

In the same spirit, various intervention functions (Table 2-7) could be applied as remedial actions, depending on the safety professional’s training and experience to conduct the intervention (Chandwick, 2018). However, there is no systematic connection among safety behaviour interventions in the aviation industry solely aiming for risk perception and communication. It is more likely to meet holistic approaches aiming to develop an aviation organisation's safety culture in general or the case of an organisation that applies remedial measures after a safety event. The context and aim of this section literature review reside on understanding the change of behaviour and not only model behaviour under the lens of risk perception. Based on the premise of examining behavioural change, this literature review investigates the relevant theoretical, applied approaches to the phenomenon as mentioned earlier by short-listing them and conclude with a suggestion of which one would be more effective and applicable to the aviation context.

Table 2-7: Intervention Functions (Michie, Atkins, & West, 2014; Chandwick, 2018)

Intervention Function	Definition
Education	Increasing knowledge or understanding
Persuasion	Using communication to induce positive or negative feelings or stimulate action
Incentivisation	Creating an expectation of reward
Coercion	Creating an expectation of punishment or cost
Training	Imparting skills
Restriction	Using rules to reduce the opportunity to engage in the target behaviour (or to increase the target behaviour by reducing the opportunity to engage in competing behaviours)
Environmental restructuring	Changing the physical or social context
Modelling	Providing an example for people to aspire to or imitate
Enablement	Increasing means/reducing barriers to increase capability (beyond education and training) or opportunity (beyond environmental restructuring)

2.9. Ethics of Human Factors in Aviation

The choices people make during decision-making have a moral perspective, as well. In complex and hazardous situations, the moral price is present and as high as it could be. The aviation context offers a significant part of moral choices since the end-users are in contact with situations where should they fail, their professional integrity would take the first hit. For example, a pilot could withhold information about his/her training to succeed in an interview, thus endangering the next appointed flight he/she was not trained for. As such, consequentialism's first trait is goal-orientation; the following appointed traits vary according to the aim of goal-orientation, which can be of relieving others (i.e. altruism) or it can be selfish (i.e. ego-oriented) (Hoppe, 2011). Consequentialism is the philosophy that normative properties depend only on consequences, meaning that the merits of an act depend on the consequences of the act itself or the consequences on the related actors (Sinnott-Armstrong, 2003). The opposing view comes from the philosophy of deontology, where an individual's actions are assessed according to a universal rule of morality (Hoppe, 2011). The Kantian deontology supports that people act on rational decisions, which are commonly true for all; "act only according to that maxim by which you can at the same time will that it should become a universal law" (Korsgaard, 1985).

The present subsection is an essential addition for this thesis because for applied safety research moral decisions, and ethics have been more closely attributed to a judicial approach, where the end-user is accountable for a deliberate action that caused a safety event. On the contrary, for the thesis's author, moral decision-making is not only a way to apply and enforce reactive judicial measures, but it can also provide a path that can lead to another perspective of risk perception and risk communication. A usual misunderstanding based on real-life practice is that failure of morality leads to accusations and mobbing among colleagues (Da Silva João & Saldanha Portelada, 2016; Meriläinen, Käyhkö, Kõiv, & Sinkkonen, 2019). These negative behaviours often frame scapegoats or stigmatise people as general threats of security and safety based on the possible rise of tensions among colleagues. Although based on a literature review, there is a tendency to emphasize the effects of security on safety and underestimate the opposite, and human factors are not part of security training to the extent are addressed in safety training, the intentionality or not of outcomes, and not of the action, can stand as a valid criterion to classify an event as a security or a safety one correspondingly (Karanikas, 2018).

Moreover, the socio-moral emotions can greatly determine decision-making, based on the risk-as-feelings hypothesis's prospect, which highlights the decision-maker's local emotional state (Loewenstein, Weber, Hsee, & Welch, 2001). However, the role of affection and emotions is yet doubted. As confirmed, individuals avoid making unethical decisions, regardless of whether they are made in public or in private, meaning that transparency is not so relevant (Bonavia & Brox-Ponce, 2018). Real-life issues are influenced by indeterminism since the actual future is more than mere probabilities, rationality, and emotions, but rather a mixture of those. An exquisite addition of literature for this thesis is the suggestion made by

Hansson (2003) that the right everyone has not to be exposed to risk can be overridden if the risk-exposure is part of an equitable system for risk-taking that works to the advantage of the individual risk-exposed person. The difference of the approach lies beyond a dualistic logistic approach of the individual carrying utilities equally attributed to all, and it lies in the argument of an indeterministic world where the end-users are unique by principle. The fallacy of taking a dualistic approach probably derives from a positivistic paradigm, which is not used in this thesis.

Another issue concerning risk perception and risk communication is the perspective about safety. The measure of perceiving or communicating risk can depend significantly on the prospect of the end-user's acknowledgement of safety's definition. The judgement of what is safe considers the type, quantity, and probability of harm, as deontological moral judgments do, while risk acceptability (perceiving and communicating risk) include potential benefits following the consequentialist moral judgments course (Macpherson, 2008). Regardless of this additional dualism, the present issue is that the end-user might not act unilaterally in all cases in real-life situations. Consequently, risk perception and risk communication may also be affected from an ethical/moral point of view concerning the end-user's general comprehension of safety and the attribution of 'moral weight' (deontological versus consequentialist) on the organisation his/her colleagues.

Consequently, the questions arising from the moral part of risk perception and risk communication are as follows:

1. Who is at risk, me or others?

The importance of a choice's consequences has to do first with whom is at risk, self or others. The first case is known as ethical egoism and the latter as ethical altruism. In the first case, the morally right choice is the one that benefits the self, or each person ought to pursue self-interest exclusively (Rachels, 2013). In the second case, the morally right choice is the one that benefits the other, which is unrealistically underestimating the vigour of individual self-interest (Hoppe, 2011). The issue lies in the choice of how the end-user perceives the world, him/herself, and others and how and why he/she chooses to communicate with them.

2. What is the gain for accepting the risk?

The view on this question is similar to the previous one with the change of focus on the benefits of taking the right decision. Specifically, the focus is balancing between self-benefit versus the benefit for others. The issue here is for whom the risk is being tolerated, the self, peers, or the organisation.

3. What are the consequences?

This question aims at the objective ethical value of the aftermath of a positive or negative choice. Claiming objectivity, in this case, is capable of generating many disputes since the answer comes from a consensus of the majority. The issue here is that an end-user may disproportionally be biased towards a choice since, for him/her, it is “common knowledge” or “something anyone would do”.

4. What could it mean for me for alerting about that risk?

Trust issues are considered from a moral lens on the end-user’s choices. Reporting culture is ambivalent that people may not work in an organisational climate, which has them prepared to report their errors and near-misses (Malone & Darcy, 2019). The issue here is that an end-user may not communicate a risk effectively based on his/her moral standards (i.e. egoism versus altruism).

2.10. Description of gap

Risk’s nature of subjectivity poses a significant amount of doubt during critical decisions. The same claim could be enacted from the level of the first-line operator to the managerial and upper organisational levels. The differential lens of subjectivity offers valid grounds for standardisation and comparisons to understand the interference of risk perception and communication within aviation organisations based on safety culture. In a growing and competitive world, with efficiency as a common target, aviation organisations should aim for competency in safety. In this thesis, the risk is fragmented into two significant components, risk perception and risk communication. The first one engulfs the part of decision-making, cognitive and emotional factors which determine the ways an individual encodes – perceives internal and external inputs to shape intentions and decisions concerning a forthcoming beneficial or not situation (Renn, 1998; Dobbie & Brown, 2014; Proctor & Chen, 2015; Aven, 2016; Serences & Wixted, 2018). The latter one engulfs all the parameters which frame all communication plans and efforts concerning a warning signal towards the operator, other operators and the organisations (Null, 1991; Yoe, 2012; CDC, 2014; Farjam, Nikolaychuk, & Bravo, 2018; ISO, 2018). Considering these two fragments, they also pose the two parts of risk behaviour, which has paramount importance for safety practice.

Among the other high-risk industries, the aviation industry has devised processes to ameliorate flaws that lead to the devastating loss of personnel, equipment, facilities, and environmental destruction (ICAO, 2015; ISO, 2018). However, real practice indicates deviations from what SMSs and SAIMs dictate, either by neglecting residual psychological effects (e.g., recovery course, 'second-victims') or by allowing too broad categorisations of phenomena (e.g., emotion label covering for all emotional responses). From a different perspective, safety professionals can deviate from the written guidelines and adjust to their organisations based on their personal experience and tuition due to unclear or logistical guidelines concerning risk perception and communication. Among the collection of safety practices, there is no direct allocation for risk perception and risk communication, leaving safety practitioners and personnel with the freedom of being subjective on an already issue majorly disputed by subjectivity, risk.

Moreover, the implications of the current approaches have been deemed unproductive. First, the culture theory (Douglas & Wildavsky, 1982) supports that risk perception can be socially constructed as four ways of life (i.e. hierarchical, individualist, egalitarian, fatalist); nonetheless, it is not widely accepted as controversial. Following, the SOAR (Kasperson, et al., 2000) aims to explain how risk perception is amplified through social means (e.g., media) but fails to interpret the perception itself beyond the scope of the amplifying fact does for the communication part.

In addition, the lack of a direct assignment of risk perception and communication parameters and the benevolence for subjectivity opens the door for social attributions in the matter. Social pressure, social identity, social stigma and the fear of mortality deter risk perception and communication (Hohenemser, Kates, & Slovic, 2000; Arndt & Vess, 2008; Basting, Towey, & Rose, 2016; Hogg, Abrams, & Brewer, 2017). The claim of subjectivity also adds the lack of a conceptual framework connecting risk perception, risk communication, and risk behaviour to the equation. As implied in the introduction chapter, there is a variety of influence associations acting upon the operators, the system and the environment, and connections that may affect risk perception and communication. Based on the critical foundation of influential associations among the investigated variables, factors and parameters, this thesis aims to generate a behavioural intervention method in the human factors field.

The approach in this thesis considers the contribution of cultural theory (Fischhoff, Hayakawa, & Fischbech, 2000), where the institutional structure regulates risk perception proactively, and risk communication is the transfer of meaningful information and shared trust. Additionally, this thesis supports the psychometric paradigm, which claims the measurable differences among individuals on several risk dimensions, based on the practice of acquiring data through the use of questionnaires to set rating scales (Sjoberg, Moen, & Rundmo, 2004; Siegrist, Keller, & Kiers, 2005; Ho, Looi, Chuah, Leong, & Pang, 2018; Cardoso, 2018; Pu, et al., 2019). The generated model by this thesis aims at providing predictability and explaining why and how individuals perceive and communicate risk (Figure 1-1). What is more, the intended behavioural intervention and overall behavioural techniques have been found effective in precisely defined behaviours and most successfully in the safety context (Stajkovic & Luthans, 1997). As such, a promising safety communication campaign based on the sound basis of strategic communication guidelines may succeed in changing operators' attitudes and behaviours.

Figure 1-1: A Diagrammatic Conceptual Model of Risk Perception and Communication Influence on Behaviour

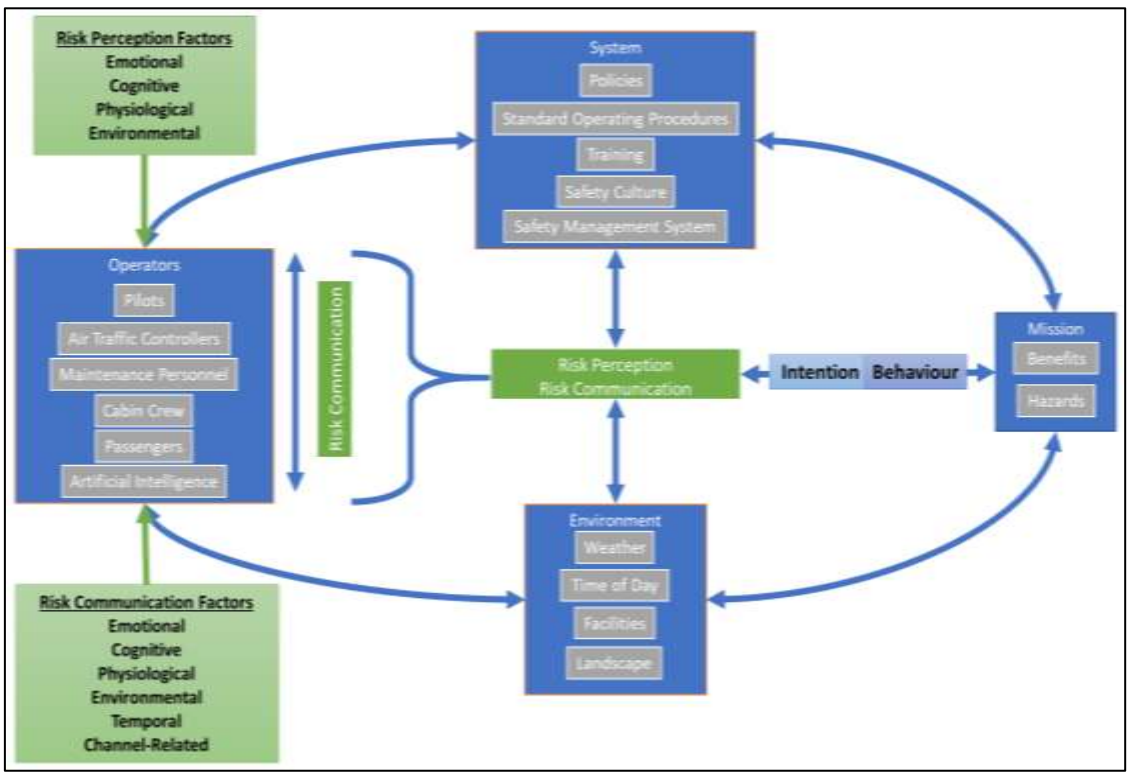
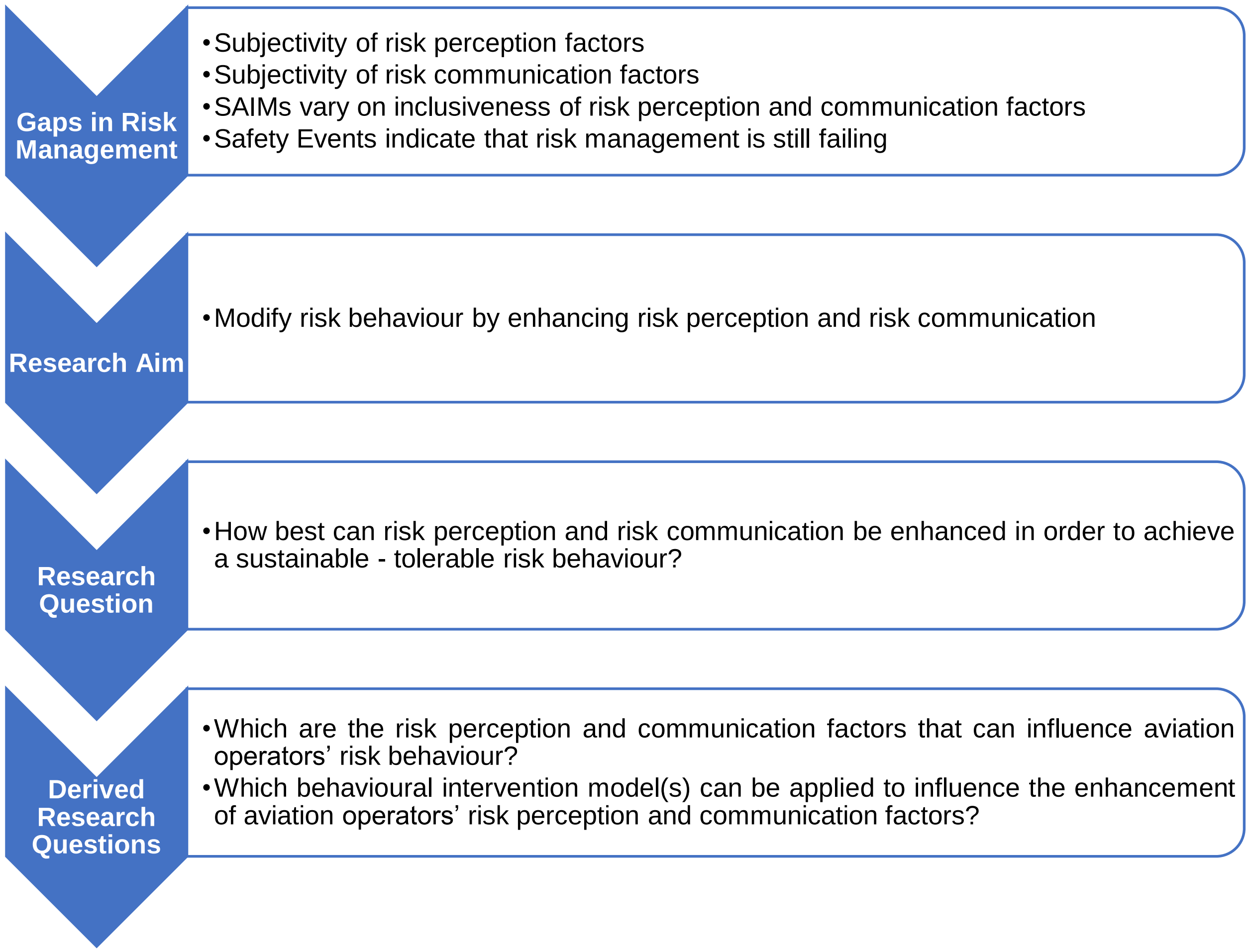


Figure 2-13: Linking Research aim, focus and questions



Each research question is briefly discussed to establish the boundaries for this thesis clearly:

<u>RQ1 Which are the risk perception factors that can influence aviation operators' risk behaviour?</u>

<u>RQ2 Which are the risk communication factors that can influence aviation operators' risk behaviour?</u>

Concerning RQ1 and RQ2, they respond to risk subjectivity by definition (Sjoberg, Moen, & Rundmo, 2004). Additionally, despite the evolution of SAIMs, they disregard risk perception and communication by not including them as separate aggregated categories in risk assessment and by taking a strict logistical approach measuring different hazards for each situation (Chionis & Karanikas, 2018). Risk perception and risk communication factors are predominantly present in the decision-making process related to incidents and accidents, and they should be categorised as separate factors. There is no proof of consensus among safety professionals and end-users concerning the processing of risk, concerning perception and communication, as dictated in official documentation, models, and policies.

> RQ3 Which behavioural intervention model(s) can be applied to influence the enhancement of aviation operators' risk perception and communication factors?

There is limited to no literature on behavioural intervention efforts in the aviation human factors context (Glendon, Clarke, & McKenna, 2006). Therefore, there is a need for an integrated, applied approach that should enhance risk perception and communication among end-users on the one hand and be incorporated in any aviation organisation on the other hand.

There is no current research study with a clear investigation orientation on generating a model to enhance risk perception and communication, resulting in tolerable risk behaviour in the aviation context. However, it is supported here that this research will provide meaningful intuitions into how risk perception and communication influence the end-user to overpass safety limits and how organisations (i.e. small or large aviation carriers) may strategically implement a behavioural safety intervention.

2.11. Summary of Chapter 2

The purpose of this chapter is to provide a collective perspective of the investigated issue based on a literature review. Insights from human factors research, risk perception and communication, and the operators' perspective are presented. Additionally, literature covering intervention approaches and ethics of human factors in aviation are detailed. After reading this chapter, the reader is affiliated with the hypotheses of this thesis.

Specifically, risk perception has been underrepresented in studies regarding its complexity as a construct in the aviation industry. Risk perception factors have not been investigated in a uniform representative way, but instead, they have specialised in each specialty or sub-context. Similarly, risk communication has not been explicitly addressed as per its contribution to incidents/accidents. Governmental organisations, such as the US National Transportation Safety Board, do not possess a specific risk perception dimension entry code or a risk communication entry code. Therefore, especially regarding the retrospective study of incidents/accidents and their safety recommendations, there can be a significant inaccuracy of referencing the importance of risk perception dimensions and risk communication, this possibly leading to inadequate proactive safety suggestions and planning. For example, safety analysis and investigation methods (SAIMs) have the goal of recommending ways to achieve safety. Risk perception and communication are essential to explain the decisions and actions made during a safety event or justify the ones planned for future interventions based on a risk assessment process. Research should examine current SAIMs and map specific factors about safety practitioners and end-users daily practice to support several improvement initiatives.

The findings of this thesis can raise the awareness of researchers and practitioners regarding the inclusiveness of risk perception factors and risk communication factors in the daily safety practitioners' and end-users' routine and lead to improvements in safety analysis, proactive safety planning, and investigations as well as training and education. The next chapter will present an overview of the research methodology, the procedures followed for the sub-studies as per the methods for data collection and tools for measuring the dependent and independent variables. The next chapter will also describe the research paradigms.

Chapter 3 Methodology

3.1. Introduction

This chapter is dedicated to describing the methodology followed to accomplish the proposed research aim and objectives. Fundamentally, it is based on the literature above sources, human factors research paradigms and their underlying empirical and epistemological foundations. These foundations provide the basis for answering the research questions, deducted questions, and this thesis's collective aim. By analysing and assessing the current trends in human factors and psychology fields, the researcher supports that a mixed-multimethod approach was appropriate. Specifically, this study investigates simultaneously multiple constructs and their associations with secondary data and data originating from human respondents. The premise is to generate a model that raises safety researchers and practitioners' comprehension to fulfil an intervention schema. The theoretical concepts already discussed in the previous sections cover the rationale around risk perception and risk communication. Ensuing follows a general outline of the total research design and the partial studies that comprise it. The data processing and analyses were performed using SPSS software Version 22 (IBM, 2013) and NVivo 12 (QSR International Pty Ltd., 2018). For a summary of the research steps and outputs, refer to Appendix 7.

3.2. General Research Design and the Choice of Research Paradigm

In order to choose a research paradigm for this study, the researcher had to assess the set of common beliefs and agreements shared in the scientific community about how risk perception and risk communication and the attempt to influence them towards their betterment should be understood and addressed (Kuhn, 1962). A paradigm, or *paradigma* in Greek, is the way a researcher can describe beliefs about the nature of reality (=ontology), courses of action that can reflect how knowledge is earned (=epistemology), and the ethics as a base of what is believed to be true (=axiology) (Chilisa & Kawulich, 2012). The reviewed literature revealed no particular methodologies on how to research risk perception and communication. However, the identity of this research context, paired with the researcher's comprehension of the ways risk perception and risk communication may interfere and deter a safe operation in the aviation context, has provided enough insight on how the research should be commenced.

3.2.1. The positivism/post-positivism paradigm

In every study, the researcher has to consider what constitutes a shared worldview and knowledge that may embody findings, beliefs, and values in a discipline through a methodological lens (Schwandt, 2001). The search for an applicable paradigm for this research leads to the assessment of the currently available paradigms. The main worldviews, as interestingly are commented on by Feilzer (2010) are those of positivism/post-positivism and constructivism/interpretivism. The positivist approach of reality mandates a singular one, holding one solution for every problem waiting for a quantitative research methodology (Feilzer, 2010; Kelly, Dowling, & Miller, 2018). As an evolutionary step, the postpositivist approach went beyond the dogmatic view of its predecessor, accepting a worldview where the scientist is not just a custodian meddling with natural laws, to a worldview fuelled with valid observations which may also include errors and theories in need of constant modification (Crotty, 1998; Trochim, 2006; Kelly, Dowling, & Miller, 2018). In total, the positivism/post-positivism paradigm focuses on prediction, theory testing, the strength of association among variables or a cause-effect association (Chilisa & Kawulich, 2012; Denzin & Lincoln, 2018). For example, the positivist researcher would aim to measure the future effects of the natural environmental factors which interfere with the operator's risk perception and communication processes. In contrast, the postpositivist researcher would include the organisational factors which oblige an operator to be involved in certain natural conditions (i.e. aircraft loading under rain).

3.2.2. The constructivist paradigm

The constructivist approach rests on a world with multiple possible solutions bound of subjectivity and only capable of being solved by qualitative research methods, using small samples to collect in-depth data (Feilzer, 2010; Kelly, Dowling, & Miller, 2018). Specifically, the reality in the constructivist's worldview is a social construct bound to the individual's experience from actions on the field based on trustworthiness and authenticity, instead of internal and external validity (e.g., positivism/post-positivism) (Denzin & Lincoln, 2018). Based on a relativist ontology, constructivism subjectively views reality and investigates the context of naturally occurring events using inductive reasoning, developing theories from specific observations (Kelly, Dowling, & Miller, 2018; Denzin & Lincoln, 2018; Davies & Fisher, 2018). Tools and methods usually associated with the constructivist approach are observation, interviews, and focus groups (Flick, 2018). For example, during a safety investigation, a series of semi-structured or unstructured interviews draw from witnesses' experience of the safety event to form and later analyse key factors and additional factors which contributed to the event.

3.2.3. The critical/emancipatory paradigm

The critical/emancipatory paradigm emerged from the philosophies, theories, and studies with a common theme of emancipating communities through group action (Chilisa & Kawulich, 2012). In other words, the critical/emancipatory paradigm focuses on raising awareness and endorsing social change (Davies & Fisher, 2018). In terms of ontology, the critical/emancipatory paradigm is fuelled with critical realism, which "is embedded in emancipatory goals" (Denzin & Lincoln, 2018, p. 726). For the researcher using this paradigm, "knowledge is not neutral" (Denzin & Lincoln, 2018, p. 752) but dependent on social, political, cultural, and power-based factors (Chilisa & Kawulich, 2012). The emancipatory rationality assumes that the investigated truth derives from consensus achieved through dialogue, using emergent and open-ended questions, also inviting participants to adapt these questions based on their knowledge and experience (Denzin & Lincoln, 2018). For example, an approach following the critical/emancipatory paradigm would search for groups in the aviation context, which may have been treated with bias in terms of safety. Such an approach, however, could have brought forward real issues, could also cause a cohort of debates concerning inequalities that the current thesis does not aim to address, especially under the premise of safety.

3.2.4. The pragmatic paradigm

Mixed methods struggle to integrate both worldviews by attempting qualitative and quantitative research methodologies (Tashakkori & Teddie, 2010). Pragmatism has come as an answer for the need for an alternative framework to accommodate the mixed worldviews approach and beyond this dispute (Feilzer, 2010; Morgan D. L., 2014; Kelly, Dowling, & Miller, 2018). Furthermore, pragmatism provides freedom of movement beyond the bivalent logic of positivism and constructivism and allows the researchers to use various methods and techniques (Feilzer, 2010; Kelly, Dowling, & Miller, 2018). Additionally, pragmatism focuses on the utility of the research for the research and the study's audience, instead of focusing on the quantitative vs qualitative dilemma (Feilzer, 2010; Morgan D. L., 2014). As profoundly put by Morgan (2014) agreeing with Dewey's (2008) philosophical approach, strict cognitive rationality ignores the emotional element for the cases of investigating human reasoning and probabilistic thinking. Not to mention that the pragmatism paradigm supports the researcher providing plurality in terms of the many research approaches, methods and designs to utilise for the best answer for the research question (Kelly, Dowling, & Miller, 2018). Inherently, pragmatism would not be focused on challenging inequalities among different groups in the aviation context; it can acknowledge real-world problems emerging from individualistic and multiple realities, providing divergent limits of how to investigate ways of knowing reality, and also providing flexibility in methods/methodologies choice (Davies & Fisher, 2018; Denzin &

Lincoln, 2018). For example, a pragmatist approach could exploit data from safety events (i.e. interviews from witnesses of accidents, accident/incident reports), methods of investigating safety events (i.e. SAIMs), and quantitative data such as frequencies of factors' occurrences during flight operations.

Table 3-8: Summary of Traits of Major Paradigms (Chilisa & Kawulich, 2012; Davies & Fisher, 2018; Kelly, Dowling, & Miller, 2018).

	Paradigms			
Traits	Positivism/Post-positivism	Constructivism	Critical/Emancipatory	Pragmatism
Aim	To discover generalisable data based on individuals or groups	To describe and understand human experience	To empower and elicit social change	To solve real-world issues
Ontology	Single reality; real-world driven by natural causes	Multiple subjective socially constructed realities	Multiple realities shaped by social, political, cultural inequalities	Single and multiple realities
Epistemology	Researcher objectivity and detached impartiality; modified objectivity; partial subjectivity	Subjectivity; dialectical	Knowledge is socially constructed	*None*
Methodology	Descriptive, cohort, cross-sectional, case-control, experimental, randomised control trials, modified experimental	Phenomenology, grounded theory, ethnography, narrative, biographical	Neo-Marxist, Feminist Research, Queer Theory, Participatory Action Research	Mixed methods research
Methods	Quantitative, Qualitative (triangulation)	Qualitative	Qualitative	Quantitative and qualitative
Axiology	Based on precise observation and measurement that is verifiable	Truth is context-dependent	It is informed by a theory that unveils illusions	Informed by contextual observation and measurement

	Paradigms			
Traits	Positivism/Post-positivism	Constructivism	Critical/Emancipatory	Pragmatism
Criticism	Does not address individual experiences. Does not always produce well-defined answers	Limited transferability and generalisability	Does not always guarantee its aims of emancipation	Flexibility in approach can lead to confusion

This study aims to investigate multiple and complex concepts to generate a model of better understanding risk. The theoretical concepts already discussed in the previous sections cover the rationale around risk perception and risk communication. For this study, a fixed mixed methods design, including four phases, was decided. Both qualitative and quantitative strands were given equal priority, as it is apparent, especially in sub-study 1. Mixed methods can be useful for assessing interventions in this research because the research questions have both qualitative and quantitative aspects (Coolican, 2014). Notably, in a new study area, an initial qualitative approach maps out the variables' properties and gives meaning, while a follow-up quantitative approach further validates results with additional data (Coolican, 2014). Data from human participants will be collected through interviewing personnel of the aviation industry and through a questionnaire. Additionally, secondary data will be used from international databases (e.g., NTSB, Aviation Safety Network) regarding incidents/accidents trends and safety methods usage.

Traditionally, research over risk and accompanying constructs has been accommodated in the study of judgement, decision-making, utility and rationality theory (Mosteller & Nogee, 1951; Edwards W. , 1953; Edwards W. , 1954; Savage, 1954; Slovic, Kunreuther, & White, 2000). The common denominator for all past research concerning risk is the absence of unnecessary risk for participants (i.e. individuals, organisations) (Johnsen, Crnkovic, Lundqvist, Hanninen, & Pettersson, 2017). As per this research, current or residual risk for individuals and organisations is incompatible and nominated as unethical conduct. Moreover, despite the definitions' barriers, the constructs used in this research -risk perception and communication- remain abstract if not analysed into further sub-factors. Like decision-making, risk perception and communication may be adherent to mental representations, as stated in the previous chapter. The research question is formulated as:

"*How best can a behavioural–based intervention be structured in order to enhance risk perception and risk communication?*"

After a review of the current literature, it was apparent that current safety schemes, theories and frameworks were insufficient to depose the above problem, as most of the available methods and frameworks focused more on policymaking, old-safety thinking, and reactive measures rather than exploiting the chance to implement or formulate empirically pro-active results. Additionally, the definition of risk as "the future impact of a hazard that is not controlled or eliminated" (FAA, 2009, pp. 1-5) yields that risk is the degree of uncertainty for a future event. Under this notion, perceiving a future event and communicating possible contributing causes puts far more stress on the decision-maker since there is no standard way to cope with factors withholding the full extent of risk perception and the best available effective communication. Therefore, the following objective for this study has been formulated:

"*To develop an integrative model using a behaviour-based approach by identifying the key factors for risk perception and risk communication*".

However, to develop the model, the research will necessitate addressing certain limitations such as time restrictions and openness for such a sensitive issue as safe-conduct from both individuals and organisations. Furthermore, this type of study will demand further research in the future since the time limitation set for the completion of the thesis does not accommodate the need for a longitudinal study. To overcome this limit, this thesis will provide the model ready to be applied in further research. Moreover, the direct report to individuals, organisations and unfinished safety investigations is prohibited due to privacy and professional integrity. As such, the researcher awaits limited openness from participants concerning safety events they have experienced. To overcome this limit, the researcher will avoid any queries (e.g., questionnaires and interviews) that could be hurtful or inconvenient to participants of this thesis.

The core of risk's definition mandates probabilistic reasoning for the model since the operator has to use rational thinking to avoid hazardous situations and tackle probabilities to handle future uncertain ones. Probabilistic reasoning, like other types of human inference, efficiency obeys individual differences (Roberts & Newton, 2005). As such, risk perception and communication for this research are determined to fit into probabilistic reasoning. The conceptual framework presented in the introduction chapter (Figure 1-1) is a Bayesian network representing the dependencies among grouped variables as the 'risk perception' and 'risk communication' nodes. The problem arises when operators take conservative decisions where a probabilistic judgement is needed. Biases may interfere with the operators' probabilistic reasoning, such as anchoring in base rates or completely ignoring them, drawing from or ignoring consensus information, and primacy effects, which are traditional concepts that interest of decision-making research (Nickerson R. D., 2004).

The paradigm of this thesis considers the above and the premise that mixed methods research (MMR) represent a combination of quantitative and qualitative methods not new in research (Maxwell, 2016). Furthermore, MMR is capable of combining different paradigms following a dominant/less-dominant (=relying on a single dominant paradigm using small components from alternative paradigms) and an equal status design (=a sum of paradigms are equally relevant to a study) (Ghiara, 2019). Ghiara (Disambiguating the Role of Paradigms in Mixed Methods Research, 2019) argued that MMR combines different paradigms, but most profoundly, MMR entails a new paradigm by itself, addressing epistemological pluralism and the combination of ontological assumptions.

Based on the above, the researcher has chosen a pragmatic paradigm for this research since hazardous situations in the aviation context are continually evolving, aiming to apply the change. This research plan involves probabilistic reasoning as a rationality framework for the operators' reasoning, agreeing with Pfeifer's suggestions to further investigate incomplete probabilistic knowledge (2013). This research aims primarily to interpret the operators' initial perception of hazardous and situational cues, which should lead to a specific inference regarding risk and how to communicate that as well. To fulfil its purpose, this research also condones that a fixed multiphase MMR will allow the maximum in-depth, realistic research in terms of individualistic, operational, and organisational experience in the human factors aviation context. For these reasons, the methods used for the sub-studies follow an explanatory sequential design, and it allows for acquiring situation awareness for the studied variables and context.

Additionally, quantitative and qualitative strands followed a sequential design for sub-study 1 and 2 since quantitative feedback (statistics of SAIMs and accident reports) were appreciated to supplementary structure the items for the qualitative parts of the study (semi-structured interviews). Furthermore, sub-study 3 contributes to this thesis by indicating the best fit tool(s) to enhance risk perception and communication. Finally, sub-study 4 follows an exploratory sequential design by employing all previously acquired knowledge and data and aims to manifest the targeted model utilising first qualitative data (safety managers interviews) and then data from sub-study 1, 2 and 3, to generate the targeted model and standardise an approach that will eventually enhance risk perception and communication among the aviation context specialities. Exceptionally for sub-study 4 the sequence or strategy of designing the model draws from the equally theoretical and practical approach of strategic communication (StratCom), as the approach capable of aiding an organisation to initially apply a compelling study of the model.

3.3. Method: Safety Aviation Investigation Methods and Accident Reports (Sub-study 1)[4]

3.3.1. Method: Safety Aviation Investigation Methods (SAIMs)

The SAIMs were extracted from the Safety Methods Database (SMD) Version 1.1 31 August 2016 (Everdij & Blom, 2016). This source was selected based on the premise that aviation is a high-risk industry, using SAIMs that coincide within the SMD. According to the goals of this sub-study, the following steps were followed:

<u>Step 1:</u> Excluding SAIMs not applied in the aviation industry.

Based on the SMD coding for domain of application/origin, the following table iterates the aviation related domains used for this sub-study from the SMD.

Table 3-9: Aviation-related domains included in the SMD (Everdij & Blom, 2016).

Domain	Description
Aviation	Operation of individual aircraft or aircraft fleets, including pilot and crew factors and airline operations.
Airport	Airport operations and airport design.
ATM	Air traffic management and air traffic control operations and equipment.
Aircraft	Aircraft technical systems and airworthiness issues. Also including rotorcraft such as helicopters.
Avionics	Electronic systems used on aircraft, satellites, and spacecraft, including communication, navigation, cockpit display.
All	Approaches that are very generic and that have been used in virtually all domains.

<u>Step 2:</u> Inclusion of SAIMs denoting safety assessment stages relevant to risk perception and communication.

The SMD categorises SAIMs into eight safety assessment stages per method as well as the outcome per stage (Table 3-10). The third column of the particular Table depicts the purpose of each stage (FAA/EUROCONTROL, 2007). In this step, the object of the examination was

[4] This sub-section represents work published in the 33rd European Association of Aviation Psychology Conference as part of the PhD research.

whether the outcomes and purposes of each stage are related to risk perception and communication. The results of this analysis are depicted in the fourth and fifth column of Table 3-10 (“Y”=Relevanve/”N=Irrelevance”). This criterion was used to filter our SAIMs not including at least one stage associated with the investigated constructs.

Table 3-10: Safety assessment stages relevance to risk perception and communication

Safety Assessment stage	Code	Outcome	Risk perception	Risk communication
1) Scope of the assessment	Ø	Safety plan; assignment of safety/risk criteria	N	N
2) Learning the nominal operation	Ø	Description of operations and systems used	N	N
3) Identify hazards	HAZ.ID	Defined hazard set	N	Y
4) Combine hazards into risk framework	MODEL	Risk Model	Y	Y
5) Evaluate risk	EVALUATE	Evaluated Risk Model; identify and evaluate dependencies, evaluation of risk against target criteria; risk-informed decision-making becomes possible	Y	N
6) Identify potential mitigating measure to reduce risk	MITIGATE	Potential mitigating measures to reduce risk	Y	Y
7) Safety monitoring and verification	MONITOR	Measurement of safety-related events & data against predictions	N	Y
8) Learning from safety feedback	FEEDBACK	Better knowledge in operations, safety assessment and design concerning how to manage safety effectively in ATM	N	Y

<u>Step 3:</u> Classification and selection of SAIMs for analysis – Sample description

Beginning with a descending chronological order, SAIMs were coded as root causal, epidemiological or systemic, according to 2.3.1. section categorisation. Based on time limitation to produce the total course of this thesis, the 100 most recent SAIMs were analysed almost equally per size for each classification category. During the analysis, the objects of recording were the year of publication for each SAIM and the inclusion of analysis stages linked to risk perception (STAGESP) and risk communication (STAGESC) to perform statistical tests. Then, the years of publication were grouped in almost equal population sizes. An overview of the sample distribution is depicted in Table 3-11, and a detailed presentation of the sample is illustrated in the appendix for sub-study 1.

Table 3-11: Research Sample

	Group	Sample Size (*N*)	Model Type (N)		
			R	E	S
Time Period	≤1994	24	9	9	6
	1995-1999	24	10	7	7
	2000-2007	28	8	9	11
	≥2008	24	5	9	10
Total		100	32	32	34

Step 4: Analysis of each SAIMs based on the following questions:

4.1 Does the SAIM refer to risk perception?

4.2 If the answer to question 4.1 is positive:

a. To which relevant analysis stages of Table 3-11 is risk perception linked?

b. Which risk perception factors (PEMF, PCOF, PPHF, PENF) are addressed in the SAIM?

4.3 Does the SAIM refer to risk communication?

4.4 If the answer to question 4.3 is positive:

a. To which relevant analysis stages of Table 3-11 is risk communication linked?

b. Which risk communication factors (CEMF, CCOF, CPHF, CENF, CTIF, CCHF) are addressed in the SAIM?

Notably, the answers to questions 4.2b and 4.4b took into account references for each factor at least mentioned in one stage per SAIM analysed. During this part of the analysis, the examination of the coverage extent of factors within each stage was not taken into account, since no explicit association was observable between SAIMs and stages.

Step 5: Analysis of data

The inclusiveness of SAIMs concerning each risk perception and risk communication factor was calculated based on the respective frequencies per factor. Additionally, based on the novelty of this sub-study, to the author's knowledge, to assess the analysis stages within a sample of SAIMs, the attempted metrics were:

(1) the frequencies of analysis stages connected with risk perception and communication across the sample, and

(2) the degree to which each SAIM mentions the stages linked to risk perception and communication, as expressed by the ratio of the number of relevant stages mentioned in the SAIM by the total number of relevant stages according to Table 3-11.

Chi-square and Fisher's Exact tests depending on the sample distribution was performed to examine associations between the references to risk perception and communication factors in each SAIM and the type of SAIM (i.e. root cause, epidemiological and systemic) as well as the period of publication (Leedy & Ormord, 2013). Associations between the reference to each analysis stage and the variables mentioned above were assessed similarly. Furthermore, Mann-Whitney tests were used to reveal any association between the inclusiveness of relevant analysis stages to the extent the SAIMs mention the risk perception and communication factors. In these tests, the "YES" and "NO" values regarding the inclusion of each factor in each SAIM comprised the grouping variables and the ratios of the relevant analysis stages referred in the corresponding SAIM was used as the measured variable.

Kruskal-Wallis tests were also used to examine associations between the ratios mentioned above and the type of SAIM and publication period. Non-parametric analysis was preferred because the ratios were not normally distributed, as shown by the Kolmogorov-Smirnov (K-S) test results (p=0.000). Despite Howell's (Statistical Methods for Psychology, 2010, p. 79) claim that K-S test is improbable for large samples (i.e. N>50), the researcher relied on it since the differences concerning the groups are very small.

Considering the continuous developments in safety research and the area of risk perception and communication, it was assumed that systemic and more recent SAIMs are more likely to engulf the investigated factors compared to the root cause and epidemiological as well as older methods and models. Similarly, it was anticipated that systemic and recent SAIMs would be more inclusive of analysis stages, and an increased ratio of reference of the latter would be associated with an increased frequency of mentioning risk perception and communication factors. The level of statistical significance for all tests was set to 0.05 (Berman & Wang, 2017).

3.4. Method: Accident/Incident Inclusiveness of Risk Perception & Risk Communication Factors[5] (Sub-study 2)

This sub-study followed a mixed-methods research through a fixed multiphase collection of data, allowing for in-depth and realistic examination of the inclusiveness of risk perception and communication factors within accidents/incidents (Tashakkori & Teddie, 2010; Feilzer, 2010; Morgan D. L., 2014; Creswell & Plano Clark, 2017; Kelly, Dowling, & Miller, 2018; Ghiara, 2019). This sub-study followed an explanatory sequential design, where the quantitative results of safety investigation reports informed a semi-structured interview protocol for safety investigators.

[5] Chionis, D., Karanikas, N., Iordan, A.-R., & Svensson-Dianellou, A. (2021). Contribution of Risk Perception and Communication in Aviation Safety Events. Transportation Research Record. https://doi.org/10.1177/03611981211051617.
Chionis, D., Karanikas, N., Iordan A-R, Svensson-Dianellou A. (2022). Risk perception and communication factors in aviation: Insights from safety investigators. Journal of Risk Research, https://doi.org/10.1080/13669877.2022.2038246

Based on the electronic sources of National Safety Boards of ICAO member countries, a list of 2991 safety events (i.e. incidents and accidents) concerning the period 2009-18 was acquired, aiming for timely relevance in up-to-date situation in aviation industry. For external reference, these accidents are available in English under the respective authorities' websites and the aviation safety network (ASN) website[6]. This criterion led to 1620 reports. The selection of these sources of events was made for the following reasons; (a) the ICAO member countries possess a list of events which are available to the public after formal request; (b) some of the ICAO member countries offer the reports with no restrictions; (c) most of them use the same format with slight structure only deviations; (d) they do not possess a filing code concerning risk perception and risk communication. During the investigation of eligible reports, the researcher met the difficulties that there were reports not following ICAO's Annex 13 (Aircraft Accident and Incident Investigation - Annex 13, 2001), and the language barrier beyond the English language. Moreover, events dated during 2017 and forward were found to be often under ongoing investigation.

Notably, the researcher examined whether each event is related to risk perception and communication. After screening the reports for risk perception and communication causal and contributing factors, the resulted reports were 443. The screening was specified as per the personnel coding the USA NTSB[7] is using, which constitutes a universal reference of ICAO countries. Due to time limitations the 100 most recent safety events were kept for analysis. A division of the flight operation cycle was used to investigate whether risk perception and communications and their factors had been found more frequently in various flight phase (i.e. Flight Planning, Pushback, Taxi, Take-off, Cruise, Descend, Final Approach and Landing) (Figure 3-14).

Concerning the inclusiveness of risk perception and communication factors' assessment, a similar to 3.3.1 sub-section methodology was followed. A calculation of the frequencies per

[6] https://aviation-safety.net/
[7] National Transportation Safety Board

attribute and factor was conducted to provide an overview of the attribution of safety events to risk perception and communication and compare the general picture with the results of sub-section 3.3.1 methodology. Additionally, the associations between risk perception and communication, including their factors, and parts of flight were examined through Chi-square and Fisher's Exact Tests[8], depending on the sample distribution (Leedy & Ormord, 2013). Similarly, significant differences in the frequencies of risk perception and communication factors over time were explored. For the latter, the reports were grouped in three periods to maintain balanced sample sizes (2009-2011: 28 reports, 2012-2014: 39 reports and 2015 – 2018: 33 reports). The main assumptions were that the distribution of risk perception and communication factors revealed during safety investigations across the various flight stages would be irrelevant, and that risk perception and communication factors have contributed to safety events more rarely in the most recent time period 2015-2018 considered in the sample.

The overall level of statistical significance for the statistical tests was set to 0.05 (Berman & Wang, 2017). To avoid the build-up of errors, we adjusted the level of significance for the two tests based on the Bonferroni correction: $P_{crit}=\alpha/k$, where k is the number of comparisons (i.e. two hypotheses tested) (Armstrong, When to use the Bonferroni Correction, 2014), resulting in $P_{crit}=0.05/2=0.025$ per test. We ran all tests with SPSS v. 25 (IBM Corp, 2017) selected the Bootstrap method with 95% confidence interval and 1000 samples to overcome limitations of the sample distribution as well as Monte-Carlo Simulation with 99% confidence level and 10.000 samples to calculate exact significances.

[8] Wherever more than 20% of cells had expected frequencies < 5, Fisher's exact test was used (Kim H. Y., 2017).

Figure 3-14: Flight Operations Stages

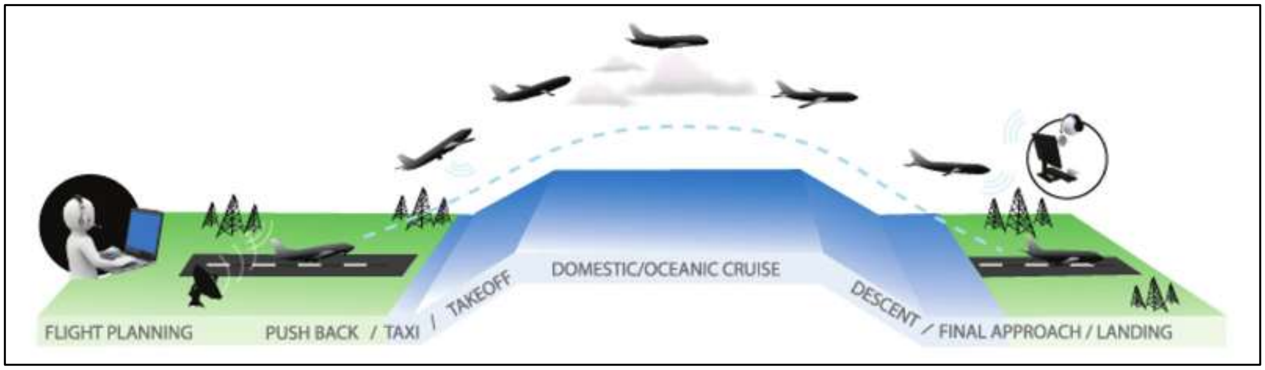


Table 3-12: Personnel Coding

Categories	Description
Action/Decision – Info Processing	Expectation/Assumption Identification/Recognition Understanding/Comprehension Complacency
Psychological – Personality/Attitude	Confidence/Reliance on Equipment Motivation/Respond to Pressure Personality Self – confidence Accuracy of Communication Common Phraseology
Personnel issues – Task Performance – Communication	Crew/Duty Change-Over CRM/MRM Techniques Following Instructions Interpretation/Understanding Issuing Instructions Lack of Communication Language/Accent Read Back

Concerning the qualitative part of this sub-study, snowballing was used to recruit Subject Matter Experts (SMEs) concerning accidents/incidents, thus safety investigators, from multiple regions and backgrounds (Slottje, Van der Sluijs, & Knol, 2008; Etikan & Bala, 2017; Frey, 2018). The call for participants was disseminated through Social Media (i.e. Facebook and LinkedIn) and e-mail. To avoid overly gathered information while achieving data saturation and analysis beyond sheer description, a baseline of six (6) initial interviews was set to provide sufficient data to conduct a Thematic Analysis and support additional interviews to refine the findings (Guest, Bunce, & Johnson, 2006). An upper limit of ten (10) interviews was set due to the sensitivity of the topic in combination with the availability of participants and data saturation. According to Morse (1994) and Creswell (1998), a minimum of six (6) and between five (5) to 25 interviews is deemed as an adequate sample size.

All data from the first six interviews were transcribed by the thesis's author, and an initial (TA) was conducted, which was later reviewed from two external researchers. After the determination of coding groups, the inter-rater agreement was calculated amongst the two additional researchers (Jackson, 2016) who were provided with lists of quotes, sub-themes and themes to match. Specifically, the thesis's author focused on data concerning risk perception and communication factors. Then, to test for validity, the two inter-raters crosschecked the themes and their definitions against quotes from the dataset (Roberts, Dowell, & Nie, 2019). Cohen's Kappa tests were executed after each reiteration to determine the degree of agreement between the two additional researchers. The inter-rater agreement was set above 80% to be sufficient (Bell, Halligan, & Ellis, 2006; Hayes & Krippendorff, 2007; Gwet, 2008; McAlister, et al., 2017). After two rounds, the desired level of agreement between the two additional researchers was achieved (Cohen's Kappa=.831, p=.000).

The sample consisted of aviation safety investigators with a minimum experience of one investigation of an accident or serious incident. None disclosure of sensitive data was acquired from all participants. All of them had been trained as investigators by their organisation, while three of them had relevant academic qualifications and training from their corresponding national authorities. What is more, four participants had past military background. The sample's details are depicted in Table 3-13.

Table 3-13: Demographic Information of Interviewed Aviation Safety Investigators

Variable	Values & Distribution (N, %)		
Age	≤ 35 (2, 20%)	36 – 50 (5, 50%)	≥ 51 (3, 30%)
Year started being involved in investigations	≤ 2000 (2, 20%)	2001 – 2010 (5, 50%)	≥ 2011 (3, 30%)
Region of nationality	European (8, 80%)	Non-European (2, 20%)	
Organisational Training	European (8, 80%)	Non-European (2, 20%)	
National Authority Training	European (5, 50%)	Non-European (0, 0%)	
Highest education level	Bachelor or lower (1, 10%)	Master or higher (9, 90%)	
Number of investigations being involved	≤ 5 (2, 20%)	11 – 50 (6, 40%)	≥ 51 (2, 20%)

3.4.1 Bridging Work as Planned and Work as Done Gap

In sub-study 1 the researcher aimed at surfacing the various reasons and ways the available SAIMs consider factors which influence risk perception and risk communication. Following, the researcher aimed at highlighting the same categories of factors as contributors in a sample of accident reports. However, these two investigations need to be combined to bring meaningful results. First, SAIMs represent ways of conducting safety management and investigations depicting the available course of action. In real practice, there is still the need to account for how the operators view the current situation. There is the limitation that it is impossible to know what SAIM the operators in the accident reports were following, either because they are deceased but mainly because their data are confidential.

Concerning the accident reports, there is yet an issue. First, the absence of a factor in a report poses a twofold case, either the investigator neglected it, or it was not a contributing factor. Next, the reports do not follow a standard model but the concepts of each investigator. This fact means that there is no clarity of the contribution of SAIMs in safety investigation.

According to what has been alleged, this part will serve as a bridge to lessen the gap of work as planned (WaP) and work as done (WaD). It will also give meaning to the combined results from SAIMs and accident reports and provide the necessary basic feedback from the operators as a baseline for the intervention plan. A general structure of the main topics was decided, and more detailed questions were asked as to when they surfaced during the interview.

The following questions were posed to safety investigators:

1. Do you follow a specific model or taxonomy during investigations?
2. How do you assess the risk perception of the involved operators during investigations?
3. How do you think emotional conditions, cognitive status, physiological status, and environmental factors influence the operators' risk perception?
4. How do you assess risk communication of the involved operators during investigations?
5. How do you think emotional conditions, cognitive status, physiological status, environmental factors, timeliness of communication, and the channel of communication influence the operators' risk communication?
6. Where do you attribute the absence, if any, of the factors as mentioned earlier during investigations?
7. What would you change to address these factors?

Exploiting the flexibility provided by the semi-structured interviews to generate more in-depth data, the researcher used the following techniques during the interviews:

1. Build Rapport: The researcher spent some time with the interviewee to build rapport. This was achieved by sharing common experiences from the aviation context. This rapport helped to gain trust and counter most of reluctance or hesitation during the interview process.

2. Thought Provoking Interjected Questions: Based on flexibility, the researcher asked wherever needed for more information on the same issue.

3. Critical Events: The interviewees were encouraged to give examples from their experience to balance the discussion over abstract replies.

3.4.1.1. Ethical Concerns

Regarding ethical concerns, all participants were provided with the Participant Information Sheet explaining the purpose of the study and the right to withdraw from it. Additionally, they had the choice to ask for the published results after the end of the thesis. The interviews were anonymised to ensure that their professional integrity will remain intact. Moreover, based on the semi-structured model, which was followed, the participants were encouraged to ask questions during the interview for clarification reasons. The current work was approved during the RE1 submission.

3.4.1.2. Procedure

Individual interviews were conducted through ZOOM (Barbu, 2013). Zoom offers the capability of face-to-face communication online while the content is being saved as a compressed file (i.e. .wav file). The lack of physical face-to-face communication was not observed to affect the data or participation in the study. On the contrary, the used online tool offered manoeuvrability and a broader sample search. Interviews were conducted verbally, and all lasted between 45 min and 65 min long. The interview schedule was programmed through the collection of participants using Survey Monkey where they expressed the will to participate, declare their identity (e.g., either safety manager or investigator), and share contact details (i.e. e-mail).

3.4.1.3. Analysis

The analysis of data took place in two stages. Concerning the first stage, six interviews were assessed using thematic analysis to produce codes which were cross-checked with the rest of the interviews to apply any necessary modifications of codes and their definitions. MS Office (Microsoft Corporation, 2013) and Nvivo12 Plus (QSR International Pty Ltd., 2018) were used throughout the analysis and theme extraction. Thematic analysis was applied according to the guidelines as instructed by Braun and Clarke (Braun & Clarke, 2006):

1. Familiarisation with data: Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes: Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Reviewing themes: Checking if the themes work with the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
4. Defining and naming themes: Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
5. Producing the report: Selection of vivid, compelling extract examples, the final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

3.4.2.1 Bridging Safety Investigators and Safety Managers

In sub-study 1 the researcher aimed at bridging the WaP and WaD gap among safety investigators as reactive and proactive safety practitioners; reactive from the side of investigating a safety event, while proactive when they proceed to safety suggestions. This came to be by converging results from SAIMs and safety events reports. However, safety investigators represent an emergent role in the aviation life cycle since an accident is needed for them to be summoned. The other side of the coin includes those who are obliged to apply safety daily, the safety managers. As stated earlier, there is a need to account for how the operators view the current situation. In order to highlight the SAIMs' real contribution, there is a need to investigate their application in routine practice and training through the corresponding stakeholders, the safety managers. As before, to attain an in-depth insight into the current practice in the field, the researcher employed semi-structured interviews (Jamshed, 2014). All participants (N=10) were encouraged to explain their views in detail. A general structure of the main topics was decided, and more detailed questions were asked as to when they surfaced during the interview. Concerning inter-rater's reliability, both external raters agreed in total (100%) with the initial array of themes and sub-themes; no measures of association could be computed for Kappa coefficient, because both variables among and within raters' responses were constants.

The following questions were posed to safety managers:

1. Do you follow a specific model or a conceptual framework during everyday practice and training for safety?
2. How do you use the models to assess risk perception of the operators?
3. Based on the model or conceptual framework you are using, how do you think emotional conditions, cognitive status, physiological status, and environmental factors influence the operators' risk perception?
4. Based on the model or conceptual framework you are using; how do you assess risk communication of the involved operators during everyday practice?
5. Based on the model or conceptual framework you are using; how do you think emotional conditions, cognitive status, physiological status, environmental factors, timeliness of communication, and the channel of communication influence the operators' risk communication?

6. Based on the model or conceptual framework you are using, where do you attribute the absence, if any, of the aforementioned factors during everyday practice and training?

7. What would you change to address these factors?

Exploiting the flexibility provided by the semi-structured interviews to generate more in-depth data, the researcher used the same techniques as with the interviews with the safety investigators. Concerning ethics, participant management, and procedure, the process was identical with the one described in part 3.3.3. The general inclusion criterion for safety managers (n=12) was the up-to-date experience and practice at an air-carrier organisation for at least a year.

Table 3-14: Demographic Information of Interviewed Aviation Safety Managers

Variable	**Values & Distribution (N, %)**		
Age	≤ 35 (2, 16.7%)	36 – 50 (4, 33.3%)	≥ 51 (6, 50%)
Year started working as Safety Manager	≤ 2000 (1, 8.3%)	2001 – 2010 (10, 83.3%)	≥ 2011 (1, 8.3%)
Region of nationality	European (11, 91.7%)	Non-European (1, 8.3%)	
Organisational Training	European (5, 41.7%)	Non-European (1, 8.3%)	
National Authority Training	European (6, 50%)	Non-European (1, 8.3%)	
Highest education level	Bachelor or lower (3, 25%)	Master or higher (9, 75%)	
Years working as Safety Manager	≤ 2 (2, 16.7%)	3 - 10 (8, 66.7%)	≥ 10 (2, 16.7%)

3.5. Method: Search for the appropriate Behaviour-Based Approach (Sub-study 3)[9]

This scoping review followed the guidelines of Tricco et al. (2018) and Munn et al. (2018) and targeted studies describing behavioural-based intervention approaches between 1979 and 2019. The period of 40 years was deemed adequate to capture a wide array of approaches.

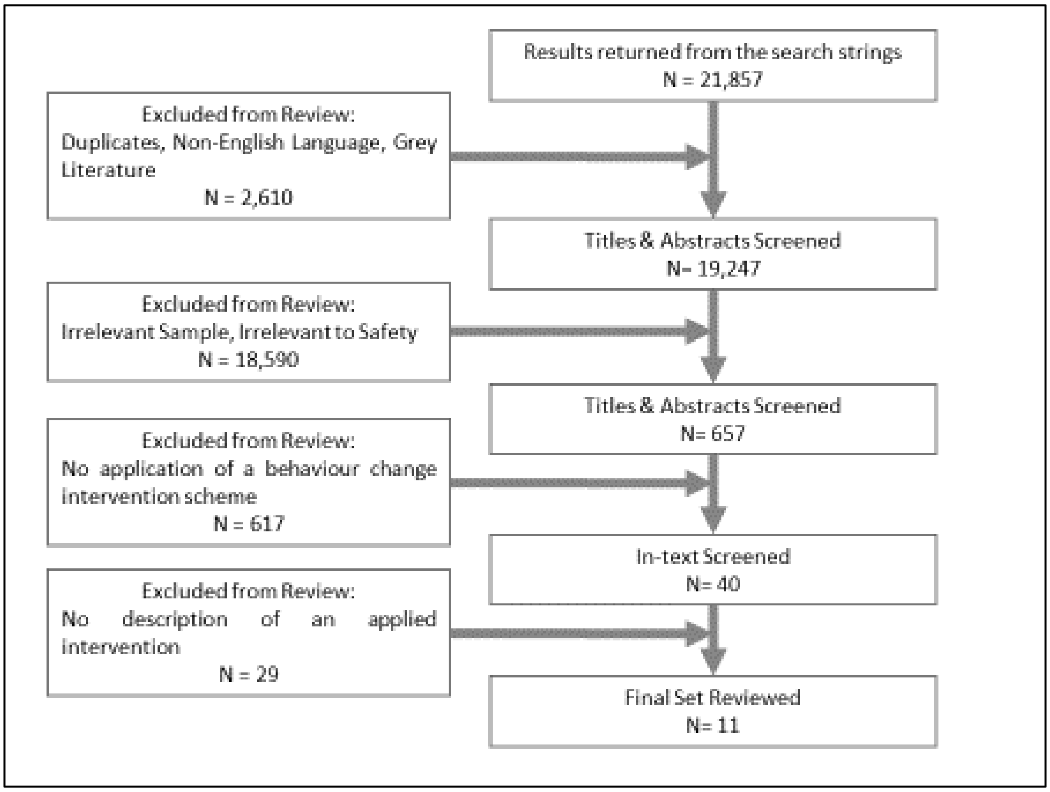
[9] Chionis, D., Karanikas, N. (2022). Risk Perception and Risk Communication from a Systems Perspective: a Study on Safety Behavioural Intervention Frameworks and Functions Systemic Practice and Action Research. https://doi.org/10.1007/s11213-022-09590-3

The bibliographic databases PsycARTICLES, PsycINFO, Scopus, Taylor and Francis online, Wiley Online Library, JSTOR and Google Scholar were searched using the string"(Behaviour **OR** Act **OR** Attitude **OR** Performance **OR** Conduct) **AND** (Change **OR** Maintain **OR** Understand **OR** Comprehend **OR** Assess) **AND** (Theory **OR** Principle **OR** Model **OR** Intervention **OR** Mediation".

The initial search returned 21,857 online records. We then excluded duplicates and non-English language and grey literature sources (e.g., professional magazine articles, industry reports), reshaping the sample at 19,247 records. Adjacent, titles and abstracts were screened to include only full-text studies using adults, addressing occupational health (long-term effects) and occupational and operational safety (short-term effects), and performed originally in the healthcare and transportation sectors. The latter criterion was applied as the initial read of several studies in other industry areas suggested they primarily regarded the migration of safety approaches from healthcare and transport to other high-risk fields (Catchpole, Sellers, Goldman, McCulloch, & Hignett, 2010; Macrae & Stewart, 2019). Additionally, based on Everdij and Blom's (2016) taxonomy, most safety analysis methods covering all system elements (e.g., hardware, software, humans, procedures, organisation) originate from or have been mainly applied to transportation and healthcare.

The abstracts of the 657 sources meeting the criteria above were further screened to include only studies about behaviour change interventions, yielding 40 records. The full versions of the latter were then assessed to include only cases of applied interventions and exclude only theoretical positions or in-vitro studies, leading to a final sample of 11 papers. An examination of the list of references of those papers did not reveal any additional study meeting the inclusion criteria above. The screening process was conducted by two researchers (Gartlehner, et al., 2020). Reliability checks between the two researchers were performed through percentages of agreement, reaching an average of 96% agreement for the four screening stages (Figure 3-15).

Figure 3-15: Flowchart of screened and reviewed articles



3.5.1. Analysis

The intervention framework/models mentioned in the literature reviewed were analysed to identify the intervention functions included (Table 2-7) and map their correspondences with clusters of system elements interactions, as per the SHELLO classification (Chang & Wang, 2010) explained below, risk perception and communication factors and specific improvement areas targeted through the latter factors. For the risk perception and communication factors, we used their categorisation into emotional, cognitive, physiological and broader environmental factors for risk perception and communication, and temporal and channel-related factors additionally for risk communication (Thomson, Onkal, Avcioglu, & Goodwin, 2004; Chionis & Karanikas, 2018).

The Software – Hardware – Environment – Liveware – Liveware - Organisation (SHELLO) classification (Chang & Wang, 2010) extends SHELL (Edwards E. , 1972; Hawkins & Orlady,

1993) as it introduces the organisation (O) separately from the environment (E), while maintaining the end-user (L) in the centre of the interactions with other system elements. Indeed, as our focus was on the end-user as the interlink connecting and interacting with all the other system components which shape and influence risk perception and communication, we considered all possible linkages between the SHELLO elements with the end-user in the centre. Hence, we contemplated the six clusters of SLHE, SLLE, LLOE, OLHE, SLOE, HLLE.

The reasoning for the analysis steps mentioned above was that:

- The number of SHELLO clusters per applied intervention framework/model would represent its current degree of inclusiveness of possible interactions amongst workplace system elements under a human-centric approach.
- The number of risk perception and communication factors per applied intervention would reflect the extent to which those factors are addressed.
- The frequencies of targeted improvements through the management of risk perception and communication factors across all applied intervention frameworks/models would highlight higher interest areas.

To identify the most inclusive intervention frameworks/models, the frequencies of SHELLO clusters and risk perception and communication factors were added per applied intervention framework/model to provide its coverage score, with 16 being the maximum possible score (i.e., six SHELLO clusters, four risk perception factors and six risk communication factors). Furthermore, we sought to detect the intervention functions which, in practice, could be less or more inclusive as self-standing approaches, and evaluate which ones could be relatively more effective and/or easier to enrich. To facilitate comparisons amongst intervention functions, we followed the steps below:

1. We calculated the frequencies and percentages of the SHELLO clusters and risk perception and communication factors per intervention across all frameworks/models those functions were used. For instance, if intervention function A was found in B

frameworks, and a cluster/factor was found C times (frequency) across those B frameworks, the percentage of the representation of the specific cluster/factor in intervention A was (C/B).

2. For the SHELLO clusters, we calculated their overall representation across each function as the average of individual cluster percentages. Then we ranked the functions, with the lowest rank corresponding to the function with the highest overall representation.
3. Regarding the risk perception and communication factors:
    a. We followed the same process described above to rank the functions based on SHELLO clusters separately for risk perception and risk communication.
    b. As the preliminary data analysis showed that only some factors were included in each intervention function, in addition we calculated how many factors were covered in each function. Then, we ranked the functions, with the lowest rank assigned to the function(s) with the highest coverage of factors per risk communication and perception regardless of their representation frequency.
    c. In the last step, we added the ranks from steps 3a and 3b above separately for risk perception and communication. In the combined ranks, the lowest score corresponded to the function with the relatively better representation and coverage of the risk perception and communication factors.

Finally, the ranks from steps 2 and 3c per function were added. The functions were ranked based on their final score, with the lowest figure corresponding to the function relatively more inclusive of the SHELLO clusters and risk perception and communication factors. We decided on the use of ranks to communicate the results in a more readable way as the consecutive additions of percentages from the steps above could result in figures challenging to read and interpret.

Two raters with extensive research backgrounds and experience in qualitative methods in psychology and neuroscience analysed the sources individually, and we performed reliability checks through percentages of agreement. The agreement reached was 96% for the intervention functions, 91% for the SHELLO clusters, and 96% for the risk perception and communication factors and improvement areas they targeted.

3.6. Method: Behaviour-Based Approach Investigation of Applicability (Sub-study 4)

The next step in the methodology for this thesis is to draft and modify a robust model capable of being integrated into an individual's and an organisation's line of operation in order to constitute both of them having enhanced risk perception and communication. In other words, the aim is to specify further the factors associated with the secondary data and which measured of the investigated variables is related to which variable and factor, and thus achieving a representation of how well the variables and factors are related. The attempted model draws from the combined results of the previous sub-studies, and the initial conceptual framework, dictating the tactical approach towards participants to finalise results (i.e. use of questionnaires, interviews, or both). The reasons for performing this sub-study were threefold. First, the aviation personnel were chosen to locate any differences concerning their attitude about factors disrupting risk perception and communication with safety investigators and managers. Second, they would provide for each category the most effective intervention method which had changed their behaviour. Third, they would provide the third part of input beyond safety investigators and safety managers concerning risk perception and communication factors affecting safety. The aviation personnel were chosen as the third part of a wider research as the relatively non-experts on safety as investigators and managers, but the recipients of their actions.

3.6.1. Connecting the Experts with the Aviation population

An online survey instrument was designed based on inputs from a panel of five experts to establish face and concurrent validity and ensure readability, clarity and a user-friendly layout. All experts are experienced in the creation and use of research surveys, and two of them are highly experienced in the field of safety. In addition to the demographics section (age, work experience and organisational type), the questionnaire consisted of two main parts (risk perception and risk communication), with two sections each (Appendix 6).

The first section of each part prompted the participants to state the five most important factors which disrupt risk perception and communication during their work activities. The second section of each part included properly reworded definitions of the intervention methods proposed by Michie et al. (2009): education, persuasion, incentivization, coercion, training, restriction, environmental restructuring, modelling, enablement. The rephrasing of the definitions aimed to present those to the sample as organisational practices. Through a 5-point Likert scale (1-very unhelpful, 2-not helpful, 3-unsure, 4-helpful, 5-very helpful), the participants were asked to rate the perceived “helpfulness” as a measure of effectiveness of each method towards improving their risk perception and communication. The sample was prompted to rate only the intervention methods they had experienced at any stage of their professional career.

All sections achieved an Average Congruency Percentage (ACP) =90% (Popham, 1978) amongst the experts, the engagement of which ensured relativeness of the survey items with the targeted sample (Bolger and Wright, 1994). The reliability check for the open-ended questions after eliminating unrelated codes and missing values resulted in 1.0 content validity ratio (CVR) (Ayre & Scally, 2014).

The anonymous survey was distributed via the Prolific platform (Prolific, 2020) to aviation personnel working or having worked as a fully licensed professional according to the applicable regulatory framework of each country. Due to the exploratory nature of this research, there was no focus on a particular region (Hackworth, Holcomb, Banks, & Schroeder, 2007) and we targeted participants of any age, including retirees. Before its release, the survey pilot tested by paid participants through the Prolific platform (Prolific, 2020) to establish reliability and apply revisions. The processing of the data from the pilot test resulted in Cronbach’s alpha values of a = 0.784 for risk perception and a = 0.846 for risk communication, which were judged as satisfactory (Cortina, 1993; George & Mallery, 2003; Coolican, 2014).

Considering the large number of professionals in the aviation industry, the minimum acceptable sample size was set to N = 267 (Adam, 2020). The data were processed with the SPSS 25 software (IBM, 2019) for the Likert-type data and NVivo12 (QSR International Pty Ltd., 2018) for the qualitative data. The first processing of the data collected suggested age and work experience were highly correlated ($r=0.810$, $p<0.001$). Therefore, during the analysis we considered only the latter as a more variable for the objectives of this research.

Regarding the quantitative data, in addition to calculations of medians to derive the overall picture, Kruskal Wallis tests were conducted to examine variations of the intervention function scores across types of organisations under a hypothesis of non-significant differences. The hypothesis was that under the context of organisational development as a critical process that supports organisations build their capacity to achieve greater effectiveness by developing strategies (Cummings & Worley, 2009), all examined organisation groups should present no variations. Also, Spearman’s correlations were performed to examine associations between the years of experience and the scores. The hypothesis was that the sample as professionals may see behavioural specificity as a challenge to their professional autonomy (Michie & Lester, 2005) and as such the higher the experience the less “helpful” the interventions would seem.

Friedman tests were used to examine significant differences amongst the nine intervention functions, under a hypothesis of significant differences based on the premise that the functions derive from various existing frameworks (Michie, van Stralen, & West, 2011). Last, Wilcoxon Signed Rank tests were conducted for the same functions between the scores they yielded for risk perception and communication. The test was under a hypothesis of non-significant differences that according to COM-B model's associations with the interventions (Michie, van Stralen, & West, 2011). As each dependable variable was used in two statistical tests against independent variables (i.e., organisation type and work experience), the overall level of statistical significance a=0.05 for the specific tests was adjusted to p=0.025 based on the Bonferroni correction (Armstrong, 2014).

Regarding the qualitative data, Thematic Analysis (TA) was used to examine patterns concerning risk perception and communication factors (Rubin & Rubin, 2012). The TA was conducted according to the guidelines by Braun and Clarke (2006). First, a random set of answers were analysed using TA to produce codes which, then, were cross-checked against the rest of the data to apply any necessary modifications of codes and their definitions. An initial TA was then conducted producing codes, which was later reviewed by three external coders (Jackson, 2016) who were provided with lists of quotes, sub-themes and themes to match.

The independent coders crosschecked the themes and their definitions against quotes from the dataset (Roberts, Dowell, & Nie, 2019). Fleiss's Kappa was performed to determine the degree of agreement between the three external coders. Each coder rated the code in three categories: "I agree", "I disagree", or "I am unsure". The inter-coder agreement was set above 60% to be sufficient (Altman, 1999). After three rounds, Fleiss' kappa showed that there was good agreement among the coders' judgements during the first round, κ=.688 (95% CI, .490 to .886), p = .000.

3.6.2. A Strategic Communication Integration Plan

This part aims at the way the model should be designed to be a purposeful part of the operators' and their organisations' mission. This transaction between the design of the model and its integration describes a delivery taking effect after communicating the model in the way to deliver its purpose as described right above. The research field addressing the manner organisations use communication purposefully for their mission purposes is strategic communication (StratCom) (Van Ruler, 2018; Heide, Von Platen, Simonsson, & Falkheimer, 2018; Werder, Nothhaft, Verčič, & Zerfass, 2018; Zerfass, Verčič, Nothhaft, & Werder, 2018). StratCom is a multidimensional concept by nature that assimilates various communication disciplines (i.e. business, corporate, organisational, and public communication), as well as sociology, psychology, and biology (O' Connor & Shumate, 2018; Heide, Von Platen, Simonsson, & Falkheimer, 2018; Seiffert-Brockmann, 2018). This teleologic approach is also justified in this thesis since StratCom's main aim is to advance through communication an organisation's mission and modularity of decision-making process is one of the foci of StratCom research (Van Ruler, 2018; Seiffert-Brockmann, 2018; Zerfass, Verčič, Nothhaft, & Werder, 2018). In this notion, the model will not only explain how risk perception and communication can be enhanced but also, ways of integrating and applying it into the work routine. The adjective "Strategic" for StratCom means the indication of goals and strategies and their development through the elaborate application (Van Ruler, 2018; Heide, Von Platen, Simonsson, & Falkheimer, 2018). The delivered product of this final sub-study will be the targeted model and a strategic communication plan or strategised communication, which is narrative by nature (Winkler & Etter, 2018). Moreover, this StratCom plan from a narrative lens in its application is usually contested, circular, and polyphonic by nature (Winkler & Etter, 2018; Heide, Von Platen, Simonsson, & Falkheimer, 2018).

In relation to the pragmatic paradigm used in this thesis, the strategic character of StratCom also draws from strategy theory where the planner (i.e. *strategos* in Greek) lays a rational long-term plan, or as it is more recently used a more emergent plan addressing a more realistic world of continuous change (Van Ruler, 2018; Winkler & Etter, 2018; Zerfass, Verčič, Nothhaft, & Werder, 2018). In a realistic world the involved stakeholders are the various specialities in the aviation context, the organisations, their policy and regulations system, as well as auxiliary systems and operators such as facilities and AI, constituting a need to address the complexity and interconnectedness of their relationships among them (O' Connor & Shumate, 2018).

From that perspective, this sub-study takes into account a network approach which will utilise the three current interrelated trends in StratCom (digital evolution, new message contributors, one-to-one communication platforms) (O' Connor & Shumate, 2018). Specifically, as O' Connor and Shumate (2018) highlight the digital evolution is a catalyst for the continuous enhancement of how organisations and operators cocreate and evolve their relationships. Adjacent, the operators themselves possess the ability to generate content receiver the role of 'influencer', weakening the organisations' ability to control communication. Moreover, the 'dark social' mandates that operators may counteract the open communications networks using digitised means (e.g., social media). This peer-to-peer chat functionality can be redeemed with the use of 'influencers' (Pineiro, 2015).

The phases of planning the integration part beyond the model follow the guidelines as posed by strategic planning for public relations as the alter ego of StratCom (Smith R. D., 2013; Macnamara, 2018; Zerfass, Verčič, Nothhaft, & Werder, 2018), and are separated in phases and stages as briefly follows:

Phase One Formative Research

Step 1: Situation Analysis

Situation analysis aims at exploiting opportunity and obstacles. Opportunity depicts the providence of advantages for the operators and the organisations. Obstacles provided with a limit needed to be overcome challenging the operators and the organisations to evolve. So, the objective of this step is to reach a consensus about whether the issue at hand is an opportunity or an obstacle, and if it is an obstacle, to turn it into an opportunity.

Step 2: Organisation Analysis

An organisational analysis is further segmented into smaller foci of research. In order to understand the organisation's communication nature, a public relations audit is required. The public relations audit addresses data from the internal/external environment and public perception.

Step 3: Target Audience Analysis (TAA)

TAA or publics analysis aims at analysing the group of individuals or an individual sharing common traits and interests. There are four main categories of public groups, the customers, those that benefit from the organisation, the producers, those that aid the normal organisational functioning, the limiters, those that obstruct the effective organisational functioning, and the enablers, those that aid the effective organisational functioning.

Phase Two Strategy

Step 4: Establishing Goals and Objectives

This step aims at clarifying the organisation's and the individual's goals and objective; what is they want to achieve. A goal is rooted in the organisation's and the individual's mission while an objective emerges from the goals as a measurable point or proof of achievement.

Step 5: Formulating Action and Response Strategies

This step urges the StratCom planner to choose between action proactive or reactive strategies. Proactive strategies enable the organisation to launch activities under framed conditions and a pre-determined timeline according to its interests. Reactive strategies counter inputs outside the organisation's and individual's intentional planning.

Step 6: Using Effective Communication

This step refers to the approach of audiences already analysed concerning the set objectives and effective methods (e.g., using verbal persuasion) to communicate them.

Phase Three Tactics

Step 7: Choosing Communication Tactics

This step describes the communication tactics as the visible elements to employ the strategic plan. These include the use of media or material equipment (i.e. whiteboards). Specifically, there are four categories; (a) face-to-face communication, (b) organisational media/aids, (c) news media, (d) advertising/promotional media.

Step 8: Implementing the Strategic Plan

This step refers to the materialisation of the material that has been prepared in the previous steps in terms of specific programming, inventory of tools, and scheduling, drafting the campaign plan.

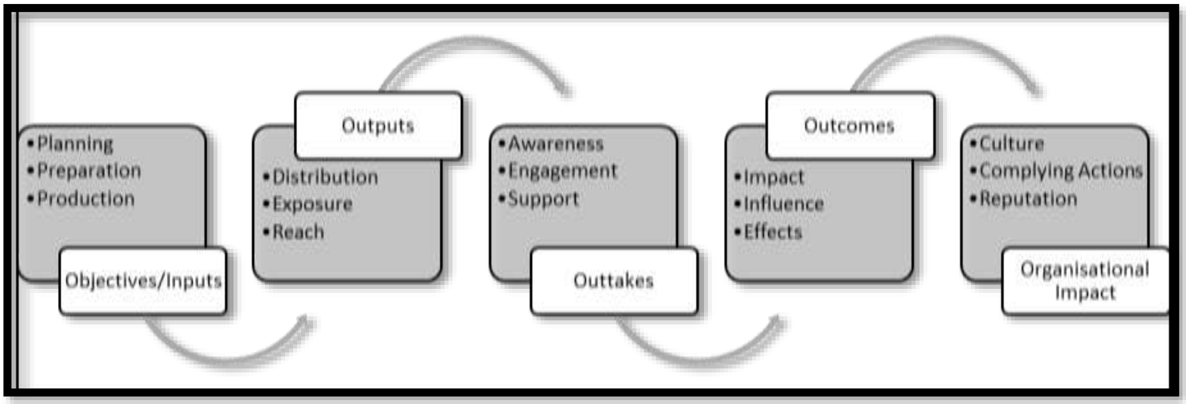
Phase Four Evaluative Research

Step 9: Evaluating the Strategic Plan

As revealed in a thorough mixed approach study by Macnamara (2018), there is a pattern in evaluation models revealing simply what is the aim to accomplish, to whom, and whose interests are attended. The common parts of the evaluation strategies review by Macnamara (2018) are the objectives and the outputs and the course they take in an organisation (Figure 3-16).

Nonetheless, steps 8-9 are not examined in this thesis since this would require further experimentation within an aviation organisation, which deviates from this thesis' scope.

Figure 3-16: StratCom Evaluation Mode (Smith R. D., 2013; Macnamara, 2018)



Also, the generated model products should follow the operational narrative formats for effectiveness, explicitly stating (a) the problem-threat, (b) causes of the problem, (c) what needs to be done about the problem-threat, (d) what needs to be avoided (conditional), (e) the end-state (Karlsson & Westenkirchner, 2018).

To collect data for the TAA, the model's pre-validation and integration process, a questionnaire is designed based on the examined factors, parameters, and concepts in the previous steps of this thesis. The questionnaire's design framework aims to examine the evaluations of the model's constructs and their affiliations by safety practitioners and end-users (i.e. other specialities) and to compare them with the samples practices as they are depicted through a second part in the same questionnaire using hypothetical scenarios.

3.7. Summary

This chapter focused on the methodological underpinnings of this thesis, which lead to the application of an interpretive mixed methods methodology. A retrospective analysis strategy on SAIMs and safety events was chosen to assess risk perception and risk communication factors inclusiveness. Adjacent, a scoping review was conducted on the available behaviour-based approaches to choose, adjust and apply in order to devise a viable intervention scheme-model of influencing-enhancing risk perception and communication. Finally, the results from the previous sub-studies fed the third sub-study in order to determine the exact intervention plan by depicting the relationships among factors and variables, and by orchestrating a strategy to promote the plan effectively to aviation stakeholders.

4. Chapter 4: Collective Findings

4.1. Introduction

In this chapter the reader will be met with the results of each sub-study in the order they were mentioned in the previous chapter. Based on the followed paradigm of research, the alignment of findings into this chapter, as per the previous one, into chapters rather than smaller narratives, serves the reader as per not forcing back and forth reconsiderations.

This chapter encapsulates the findings for the inclusion of risk perception and communication factors in Safety Aviation Investigation Methods (SAIMs), the inclusiveness of the mentioned factors in safety events' reports with the reflection of SMEs of the field, the most appropriate behaviour-based approach to the issue, and a final recuperation of applicability of the whole model. Notably, parts which would interfere with the text's flow are available in the appendices.

4.2. Sub-Study 1 Findings

According to the frequency analyses of risk perception and communication factors and the safety/risk assessment stages (Figures 4-17 to 4-19), the results are as follows:

a. The least represent factors in the sample concerning risk perception (19%) and risk communication (14%), were the emotional factors.

b. The environmental factors were found in 72% of the sample.

c. The remaining factors were found at an average rate, ranging from 49% to 56%.

d. Safety/risk assessment stages speckled between 21% and 45%.

e. The stages of Identification of Hazards (HAZ.ID), Risk Modelling (MODEL) and Risk Evaluation (EVALUATE) were embodied more frequently than the ones of Risk Mitigation (MITIGATE), Risk Monitoring (MONITOR) and Feedback (FEEDBACK).

Figure 4- 17: SAIMs' Distribution per Risk Perception Factors

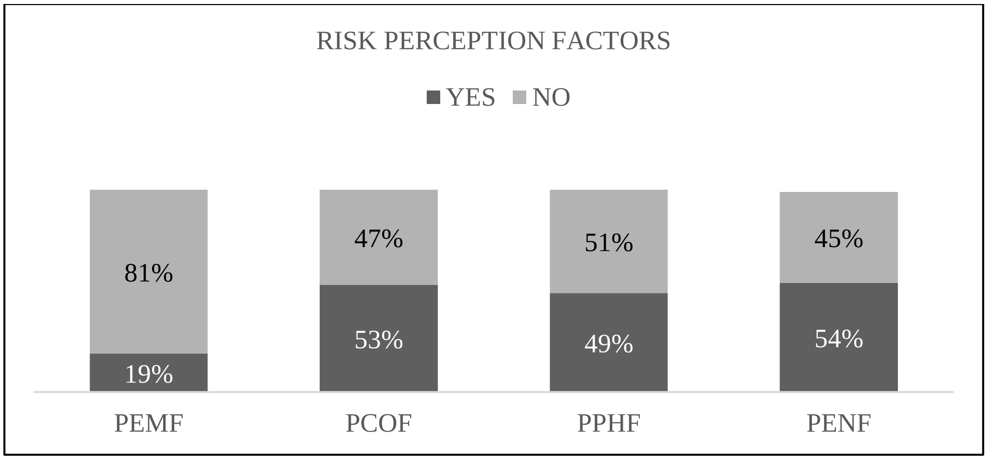


Figure 4- 18: SAIMs' Distribution per Risk Communication Factors

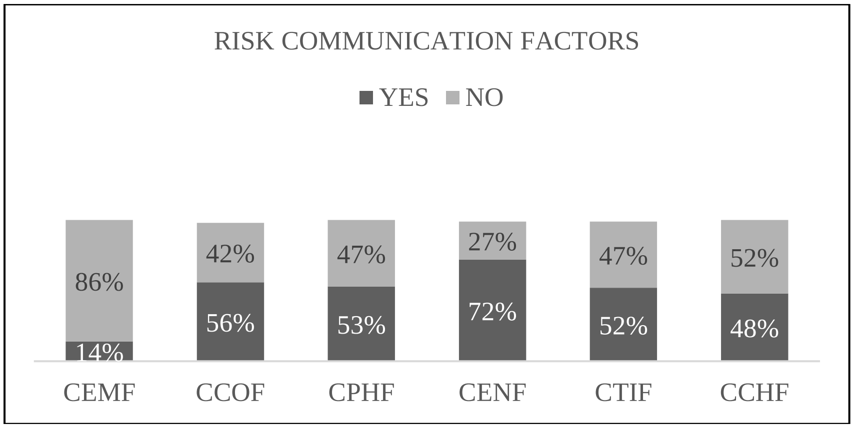
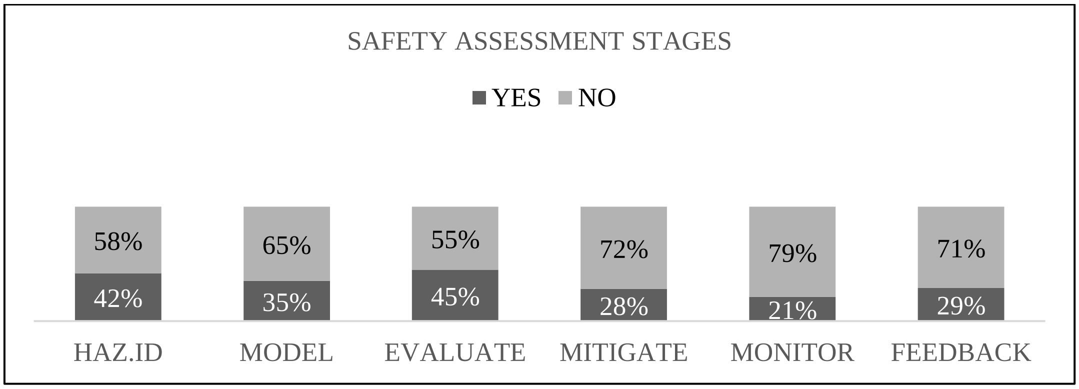


Figure 4- 19: Frequencies of Safety Assessment Stages



According to the Chi-square tests results, the risk-related analysis stages' inclusion within the SAIMs was not significantly different across the three SAIM types and four time periods. No significant differences about the risk perception factors were found regarding the distribution of risk perception and communication factors across the types of SAIMs and periods of publication, through the conducted Chi-square and Fisher Exact tests. However, regarding risk communication factors the following were found:

a. Emotional factors were found more frequently in systemic SAIMs and the ones published in the period 2000-2007.

b. Physiological factors were detected more in systemic SAIMs.

c. Environmental factors were more frequent in epidemiological and systemic SAIMs as well as in the ones published later than the year 2000.

d. Timeliness factors were mentioned more frequently in systemic SAIMs.

e. Communication channel factors were found more in epidemiological SAIMs, followed closely by systemic ones.

According to the Kruskal-Wallis tests, the inclusiveness of risk perception and communication related analysis stages was not statistically different across the SAIM types. Regarding the time period, the more recent the SAIM, the higher the ratio of the stages linked to risk communication [$\chi^2(3, n=100) = 9.163, p=.027$]. Moreover, Mann-Whitney tests results showed that the higher the ratio of analyses stages relevant to risk perception, the more frequent the reference to emotional, cognitive, physiological and environmental factors mentioned in SAIMs. Similarly, the ratio of analyses stages relevant to risk communication were found associating with the cognitive, physiological, environmental and channel factors.

Table 4- 15: Within Group Differences – Factors * Model Type * Time Period

Factors	Model Type			Time Period		
	Chi-Square Test Results	Percentages		Chi-Square Test Results	Percentages	
		Highest	Lowest		Highest	Lowest
CEMF	p = 0.022	S (64.3%)	R (7.1%)	p = 0.022	2000-2007 (28.6%)	1995-1999 (0%)
CENF	p = 0.025	E (38.9%)	R (23.6%)	p = 0.019	≥2008 (95.7%)	1995-1999 (58.3%)
CPHF	p = 0.010	S (73.5%)	E (38.2%)			
CTIF	p = 0.022	S (64.7%)	R (32.3%)			
CCHF	p = 0.019	E (61.8%)	R (28.1%)			

Table 4-16: Within Group Differences – Factors * STAGESC * STAGESP

Factors	STAGESP			STAGESC		
	Mann-Whitney Test Results	Ranks		Mann-Whitney Test Results	Ranks	
		Highest	Lowest		Highest	Lowest
PENF	p = 0.000	Y (64.69)	N (32.38)			
PCOF	p = 0.000	Y (67.07)	N (31.82)			
PPHF	p = 0.000	Y (65.84)	N (35.76)			
PEMF	p = 0.039	Y (62.32)	N (47.73)			
CCOF				p = 0.005	Y (56.05)	N (40.76)
CPHF				p = 0.027	Y (56.17)	N (44.11)
CENF				p = 0.000	Y (57.23)	N (30.72)
CCHF				p = 0.008	Y (57.99)	N (43.59)

4.3. Sub-Study 2 Findings

4.3.1. Sub-Study 2 Quantitative Findings

After the assessment of the whole sample of safety Investigation reports, risk perception and communication environmental factors were those met more frequently (i.e. 77% and 73% respectively). As per other distinctive factors, physiological were the underrepresented (i.e. 2% and 3% respectively) with next the emotional factors (20% and 18% respectively). The rest factors were found in average frequencies (i.e. 39% to 66%). Particularly, risk communication exclusive factors, thus timeliness and channel-related factors were met as contributory factors in 43% and 66% respectively of the reports assessed.

Figure 4-20: Total Events' Distribution per Risk Perception Factors

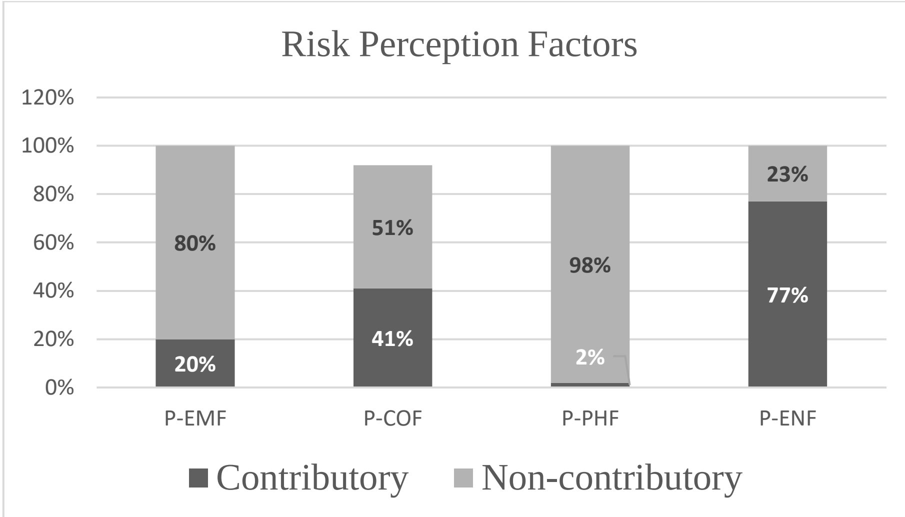
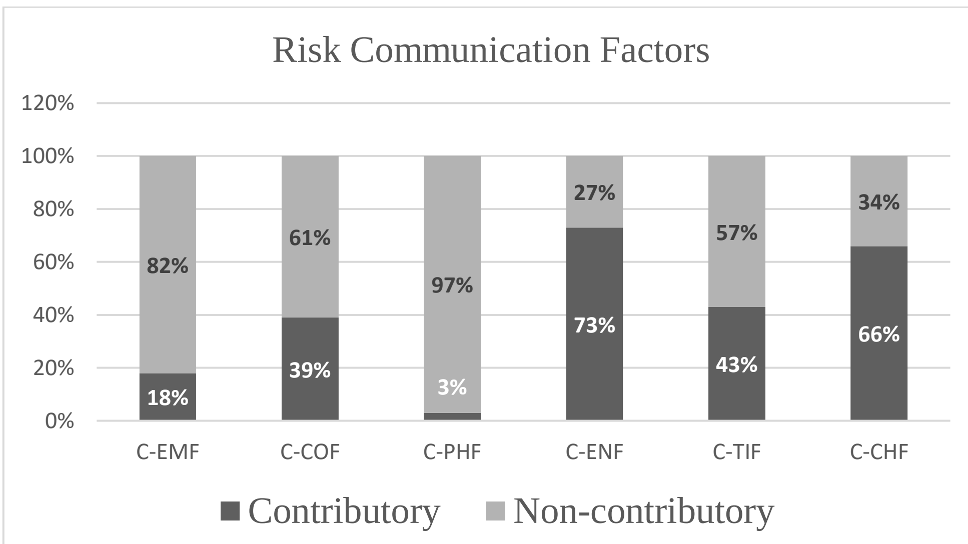


Figure 4-21: Total Events' Distribution per Risk Communication Factors



Among the flight stages, risk perception related ones varied between 12% and 64%; the higher frequencies were presented by flight planning, final approach and landing. On the other hand, risk communication related flight stages fluctuated between 30% to 87%, while cruise, final approach and landing were met with this contributory attribute. Notably, based on the findings, risk communication factors superseded risk perception factors, in all flight phases except flight planning (Table 4-20).

Table 4-17: Contribution of Risk Perception and Risk Communication per Flight-Stage

Flight Operations stages	Code	Risk perception (N, %) *	Risk communication (N, %) *
Flight Planning	FP	43	30
Push Back	PB	12	30
Taxi	TA	15	33
Take-Off	TO	31	40
Cruise	CR	33	47
Descend	DE	23	31
Final Approach	FA	42	59
Landing	LA	64	87

* Frequencies and percentages are the same since the sample size was 100

The tests on the distribution of contributing factors of risk perception and communication across the flight stages showed that:

- During the Flight Planning phase:
  - Cognitive factors (P-COF) of risk perception were more frequent [X^2 (1, N=100)=6.077, p=.018].
  - Environmental (C-ENF), Timeliness (C-TIF) and Channel (C-CHF) factors relating to risk communication were found less frequently present {correspondingly: [X^2 (1, N=100)=7.458, p=.009]; [X^2 (1, N=100)=7.194, p=.010]; [X^2 (1, N=100)=7.190, p=.014]}.
- In the Push Back phase, only risk communication Timeliness (C-TIF) was detected more frequently [Fisher's Exact test: N=100, p=.008].
- The Cruise phase concerned, only risk communication Cognitive factors (C-COF) were reported more frequently [X^2 (1, N=100)=8.591, p=.005]

The tests regarding the frequencies across the three time periods (2009-2011, 2012-2014 & 2015-2018) revealed the following significant differences:

- Cognitive (P-COF) and Environmental (P-ENF) factors related to risk perception and Cognitive factors (C-COF) of risk communication were observed in the latest period of 2015-2018 significantly less frequently with percentages 16.9%, 26.0% and 12.8%

respectively {[X^2 (1, N=100)=17.356, p=.000]; [X^2 (1, N=100)=9.120, p=.009]; [X^2 (1, N=100)=12.602, p=.002] correspondingly}.

- Timeliness (C-TIF) and Channel (C-CHF) factors of risk communication were found more frequently in the latest period 2015-2018 with percentages of 39.5% and 47.1% respectively {[X^2 (1, N=100)=8.056, p=.016]; [X^2 (1, N=100)=7.912, p=.020] correspondingly}.

4.3.2. Sub-Study 2 Qualitative Findings

4.3.2.1. Sub-Study 2 Qualitative Findings – Safety Investigators

The Thematic Analysis conducted over the safety investigators revealed four themes referred to the hypotheses, with their respective sub-themes, encapsulating the sample's messages about risk perception and communication factors, as well as their roles as aviation practitioners and safety investigators. Table 4-21 reveals the particular themes and their sub-themes, with the number of their references in the interviews. Notably, Table 4-22 presents the specific factors the participants mentioned to affect risk perception and communication. Next follows a summary per theme and its sub-themes using extracts from the data.

Table 4-18:Thematic Analysis Findings for Safety Investigators

Themes & References (N, %)	**Sub-Themes**	
	Description	**References (N, %) within the Theme**
Risk Communication: Factors disrupting risk communication in operations (112 references – 45.90%).	Organisational Risk Communication: The role of supervision, training, and organisational communication structure is illustrated as crucial for risk communication to work. Unreliable supervision, insufficient training, as well as a complex communication network can unsettle risk communication.	48 (42.85%)
	Timeliness in risk communication: The participants highlighted timeliness as a core trait and requirement for effective risk communication. Timeliness also interacts positively with time availability, training and the tasks' gravity.	17 (15.18%)

Themes & References (N, %)	Sub-Themes	
	Description	**References (N, %) within the Theme**
	Cognitive factors influencing risk communication: Information overload, faulty prioritisation processing, bias, complacency, experience, and speed in information processing were found to be equally important.	16 (14.28%)
	Emotional influence on risk communication: Emotion interacts with all other factors through anger, fear, and envy.	17 (15.18%)
	Communication means: The ways the information is transferred with the eloquent use of verbal communication.	10 (8.93%)
	Physiological factors influencing risk communication: Fatigue, sleep deprivation, high average age, resilience to workload, and spontaneous bodily disfunctions.	4 (3.58%)
Risk Perception: Factors disrupting risk perception in operations (97 references – 39.75%).	Organisational Risk Perception: The organisation influences risk perception through standard practices, through the amount of involvement, during operations, supervision, training, and culture.	34 (35.05%)
	Cognitive factors influencing risk perception: Cognitive factors influence risk perception through knowledge, life events, abstinence from work, experience, and time-availability for decisions.	24 (24.74%)
	Environment's influence on risk perception: Environment influences risk perception by spontaneous events which delay perception and by creating a tunnelling effect.	16 (16.50%)
	Emotional Influence on Risk Perception: Emotional factors disrupting risk perception are fear, peer pressure, personality, and the need for emotional diffusion.	15 (15.46%)
	Physiological factors influencing risk perception: The physiological factors were specified as high average age, fatigue, hyperactivity, and resilience to workload.	8 (8.25%)
Investigators' practices for risk perception (20 references – 8.20%)	Practices drawing from experience for risk perception; subjective and contextual process	13 (65%)
	Heuristics for risk perception with an emphasis on personal and environmental factors	7 (35%)
Investigators' practices for risk communication (15 references – 6.15%)	Practices drawing from experience for risk communication including employment of discretion, organisational data, information from investigated events and training on communication.	10 (66.67%)
	Heuristics for risk communication with a focus on handling of emotions.	5 (33.33%)

Table 4-19: Factors Influencing Risk Perception and Communication – Safety Investigators.

Category	Specific factors	Risk communication	Risk perception
Cognitive factors	Information overload	X	X
	Faulty prioritisation processing	X	X
	Complacency	X	X
	Personal proficiency	X	X
	Bias	X	-
	Experience	X	X
	Speed in information processing	X	-

Category	Specific factors	Risk communication	Risk perception
	Abstinence from work	-	X
	Life events	-	X
	Knowledge	-	X
	Time-availability for decisions	-	X
Emotional factors	Fear	X	X
	Lack of empathy	X	-
	Role models	X	-
	Anger	X	-
	Envy	X	-
	Peer pressure	-	X
	Personality	-	X
	Need for emotional diffusion	-	X
Physiological factors	High average age	X	X
	Fatigue	X	X
	Resilience to workload	X	X
	Sleep deprivation	X	-
	Hyperactivity	-	X
	Spontaneous bodily disfunctions	X	-
Environmental factors (Organisational)	Amount of involvement	X	X
	Organisational-cultural trends	X	X
	Gap between management and first liners	-	X
	Bad planning	X	-
	Unreliable supervision	X	X
	Organisational culture	-	X
	Insufficient training	X	X
	Unorganised multitasking	-	X
	Complex communication network	X	-
	Behaviour trends	-	X
Environmental factors (Physical)	Distance among peers	X	-
	Spontaneous events	-	X
	Tunnelling effect	-	X
Channel-related factors	Lack of uniform code of communication	X	Not Applicable
Timeliness factors	Time pressure-availability	X	
	Lack of effective group re-training	X	
	Tasks' gravity	X	

4.3.2.1.1. Risk Communication Theme – Safety Investigators

Based on the risk communication interview questions, safety investigators mainly referred to disrupting factors. This theme was noted in 112 references across the whole sample, representing 45.90% of total references across all four themes, while indicating the importance of these factors.

> Participant 110: "Communication is number one, the foundation of being safe".

Mainly, participants focused on organisational factors; unreliable supervision, insufficient training and complex organisational communication structure. Additional organisational factors were the operator's amount of involvement in a task and organisational-cultural trends. Next in a frequency scale was timeliness, followed by cognitive factors; bias, complacency, experience, speed in information processing, information overload and faulty prioritisation processing. Moreover, emotional factors were deemed highly important; anger, fear, and envy, lack of empathy, role models, and the eloquence to use mainly verbal communication. Overtly highlighted emotional factors were the divergent prioritisation of tasks, emotional distance among communicators, fatigue and time pressure, and limited audience to communicate. The least mentioned factors were the physiological ones. References for those factors included high average age, fatigue, sleep deprivation, and spontaneous bodily dysfunctions (i.e. medical emergency). Additionally, a broad weight was given on the influential role of individual capabilities, specifically mentioning resilience to workload, constitution, habituation, and reluctancy in expression.

4.3.2.1.2. Risk Perception Theme – Safety Investigators

Similarly, all the participants mentioned the factors disrupting risk perception with 97 references, in a 40% of the total references documented. As before, the participants prioritized emphasis on specific factors. Organisational factors were again first in focus, influencing risk perception through standard practices during operations, supervision, training, and culture.

Participant 102: "Operational needs for quick deliveries diminish risk perception and situation awareness".

Next in focus were the cognitive factors. The participants stressed knowledge, experience, and decisions under limited time as important cognitive factors. A lesser focus was shared with the subthemes of emotional and environmental influence and physiological factors. Concerning the emotional factors, the participants described the influence of peer pressure, personality, and the need for emotional diffusion. Also, they held environmental factors responsible for delaying perception and creating a tunneling effect. Following, the participants overtly stressed the importance of volatile environmental inputs (i.e. weather), organisational culture, multitasking, peer-pressure, and complacency. Concerning the physiological factors, they specified them to be fatigue, hyperactivity, and physical resilience.

Participant 104: "… so usually when I am frustrated with something, I tend to make decisions that are blunter…I am harsher with other people or with the people that are involved".

Participant 101: "The more tired you are, you have a more distorted perception".

4.3.2.1.3. Investigators' Practices for Risk Perception

Based on their duties as investigators, the participants referred on their ways to detect factors influencing risk perception and assess risk perception overall. Seven participants out of ten , in 20 references, shared that investigation of risk perception and any associated factors is mostly based on the investigator's experience and perception of the situation of interest. Notably, investigators rely on their professional background (i.e. pilots, engineers) to comprehend any factors disrupting risk perception and determine whether it was at fault by examining the outcome of events.

Participant 102: "We understand risk perception from the outcome".

Risk perception was described as subjective and contextual (13 references from 6 participants), while the lack of experience may lead an investigator to apply heuristics (i.e. judging by the appearance) to understand the influence of environmental and personal factors (7 references from 4 participants).

Participant 103: "Different individuals,see different risks. [They have] risk assumptions based on their contextual experiences ".

Participant 107: "Nowadays an investigator can understand. If the investigator knows the context, he should consider it in my opinion again with the frequency of exposure of these people in this natural environment how accustomed they were to do this work or this task or whatever they do in this natural environment. In the organizational environment, there are two cases again, if he knows it and he has experienced it, it is easier to perceive and to exclude some factors, which they're not going to lead him anywhere. Because even if he's going to believe they're going to lead him somewhere, he won't be able to prove it, which is why the most fundamental thing about investigating, is backing the findings. Those that we believe urge us to try to be motivated to comprehend our findings on the basis of data and information we collect in an investigation ...That's for the organizational environment".

4.3.2.1.4. Investigators’ Practices for Risk Communication

This theme encapsulates the ways safety investigators consider and evaluate risk communication influence and relevant factors. Seven participants described within fifteen references, grouped into two sub-themes, their practices. Concerning the heuristics they employ (5 references from 4 participants), they underlined on the role of emotions when communicating risk. On the occasion they need to draw from their experience (10 references from 7 participants), they stressed the use of discretion, the use of organisational data to interpret organisational involvement, lessons learned from investigated events, and training on communication.

Participant 103: "Some people are very reluctant to express their ideas and their feelings. Right. Some people don't. Sometimes they even don't laugh. They don't smile right. They don't talk to each other. ... Basically, what we do is this; we try to understand the body language using the body language techniques".

Participant 109: "I will give you our situation here. For example, in my country. How we act after any accident. After any accident you have to be at the workplace and to investigate the reasons of the accident. And after that, we have to apply the legislation directly. We have to go to ameliorate and avoid these causes, work with it. We support each other. We give it [organisation] the guidelines we give it the training. We speak about emotion by example, thinking by example, give them other examples of other companies who have succeeded to avoid accidents like theirs. We have seen many other situations. And we can give them your [an investigator] point of view. And how well to practice by example and by your experience you can help them to improve and overcome this like this situation".

4.3.2.2. Sub-Study 2 Qualitative Findings – Safety Managers

Similar to the case of safety investigators, safety managers maintained their focus on four themes and sub-themes describing the role of factors affecting risk perception and communication during daily flight operations. Table 4-23 includes the themes and sub-themes with their ratio within the interviews. Subsequently, Table 4-24 enumerates specific factors which safety managers suggest that affect risk perception and communication. The following paragraphs constitute a summary per theme and respective sub-themes using extracts from the interviews.

Table 4-20:Thematic Analysis Findings for Safety Managers

Themes & References (N, %)	**Sub-Themes**	
	Description	**References (N, %) within the Theme**
Risk Perception: Factors disrupting risk perception in operations (132 references – 37.93%).	Cognitive factors disrupting Risk Perception: Rational judgement can be disrupted by safety thinking, experience, biases and workload.	43 (32.57%)
	Emotional Factors disrupting Risk Perception: Naturalistic thinking and sentimental attitudes are disrupted by anger, fear, trust, stress and conflict between intention and self-capacity.	34 (25.75%)
	Organisational Factors disrupting Risk Perception: Externally to the risk assessor can be added pressure, injustice, cultural discrepancies and inconsistent procedures.	30 (22.72%)
	Physiological Factors disrupting Risk Perception: Risk perception can be disrupted through physical and mental fatigued state, the audio-visual channel, and the physical task load pressure.	13 (9.84%)
	Environmental Factors disrupting Risk Perception: The environment can disrupt risk through intolerable temperatures, noise, and lighting.	12 (9.09%)
Risk Communication: Factors disrupting risk communication in	Organisational Influence on Risk Communication: Contextual culture issues widen the trust gap among personnel levels within organisations.	26 (19.55%)

Themes & References (N, %)	Sub-Themes	
	Description	**References (N, %) within the Theme**
operations (133 references – 38.21%).	Communication Means: A limited capacity to use traditional and modern means of communication can inhibit the demanded potential of the reporting system.	26 (19.55%)
	Emotional disruption on Risk Communication: Emotion inhibits communication initiative and flow due to fear and conflict between intention and self-capacity.	24 (18.04%)
	Cognitive Factors disrupting Risk Communication: Experience and memory capacity, personal biases and educational level disrupt proper circulation of information.	20 (15.04%)
	Timeliness in Risk Communication: Participants rendered timeliness of message deliverance as the core principle to circulate the right information to the right stakeholders from a mixed perspective.	19 (14.28%)
	Physiological Factors disrupting Risk Communication: Physiological limits disrupt psychosomatic state rendering imbalances on communication initiatives.	12 (9.02%)
	Environmental disruption on Risk Communication: Proper Personal Protective Equipment (PPE) and policies should not hamper working conditions.	6 (4.51%)
Managers' practices for risk perception (56 references – 15.95%)	Heuristic Practices for Risk Perception: Managers use heuristics for risk perception with an emphasis on personal and environmental factors.	35 (62.5%)
	Practices Drawing from Experience for Risk Perception: Managers use practices drawing from experience for risk perception; subjective and contextual process.	21 (37.5%)
Managers' practices for risk communication (27 references – 7.69%)	Heuristic Practices for Risk Communication: Managers use heuristics for risk communication emphasising on the personal difference a Safety Manager can make mediating for all disrupting factors of risk communication.	14 (51.85%)
	Practices Drawing from Experience for Risk Communication: Managers use practices drawing from professional past background used to apply safety models and use communication means in a timely manner.	13 (48.15%)

Table 4-21: Factors Influencing Risk Perception and Communication – Safety Managers.

Category	Specific factors	Risk communication	Risk perception
Cognitive factors	Experience	X	X
	Bias	X	X
	Mental Workload	-	X
	Memory Capacity	X	-
	Mental Fatigue	-	X
	Habits	X	X
	Routine	-	X
	Distraction	-	X
	Naturalistic vs Rational Thinking	-	X
	Educational Level	X	-
Emotional factors	Anger	-	X
	Fear	X	X
	Trust	-	X
	Stress	-	X
	Mood	-	X
	conflict between intention and self-capacity	X	-
Physiological factors	Sight	X	-
	Hearing	X	-
	Physiological Fatigue	-	X
	Psychosomatic Issues	-	X
	Physical Task Load Pressure	-	X
Environmental factors (Organisational)	Pressure	-	X
	Injustice	-	X
	Cultural Discrepancies	-	X
	Lack of Training	X	-
	Complex Organisational Structure	X	-
	Inconsistent Procedures	-	X
	Lack of Flexibility	X	-
	Level of Mutual Trust	X	X
Environmental factors (Physical)	Temperature	X	-
	Noise	X	-
	Lighting	X	-
Channel-related factors	Versatility in using traditional and new media	X	Not Applicable
	Inadequate of Technical Means	X	
	Customised Means to Target Audience	X	
Timeliness factors	Time pressure-availability	X	
	Information Complexity	X	
	Message Comprehensibility	X	
	Information Criticality	X	

4.3.2.2.1. Risk Perception Theme – Safety Managers

Safety managers referred to factors disrupting risk perception in daily operations, per their experience. This theme was noted within 132 references, constituting 37.93% of all the references used from all four themes, indicating the importance given to risk perception from the managers. The general notion of this theme was that risk perception is derived by the consistency and extend of safety thinking applied in daily operations. Hence, any diversions leading to unsafe situations mandate foremost a change of safety thinking.

Participant 201: “First of all we need to change the safety mindset. Of course we have to change the safety thinking”.

The factors influencing risk perception were identified from the allocation of interest concerning the sub-themes. The diversions caused by safety thinking can be depicted by the allocation of focus on the following factors. Most prevalent were the cognitive factors with 43 references from 10 participants. Safety investigators mainly underlined that risk perception is influenced by the safety thinking on all levels in the organisation. Hence, they also focused on the influence of experience, personal biases and workload.

Participant 204: "If you have not managed the person involved in a process to be at that cognitive level that the procedure requires, it becomes extremely difficult for that person to perceive the risk in its correct dimension, thus being willing to take a greater risk".

Following, emotional factors were mentioned with 34 references by 11 participants. Safety managers argued that all personnel are subjected to the influence of anger, fear, trust, stress and considerations over their self-image, leading them to divert their risk perception.

Participant 207: "In other words, we have three cases where emotion affects the user to be impulsive, self-righteous, to be a little more sensitive to criticism. That's what we're dealing with".

Ten participants with 30 references concentrated on the way that organisational factors influence risk perception. Once more, the participants described disrupting factors, which were pressure to deliver results, injustice as delivered from a sense of depreciation due to lack of just culture and meritocracy. The latter being in conjunction with cultural discrepancies deriving from national and organisational culture. Additionally, organisational inconsistency over procedures disrupts risk perception according to the interviewed safety managers.

Participant 201: "So something that will be considered as a high risk for a frontline operator for the management it might be just a low risk and vice versa. So there is a gap there".

Participant 202: "The absence of just culture is what might affect the individual's risk perception. If they would be afraid that they will be punished they would not report any errors or any mistake".

Concerning physiological factors, 7 out of 12 participants with 13 references confirmed their disrupting role. Interestingly, the participants underlined mostly the initiation of physiological reaction as a derivative from emotional states, leading to a psychosomatic reaction in total. However, they argued that a comfort self-image could lead to an invulnerability state, which could lead to physiological inadequacies, depending the context. Based on that vicious cycle, risk perception and its relationship with physiological factors is through the bodily process of fear, impatience and biases.

Participant 207: "Of course, if we go into individual bodily functions such as vision or hearing there it certainly affects because an employee who provides a high-risk job and does not see well will have to be particularly careful with the rest of them so that it cannot work badly for the work they provide. The man is also selfish from the inside may think that he is judging it and does not seem to affect his work, secondly he may not want to admit that it has a critical effect on his work, thirdly he may have found a way to hide it".

Participant 211: "Physiology to the extent that it coincides with psychology is relative. One may have an overestimation of potential to downplay risks because they feel able to do anything, so physiology is indirectly related".

Regarding the environment's contribution to risk perception, half the participants that it disrupts risk perception, with 12 references. However, they deemed its role as indirect and confounded with the sense of discomfort due to heat, noise and lighting conditions towards haste during procedures and confirmation bias.

Participant 205: "I am thinking that the environmental factors is a mediator of the cognitive status, the psychological status, the physiological status and the emotional status. So if we are talking about intensity of light, if we are talking about the density of noise, if our environmental factors are that I'm thinking them as the mediator for the cognitive and psychological status, but if we are talking the environment is the internal business administration, if we mean the political environment if we mean the country's cultural environment, it is difficult. It is different. Yes".

Participant 210: "The environment affects much more if we get into a logic of exaggeration. Climate conditions, for example, as long as they become more severe in terms of heat or cold to produce a particular project, are sure to have a contribution rate to which a project is at risk".

4.3.2.2.2. Risk Communication Theme – Safety Managers

This theme presents the factors disrupting risk communication in daily operations, as depicted by safety managers. The theme "Risk Communication" collected 133 (37.81%) references among all 12 participants. The main focus was that risk communication is the main catalyst to shape the information environment around safety and risk management.

Based on that, it is also implied that risk communication works as the facilitator for an effective risk perception.

Participant 205: "Based on my experience the risk communication's main purpose should be that everybody understands, perceive and assure that there is a safety management system and it runs effectively. So the people in the company should every time take memos take the report of the conventions, get the feedbacks about their reported hazards. They think that yes, there is something happening here about the safety and the company thinks about our safety. They are thinking us they are trying to do something to improve our safety. They should think like that. So the risk communication is very important safety communication risk communication is very important to assure everybody that the safety management system is running effectively".

According to the references' ratio of the sub-themes, they were ranked accordingly. First, were the organisational factors claimed to disrupt risk communication, according to 10 participants with 26 references. The message from this sub-theme is that the contextual culture issues widen the trust gap among personnel levels within organisations.

Participant 208: "This [trust] is the alpha and the omega, that's what will give the right communication of danger and that's if it doesn't exist that will stop communication and make it almost impossible".

Equally important as in number of participants and references, were the communication means sub-theme, representing their considerations about the communication channel influence on risk communication. In particular, the participants unveiled the enabling role of a versatile communication channel, which may exploit modern and traditional media, from social media to face-to-face communication. Additionally, this factor is viewed as highly associated with the content of the communication. However, communication means rely highly on the safety manager's capabilities to facilitate appropriate conditions.

Participant 211: "The communication channel has a great influence on employee risk communication, because the different communication media have a different periodicity. As we said before, depending on the level one can perceive and can perceive a piece of information we can pass it right using visual, audio channels. A poster can have the same effect as an entire manual document. The purpose is not to scare, it's to raise awareness. Therefore, due to the different psychosynthesis of individuals, a different approach may have better results. One can respond better to audio messages. One can be visualiser. So the rotation will have better results, per specialty".

After cognitive factors, timeliness was deemed as an important disrupting factor by ten participants with 19 references. Notably, the participants rendered timeliness of message deliverance as the core principle to circulate the right information to the right stakeholders from a bottom-up and top-down perspective. Hence, they insisted on the important role of timely perceiving hazards and aiding the accurate perception from co-workers as well. Nevertheless, the mixed approach as pointed out by the participants, insinuates that there should be no differences of timely information exchange, regardless of the decision-making level within the organisation. In this manner, the participants highlighted the "living" character of the organisation, from the top managerial level to the front-liners.

Participant 206: "thus having frequent feedback throughout the context and range of work and so that in a timely manner the potential risks are identified and appropriate measures are taken after discussion and information to minimise risks...Here this is a critical piece that can limit the risk to organisations, it is the right timing and the transmission of information".

Participant 207: "For me, the biggest and primary role is communication to be able to communicate with the employee, it's the alpha and the omega, because when you can communicate the employee is constantly bombarded with information so he works it on his mind. Everything you need to announce immediately before the employee can realize that this can happen as well".

Following, the physiological status of the risk respondent was reported from 8 participants with 12 references. The specific factor were considered almost last due to the fact that in everyday industrial routine there are mostly acute situations were one can be physically incapacitated to communicate. As stressed by one of the participants, the workforce in aviation is constantly checked up to be physically and mentally fit for work. However, the human physiology plays its role due to the human limits, which are constantly tested in the aviation environment. The major disruption of physiological issues during operations is the cause of haste to avoid the physically straining situation. Additionally, the participants highlighted the physical and mental link towards physiological responses to stress or discomfort due to social pressure, such as a supervisor's "wrong-doing" against them. Similarly, physiological factors were associated with cognitive bias of invulnerability or the opposite.

Participant 205: "the physiological disturbances make people hurry to complete their job. So the physiological components may affect the risk communication process by just ignoring to report something, ignoring to communicate, forget to communicate at all".

Participant 206: "There should be some limits to communication between the supervisor and the employees so that it is easy if there is to be proper rest and that we do not take any risks to do some work which hides some dangerous characteristics in a psychosomatic state which does not give us the right to carry out this task".

Participant 211: "Someone with a good physiology may have a feeling of invulnerableness, so they may not quite understand the importance of the information they receive. And vice versa, someone who doesn't have a good physiology feels disadvantaged, the slightest thing seems dangerous, so he overloads his communication".

Only 4 participants spend some points on the influence of environmental factors on risk communication with 6 references. The environment is mostly considered as an intermediate factor which regulates the worker's resilience and capacity to communicate, although highly appreciated from 4 participants. Specifically, the role of PPE and policies that advocate procedures to combat heat, noise and lighting can make the communication environment not "worker-friendly". Additionally, it is associated with physiological strain put on the worker.

Participant 205: "In written communication I think the environment does not have much effect, but it is rare but in the risk communication process, it's just it is very understandable that the high noise can interrupt the communication or the intensity of light can make that you if you read something you can misunderstand it".

Participant 207: "The environment affects communication to a large extent because if the environment is not worker-friendly it will not allow it to perceive a risk that is coming so the safety manager will propose a change and improvement of the working environment".

Participant 208: "It is the biggest factor that will affect how properly and how often the risk will be communicated by the average person".

4.3.2.2.3. Safety Managers' Practices for Risk Perception

This theme embodies the practices managers follow in their daily routine to perceive risk and aid others to perceive risk as well. Also, this theme collected 56 references (15.95%) from all participants. They divided their source of intuition between heuristics (35 references) and experience (21 references). Ten out of twelve participants suggested that risk perception is mostly based on the abilities of the staff and the safety manager to work as a team. This "team resourcefulness" rests upon the safety manager's heuristics capacity and abilities. For that reason as well, safety managers usually rely on their professional background, either being a pilot or an engineer, to interpret contextual contributing factors disrupting risk perception. The outmost suggestion about risk perception is its binary role as both subjective, when describing personnel, and objective, when describing non-human activities. However, there was not a clear line between use of experience and heuristics, but rather an interchanging role between the two.

Participant 201: "it's very important to have a process by which you will try to minimize the influence of human behaviour on risk perception...What is a risk for one organization cannot be, maybe will not be a risk for another one".

Participant 203: "This was one of the or the biggest challenges, because as you know, we have one culture that is that's coming from the professional background and also a natural culture. So one of the biggest problem we faced was how would we interfere to their culture and day to day activities".

Participant 207: "The Safety manager can't do much, but if he finds an employee through his manager he can put him in lighter functions on his job not to put him in some high-risk job to have him a little further back until we watch him see how he develops there and if he can rise to the level".

4.3.2.2.4. Safety Managers' Practices for Risk Communication

This theme describes the manner safety managers take advantage of heuristics and their background experience to facilitate effective risk communication. 27 references (7.69%) from 10 out of 12 participants included two sub-themes for heuristics (14 references from 8 participants) and experiential practices (13 references from 6 participants). Concerning heuristics, they emphasised on the personal initiative the safety manager has to take to motivate others and shape a suitable communication environment. In this environment the safety manager is the central filter of circulating information going all ways during the organisational function. Their outmost concern was the case of an indifferent management and reporting culture at all organisational levels. Regarding experiential practices, the safety managers make good use of their previous connection with the field, either as pilots or engineers mostly, underlining the importance of timely circulation of information with the appropriate means for each operation.

Participant 201: "So what is my job is to try to establish an effective process; that whatever the emotions at least I'm sure that the which risk has been identified is valid, the risk has been communicated and I have received the level of authorization that I should receive. So if it's a high risk it's the CEO that has to authorize the risk if it's a medium risk, it might be a supervisor or a manager can authorize the operation if it's a low risk even you can raise the risk you can authorize your operation. So this is the intervention of the safety manager".

Participant 207: "The Safety manual is an inanimate piece of paper from there, it can't help you. You have to understand that you have to get into the mind and psychology of every employee and there you can communicate with him and provide him with daily communication with people even on the helicopter, we talk, I ask them how I will do this and what they have realized and I see that because they are professionals , because it does not mean that on board the helicopter will climb the beginner and the experienced will stay down drinking coffee, they go together, one pointing at each other...we operate according to the data we see in front of us, that is, we have no way to deal with it better".

Participant 210: "I would like to stress again that the task of the safety manager is to convince the first liners but much more the upper management, that if time and much more money is invested, in the end with the improvement of a process they are all won".

4.4. Sub-Study 3 Findings

The characteristics of the sample of eleven studies that met the inclusion criteria are reported in Table 4-22. The sources assessed and data distilled are depicted in the Appendix. The populations studied in the transportation industry outnumbered the ones in healthcare. “education” was identified as an intervention function in all sources, followed by “persuasion” in about half of the sample. “incentivisation” was not found in the studies reviewed, and several studies regarded more than one population group, intervention function and outcomes. Additionally, slightly more than half of the interventions reported behaviour changes. About a quarter of the sample mentioned outcomes related to intention changes—only three out of the 11 interventions attributed reduced rates of adverse consequences to the behaviours targeted.

Table 4-22: Sample characteristics

Population	**N**	**Percentage**
Drivers	6	54.54%
Aviation workers	4	36.36%
Sea transportation workers	1	9.09%
Railroad workers	1	9.09%
Pedestrians in traffic	1	9.09%
Individuals with chronic illness	1	9.09%
Individuals in leisure activities	1	9.09%
Intervention Functions		
Education	11	100%
Persuasion	6	54.54%
Restriction	4	36.36%
Environmental restructuring	3	27.27%
Enablement	3	27.27%
Modelling	2	18.18%
Training	2	18.18%
Coercion	2	18.18%
Reported Outcome Types (more than one per intervention)		
Behaviour Change	6	54.54%
Intention Change	4	36.36%
Crash Rate	3	27.27%

According to the data presented in the Appendix, "recognition primed decision making - RPDM (Johnson, Kirwan, Licu, & Stastny, 2009) scored the highest coverage with 10 out of 16. Four applied intervention frameworks/models scored 9 out of 16: "Netherlands: sustainable safety" (Hughes, Anund, & Falkmer, 2015), "naturalistic decision making" (Johnson, Kirwan, Licu, & Stastny, 2009), INDICATE (Identifying needed defences in the civil aviation transport environment)" (Nævestad, Hesjevoll, & Phillips, 2018) and "post-training feedback" (Molloy, Molesworth, & Williamson, 2018). The ones with the lowest scores were "proactive risk management" (Bui, et al., 2018) with a score of 3 and "enhanced and refresher training" (Bui, et al., 2018) with a score of 2.

Table 4-23 presents the frequencies of the six SHELLO clusters across the intervention functions included in all frameworks/models where those functions were mentioned. Whereas all clusters were addressed by all intervention functions, “enablement” included them with the highest frequency (89%), followed by “training” (83%) and “coercion” (83%). In contrast, “modelling” and “persuasion” addressed the clusters on an average level. Additionally, the SLLE and HLLE clusters were most often addressed by intervention functions (both scoring 88%), followed by SLHE and SLOE. On the other hand, the clusters LLOE and OLHE appeared with about half but equal frequencies of 48% and 45%, respectively.

Table 4-23: SHELLO clusters across intervention functions (percentages rounded at the level of integers).

Intervention function (N*)	SLHE	SLLE	LLOE	OLHE	SLOE	HLLE	Overall representation of clusters	RANK
Education (N=11)	9 (82%)	9 (82%)	5 (45%)	6 (55%)	9 (82%)	9 (82%)	71%	5.5
Modelling (N=2)	1 (50%)	1 (50%)	1 (50%)	1 (50%)	1 (50%)	1 (50%)	50%	8
Restriction (N=4)	3 (75%)	3 (75%)	3 (75%)	2 (50%)	3 (75%)	3 (75%)	71%	5.5
Environmental restructuring (N=3)	3 (100%)	3 (100%)	1 (33%)	1 (33%)	3 (100%)	3 (100%)	78%	4
Enablement (N=3)	3 (100%)	3 (100%)	2 (67%)	2 (67%)	3 (100%)	3 (100%)	89%	1
Persuasion (N=6)	4 (67%)	6 (100%)	2 (33%)	1 (17%)	4 (67%)	6 (100%)	64%	7
Training (N=2)	2 (100%)	2 (100%)	1 (50%)	1 (50%)	2 (100%)	2 (100%)	83%	2.5
Coercion (N=2)	2 (100%)	2 (100%)	1 (50%)	1 (50%)	2 (100%)	2 (100%)	83%	2.5
Total N=33	27 (82%)	29 (88%)	16 (48%)	15 (45%)	27 (82%)	29 (88%)		

*Number of intervention methods the function was included

Tables 4-24 and 4-25 report the frequencies of risk perception and communication factors across the intervention functions, correspondingly. Overall, risk perception factors were more frequently targeted by interventions (42%) than risk communication factors (22%). More specifically, cognitive factors were by far the most present for risk perception (62%), with emotional, physiological and environmental factors yielding lower and comparable frequencies in the range of 33-36% (Table 4-24). “Environmental restructuring” and “enablement” were the most inclusive functions (i.e., with the lowest combined ranks). In contrast, “coercion” and “modelling” were found to address risk perception factors with the lowest frequency and coverage.

Regarding risk communication (Table 4-25), channel-related factors were not found in the intervention functions of the frameworks reviewed. Emotional factors were the most frequent in the sample (36%), followed by temporal factors (30%). Physiological factors presented the lowest frequency across the whole sample (6%). “Education” and “persuasion” were the functions with the highest frequency and coverage of risk communication factors. On the contrary, “modelling” and “coercion” were the least inclusive functions.

Table 4-24: Risk perception factors across intervention functions (percentages rounded at the level of integers).

Intervention function (N*)	PCOF	PEMF	PPHF	PENF	Overall representation (Rank)	Coverage (Rank)	Combined Rank
Education (N=11)	7 (64%)	2 (18%)	4 (36%)	5 (45%)	41% (5)	4 (2)	7
Modelling (N=2)	1 (50%)	0	0	1 (50%)	25% (7)	2 (7.5)	14.5
Restriction (N=4)	1 (25%)	1 (25%)	1 (25%)	0	19% (8)	3 (5)	13
Environmental restructuring (N=3)	2 (67%)	1 (33%)	3 (100%)	3 (100%)	75% (1)	4 (2)	3
Enablement (N=3)	2 (67%)	1 (33%)	2 (67%)	2 (67%)	58% (2)	4 (2)	4
Persuasion (N=6)	4 (67%)	5 (83%)	0	1 (17%)	42% (4)	3 (5)	9
Training (N=2)	2 (100%)	1 (50%)	1 (50%)	0	50% (3)	3 (5)	8
Coercion (N=2)	2 (100%)	1 (50%)	0	0	38% (6)	2 (7.5)	13.5
Total N=33	21 (64%)	12 (36%)	11 (33%)	12 (36%)	56 (42%)		
*Number of intervention methods the function was included							

Table 4-25: Risk communication factors across intervention functions (percentages rounded at the level of integers).

Intervention function (N*)	CCOF	CEMF	CPHF	CENF	CTEMP	Overall representation (Rank)	Coverage (Rank)	Combined Rank
Education (N=11)	2 (18%)	3 (27%)	1 (9%)	2 (18%)	4 (36%)	22% (2)	5 (1)	3
Modelling (N=2)	0	0	0	2 (100%)	0	20% (5.5)	1 (7.5)	13
Restriction (N=4)	1 (25%)	2 (50%)	0	0	1 (25%)	20% (5.5)	3 (4)	9.5
Environmental restructuring (N=3)	1 (33%)	1 (33%)	0	1 (33%)	0	20% (5.5)	3 (4)	9.5
Enablement (N=3)	1 (33%)	1 (33%)	0	0	1 (33%)	20% (5.5)	3 (4)	9.5
Persuasion (N=6)	2 (33%)	3 (50%)	0	0	2 (33%)	23% (1)	3 (4)	5
Training (N=2)	1 (50%)	0	1 (50%)	0	2 (100%)	20% (5.5)	3 (4)	9.5
Coercion (N=2)	0	2 (100%)	0	0	0	20% (5.5)	1 (7.5)	13
Total N=33	8 (24%)	12 (36%)	2 (6%)	5 (15%)	10 (30%)	37 (22%)		
*Number of intervention methods the function was included								

Following the above, Table 4-26 depicts the final ranking of the intervention functions by considering their overall relative inclusiveness of the SHELLO clusters and risk perception and communication factors. "Enablement" was the most inclusive function, followed by "education" and "environmental restructuring". The functions with the lowest inclusiveness were "coercion" and "modelling".

Table 4-26: Intervention Function Combined Ranking

Intervention	SHELLO Rank	Risk Perception Combined Rank	Risk Communication Combined Rank	Sum of Ranks	Meta Ranking
Education	5.5	7	3	15.5	2
Modelling	8	14.5	13	35.5	8
Restriction	5.5	13	9.5	28	6
Environmental restructuring	4	3	9.5	16.5	3
Enablement	1	4	9.5	14.5	1
Persuasion	7	9	5	21	5
Training	2.5	8	9.5	20	4
Coercion	2.5	13.5	13	29	7

The improvement areas targeted through risk perception and communication factors are shown in Table 4-27. The cognitive and emotional aspects of risk perception and communication were associated with more areas than the other categories. Regarding risk perception, "awareness" and "distraction" were the areas most and least frequently targeted by cognitive-related interventions correspondingly. On the other hand, "accuracy" and "fear of punishment" were found with the highest frequencies in emotional factors, "fatigue" in physiological factors and "social impact" in environmental factors.

The risk communication concerned, "biases" and "information load" were the areas most and least frequently targeted by cognitive-related interventions, respectively. "Fear of punishment" for emotional factors, "Responsibility" for environmental factors and "Accuracy" for timeliness factors were the most frequent areas across the sample. “Injuries” was the only area related to physiological factors of risk communication.

Table 4-27: Improvements targeted through intervention methods concerning risk perception and communication factors.

PCOF (N=21)	PEMF (N=12)	PPHF (N=11)	PENF (N=12)	CCOF (N=8)	CEMF (N=12)	CPHF (N=2)	CENF (N=5)	Timeliness (N=10)
Cognitive Capacity (3, 14%)	Aggression (1, 8%)	Drug abuse (2, 18%)	Exposure to others (3, 25%)	Biases (3, 38%)	Sensitisation (3, 25%)	Injuries (2, 100%)	Responsibility (2, 40%)	Information circulation (4, 40%)
Skills (2, 9%)	Accuracy (4, 33%)	Fatigue (6, 54%)	Social Impact (5, 42%)	Skills (2, 25%)	Fear (2, 17%)		Unauthorised interventions (1, 20%)	Accuracy (5, 50%)
Experience (4, 19%)	Fear of punishment (4, 33%)	Injuries (2, 18%)	Social norms (2, 17%)	Information load (1, 13%)	Fear of punishment (4, 33%)			Feedback (2, 20%)
Distraction (1, 5%)	Fear of death (1, 8%)			Awareness (2, 25%)	Fear of death (1, 8%)			
Inaccuracy (4, 19%)	Anger (1, 8%)				Anger (1, 8%)			
Biases (4, 19%)	Motivation (1, 8%)							
Penalties (2, 9%)								
Awareness (6, 28%)								

4.5. Sub-Study 4 Findings

4.5.1. Quantitative Findings – Aviation Personnel

The sample consisted of 420 aviation personnel of multiple categories and duties. The average age was 34.65 years (*SD* = 12, *Mdn* = 30, *Range:* 18-76 years) and the average work experience was 9.41 years (*SD* = 10.356, *Mdn* = 5, *Range:* 1-55 years). Due to highly unbalanced sample sizes, the initial set of 12 organisation types available in the survey was grouped into three categories: “Commercial” (n=139, 33.1%), including passenger and cargo organisations, “Military” (n=101, 24%) and “Miscellaneous” (n=111, 26.4%) for the rest of the organisation types such as general aviation and flight training. The “Other” category accounted for 16.4% of the sample (n=69, 16.4%).

Overall, most of the intervention functions were reported as “helpful” (median=4) for both risk perception and communication (Table 4-28). Incentivisation was the only function that yielded a median of 3 (i.e., “neutral”) in both constructs, and training was the only one with a median of 5 (i.e., "very helpful") regarding risk perception. Figures 4-22 and 4-23 present the distribution of intervention function scores for risk perception and communication, respectively.

Table 4-28: Median Scores of Intervention Functions

	Education	Persuasion	Incentivisation	Coercion	Training	Restriction	Environmental Restructuring	Modelling	Enablement
Risk Perception	4,00	4,00	3,00	4,00	5,00	4,00	4,00	4,00	4,00
Risk Communication	4,00	4,00	3,00	4,00	4,00	4,00	4,00	4,00	4,00

Figure 4-22: Distribution of scores of intervention functions for risk perception

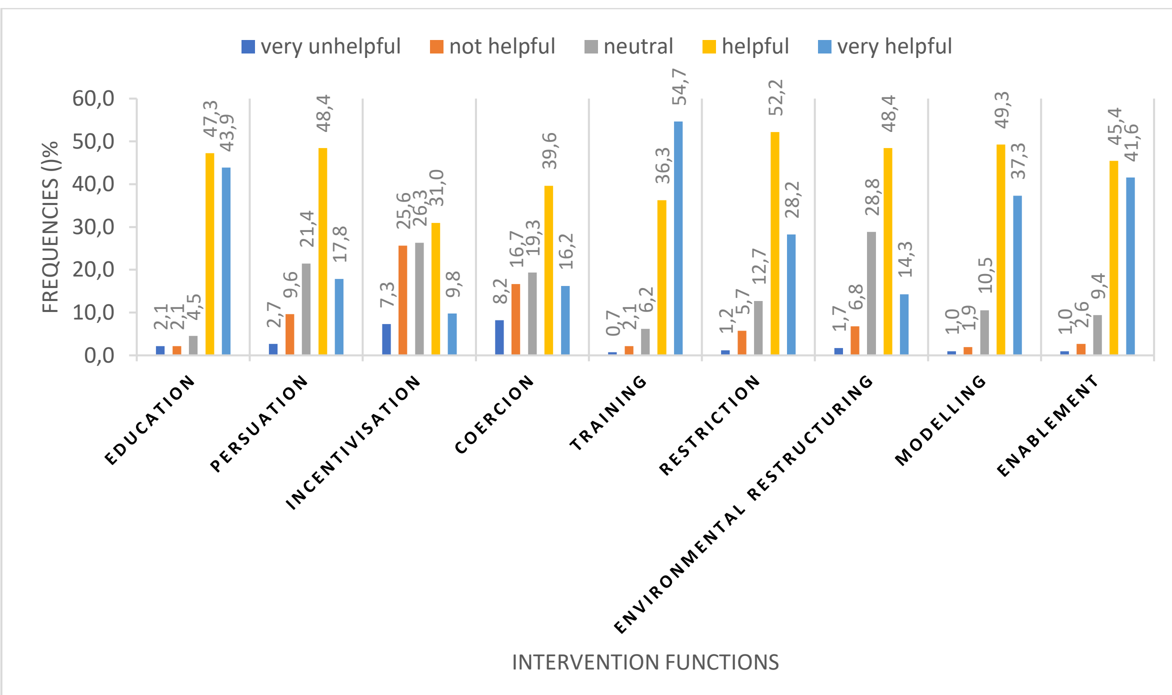
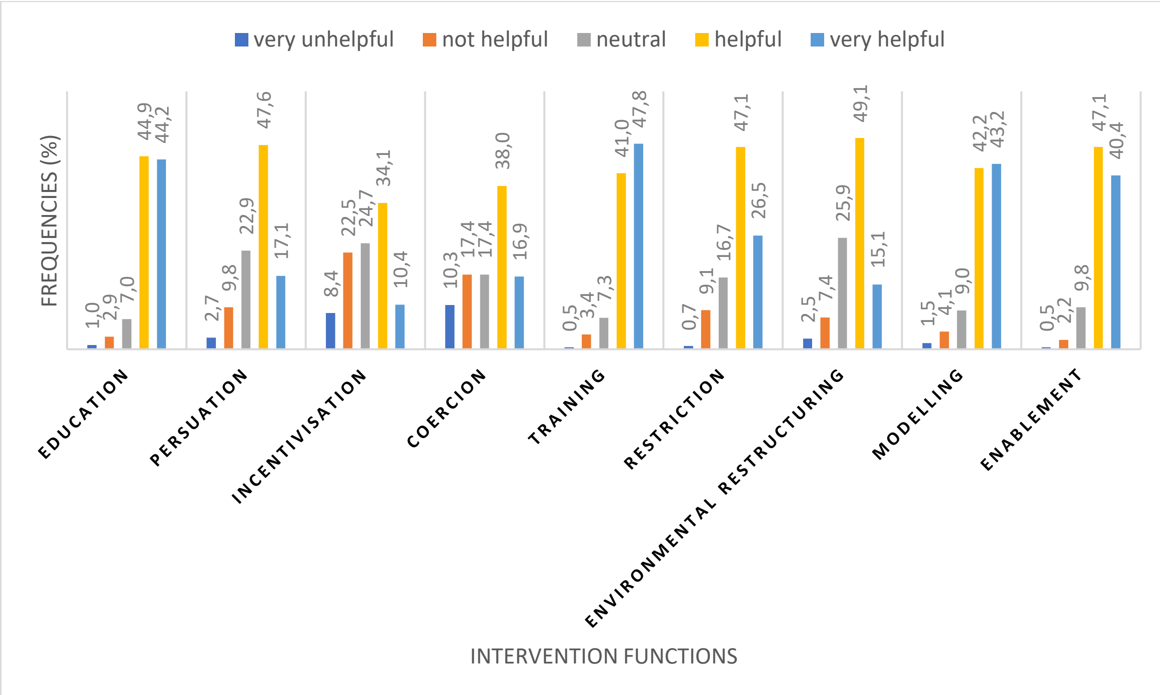


Figure 4-23: Distribution of scores of intervention functions for risk communication



The Kruskal-Wallis tests showed that there were statistically significant differences between intervention functions across types of organisations. Specifically, there was a significant difference concerning the Environmental RestructuringRP [X^2 (3) = 10.542, p = .014] with a mean rank of organisation type score of 228.97 for Other, 211.09 for Miscellaneous, 208.97 for Commercial and 180.81 for Military. Adjacent, there was a significant difference about the EnablementRP [X^2 (3) = 10.669, p = .014] with a mean rank of organisation type score of 229.34 for Military, 218.34 for Miscellaneous, 208.59 for Commercial and 182.36 for Other. Also, there was a significant difference about the EducationRC [X^2 (3) = 10.178, p = .017] with a mean rank of organisation type score of 234.58 for Miscellaneous, 215.75 for Commercial, 207.11 for Military and 182.56 for Other. Likewise, there was a significant difference about the ModellingRC [X^2 (3) = 17.303, p = .001] with a mean rank of organisation type score of 239.93 for Miscellaneous, 224.06 for Military, 199.15 for Commercial and 175.99 for Other. Similarly, there was a significant difference for the EnablementRC [X^2 (3) = 12.733, p = .005] with a mean rank of organisation type score of 227.50 for Military, 218.30 for Miscellaneous, 200.66

for Commercial and 177.37 for Other. Consequently, the hypothesis was not confirmed for two intervention functions regarding risk communication, one for risk perception, and one for both ends.

The Spearman's correlation tests showed significant positive associations between work experience and the Education function [RP r_s (1) = .214, p = .000, RC r_s (6) = .164, p = .001] and Enablement [RP r_s (4) = .18, p = .000, RC r_s (12) = .182, p = .000] for both risk perception (RP) and risk communication (RC). Furthermore, significant negative associations were found between years of experience and Incentivisation [RP r_s (10) = -.188, p = .000, RC r_s (15) = -.239, p = .000], and Coercion [RP r_s (6) = -.126, p = .000, RC r_s (10) = -.167, p = .001] for both constructs. It is noted that the strengths of all associations above were low. Therefore, the hypothesis was partially confirmed for Incentivisation and Coercion functions.

The results from the Friedman tests (Table 4-29) showed significant differences of the helpfulness of intervention functions on both risk perception [X^2 (8) = 717.278, p =.000] and risk communication [X^2 (8) = 645.873, p =.000]. As presented in Table 4-29, the participants scored training and education as most helpful and coercion and incentivization as the least helpful in supporting both risk perception and communication. Therefore, the hypothesis was confirmed.

Table 4-29: Intervention functions' mean ranks from the Friedman test

Intevention Functions	Risk Perception Mean Ranks	Risk Communication Mean Ranks
Education	6,01	5,97
Persuasion	4,42	4,44
Incentivisation	3,15	3,36
Coercion	3,95	3,93
Training	6,41	6,17
Restriction	5,23	4,98
Environmental Restructuring	4,24	4,30
Modelling	5,75	5,93
Enablement	5,84	5,93

Regarding the comparison between the helpfulness of the same function on risk perception and communication, the Wilcoxon signed-rank tests showed there was no difference on facets for seven out of nine functions. Significant differences were found only between for Training and Restriction, showing that both functions were scored as more helpful in supporting risk perception than risk communication (TrainingRC < TrainingRP = 75 negative ranks, TrainingRC > TrainingRP = 39 positive ranks n = 410), z = -3.532, p = .000, r = 0.17), (RestrictionRC < RestrictionRP = 93 negative ranks, RestrictionRC > RestrictionRP = 60 positive ranks, n = 407), z = -2.929, p = .003, r = 0.14). However, both tests yielded small effect sizes. Therefore, the hypothesis was partially confirmed, except for two intervention functions.

4.5.2. Qualitative Findings – Aviation Personnel

The participated aviation personnel reported the factors which influence risk perception and communication, according to their daily experience in the field. Specifically, they described the factors in two major themes, six and four sub-themes for risk communication and perception respectively. Table 4-30 incorporates the themes and sub-themes with their ratio within the sample. Next, Table 4-31 lists specific factors reported by the sample as disruptors of risk perception and communication. Consequently, the following sub-headings comprise a summary per theme and respective sub-themes.

Table 4-30: Thematic Analysis Findings for Aviation Personnel

Themes & References (N, %)	**Sub-Themes**	
	Description	**References (N, %) within the Theme**
Risk Communication: Factors disrupting risk communication in operations (190 references – 37.62%).	Communication Channel related factors: This theme summarizes the participants' experience influencing their risk communication. The notion is that the availability of communication channels used, in combination with communication barriers (e.g., jargon, reporting culture) inhibit or discourage effective communication. In more detail, the availability of relative phraseology, in conjunction with an effective reporting culture is capable to facilitate effective risk communication.	81 (42.63%)

Themes & References (N, %)	Sub-Themes	
	Description	**References (N, %) within the Theme**
	Communication Environmental factors: This theme shows the complexity of the workspace along with the communication dynamics as they are shaped in the same context, as disruptors of risk communication. The working environment is represented as a framework in need to converge common practices, ethics, and safety driven mindset. Additionally, the role of an ineffective reporting culture is stressed. Moreover, the participants stressed the need of a risk-based approach towards daily practice, to manage risk effectively in total.	75 (39.47%)
	Cognitive factors influencing risk communication: The participants exalted the role of training, knowledge, communication skills, risk assessment, and awareness capacity, as factors influencing risk communication in an adverse manner when they are in lack.	69 (36.31%)
	Timeliness communication factors: The participants highlighted the need for periodicity and availability of communication as a mean of timely communication during their daily work activity.	8 (4.2%)
	Emotional factors influencing risk communication: The participants focused on fear to report, work related stress, and the urge to overcommunicate during a state of anxiety.	3 (1.57%)
	Physiological factors influencing risk communication: The participants referred to the generic inhibition of communication due to health issues.	1 (0.52%)
Risk Perception: Factors disrupting risk perception in operations (315 references – 62.37%).	Cognitive factors influencing risk perception: The participants projected multiple factors which influence their risk perception. These factors were work experience, the need for training, ergonomic limitations, the extend of knowledge, the capacity to comprehend risk probability, a safety compliance mindset, and the situational awareness capacity.	150 (47.61%)
	Environment's influence on risk perception: The participants expressed the environment's influence according to the operational environment's conditions, the work means maintenance, the organisational management, and the compliance to effective procedures.	146 (46.34%)
	Physiological factors influencing risk perception: The participants approximated that the physiological factors which may influence their risk perception is the fitness to operate and their physiological capacity to withstand physically their workload.	18 (5.71%)

Themes & References (N, %)	Sub-Themes	
	Description	References (N, %) within the Theme
	Emotional Influence on Risk Perception: The participants revealed that emotional tension deriving from their supervisors or managerial level disrupts their risk perception.	1 (0.31%)

Table 4-31: Factors Influencing Risk Perception and Communication – Aviation Personnel

Category	Specific factors	Risk communication	Risk perception
Cognitive factors	Training	X	
	Knowledge	X	
	Communication skills	X	
	Risk Assessment	X	
	Awareness capacity	X	
	Training		X
	Ergonomic limitations		X
	Experience		X
	Knowledge		X
	Risk probability comprehension		X
	Safety compliance		X
	Situational awareness		X
Emotional factors	Fear to report	X	
	Anxious to overcommunicate	X	
	Work stress	X	
	Afflicted with managerial pressure		X
Physiological factors	Incapacitation due to health issues	X	
	Fitness to operate		X
	Physiological capacity		X
Environmental factors	Communication process	X	
	Safety behaviour in the workplace	X	
	Safety mindset	X	
	Work environment	X	
	Operational environment conditions		X
	Work means maintenance		X
	Compliance to effective procedures		X
	Organisational management		X
Channel-related factors	Channels availability	X	Not Applicable
	Language barriers	X	
	Reporting Culture	X	
Timeliness factors	Working conditions	X	

Category	Specific factors	Risk communication	Risk perception
	Safety data	X	
	Daily communication	X	
	Availability of means	X	

4.5.2.1. Risk Perception Theme – Aviation Personnel

The aviation personnel reported with high importance (315 references – 62.37%) the weight of risk perception as a disrupting catalyst to their behaviour. Mainly, they underlined the importance of two groups of factors; cognitive (150 references – 47.61%) and environmental (146 references – 46.34%). Regarding the cognitive factors, their main point was that they may inhibit effective hazard processing and may incapacitate the end-user to estimate the risk effectively. Considerably, the factors limiting their cognitive capacity to perceive risk effectively were work experience, workspace design, and the capacity to comply to a safety mindset, while possessing an equally matching situational awareness. Concerning the environmental influence, the participants highlighted the importance of the workspace conditions. In addition, they referred to organisational environment's influence by addressing the available means' maintenance, the relevant management, and the compliance to effective procedures.

Beyond the first two categories, physiological factors were reported next and with low level in priority (18 references – 5.71%), while emotional factors were reported once (1 reference – 0.31%). The physiological factors were narrowed to being fit to operate, while the end-users should be capable to withstand the workload they handle physically. Adjacent, the single reference on emotional factor referred to the emotional tension deriving from the supervision level or higher.

4.5.2.2. Risk Communication Theme – Aviation Personnel

With regard to the factors which affect the end-user's risk communication, the participants responses placed them second after risk perception (190 references – 37.62%). Principally, three categories of factors within risk communication shared the largest portion of responses; channel related factors (81 references – 42.63%), environmental factors (75 references – 39.47%), cognitive factors (69 references – 36.31%). Respectively, the respondents stress the disruption caused by systemic communication inflexibility and ineffective reporting culture. Next, they highlight the influence of organisational-environmental complexity and no-uniform mindset, as versatility inhibitors preventing accurate and effective risk communication. Additionally, they referred to the influence of cognitive aptitude as a result of training on communication skills.

Adjacent, three additional categories shared a minimal portion of collected responses; timeliness (8 references – 4.2%), emotional factors (3 references – 1.57%), physiological factors (1 reference – 0.52%). The participants mentioned the importance of timely circulated information, while likewise the emotional pressure disrupts the accuracy of the same information. On a last accord, the physiological factors were last and referred to general health issues which may inhibit effective communication.

4.6. Summary

The purpose of this chapter was to provide the results of the sub-studies which provided the necessary data and insights to structure the initial conceptual framework of how to enhance risk perception and communication to lead safe behaviours, into a model. Sub-study 1 provided the input that emotional factors are underrepresented in Safety Aviation Investigation Methods (SAIMs), and significant differences over time and amongst SAIM types. Sub-study 2 showed that safety investigators consider and search risk perception and communication factors with a different emphasis compared to the extent these are represented in investigation methods, while they have indicated specific factors disrupting risk perception and communication. Similarly, safety managers facilitate safe behaviours concerning risk perception and communication based on their professional background and the availability of organisational means, trying to regulate the socio-technical context within their respective organisation. Sub-study 3 showed that the education intervention function was the most inclusive for a systemic approach on the aviation context, while behaviour based frameworks may adapt, include and focus risk perception and communication factors. Sub-study 4 showed the common factors influencing risk perception and communication, through the comparison among the safety investigators, managers and aviation personnel, while the StratCom framework incorporated the mode of delivery for the model to be applied by organisations.

5. Chapter 5: Collective Discussion

5.1. Introduction

Overall, effective risk management is highly important to aviation safety. In particular, this thesis was based on the importance of risk perception and risk communication as the two main pillars of effective risk management, thus safe behaviour. Consequently, the limited attention to the influence and consideration of these two attributes and their factors in the aviation industry was the bedrock for this thesis.

This chapter aims to discuss the overall results and implications of the study to present an answer to the original questions of this research. Moreover, this chapter demonstrates the suggestion for a novel approach regarding the behavioural intervention towards risk perception and communication.

5.2. Sub-Study 1 Discussion

The basic role of risk perception and communication as depictions of effective risk management was initially investigated on the way they are addressed and on the degree they are recognised by Safety Aviation Investigation Methods (SAIMs). This strand showed an underrepresentation of emotional factors and significant differences over time and amongst SAIM types regarding the inclusion of analysis stages relevant to risk perception and communication as well as their associated factors.

Especially, the disproportionally low percentages of emotional factors in the SAIMs along with the greater frequencies of broad environmental factors indicate that the particular SAIMs overlook residual psychological effects (e.g., upset transferred to family and friends, depression) (Hrymak & Pérezgonzález, 2007), although they are aware of the effects of broader factors. This illustrates a discrepancy between considering the underlying personal causes and examining external influences. That conclusion is most likely attributable to the consistent increases in organizational and system layers that have been present in the SAIMs (Reason, 1990; Rasmussen, 1997; Leveson, 2004) and the time-consuming difficulties in risk management that arise when trying to investigate parameters of the people involved (Grote, 2012; French & Steel, 2017; Nixon & Braithwaite, 2018).

Interestingly, the six risk-related analysis stages were not covered by the SAIMs under consideration, even though it's shown that the impact of safety is heavily connected to real-time or asynchronous risk management (Fang, Cho, & Chen, 2016; Yu, Neal, Dawson, & Madera, 2017; Shamsunnahar, Eluru, Wang, & Abdel-Aty, 2018). While many of the SAIMs assessed in this work, such as the Hazard Crystallisation, the Socio-Technical Risk Analysis, the Regulatory-based Causal Factor Framework, and the Risk Analysis Tool, concentrate on potential parts of the systems where problems could occur (e.g., structural elements and their connections) and do not specifically highlight means for overcoming them, it is nevertheless likely that the identified particular result can be attributed this. Additionally, the frequencies of the three later stages of risk analysis (i.e. Mitigate, Monitor and Feedback) where mentioned by the SAIMs are lower than the three first stages (i.e. Identify Hazards, Model Risk and Evaluate). Despite this, it is often assumed that risk management consists a round process where each step is equally necessary and reliable to the next one (Parson, 2005; Müller, 2011). Thus, even though SAIMs incorporate risk analysis as a necessary component of attaining safety, they do not sufficiently cover all phases of an inclusive risk management approach. This specific occurrence may corroborate the overemphasis on plans and actions and underestimate of the significance of inspections and improvements, as Marais and Robichaud (2012) shown via their work analysing maintenance activity patterns and their contribution to aviation risk. Another example of omitting checks and improvements comes from Shao et al. (2012), who conducted a risk study that focused on identifying high-risk vs low-risk activities.

Furthermore, the image given above was consistent across SAIM types and publication dates, indicating that even newer and more systemic methods suffer from the same underrepresentation of risk analysis phases as older and less systemic methods. When examining the degree of inclusion of stages associated with risk communication and perception in particular, the picture remained same, except for the considerably greater inclusiveness ratios found for risk communication-related stages in later time periods. With regards to the model types, the suggestion is that they are almost universally focused on cause-effect controls rather than on the individual and team perceptions and processes that influence the efficacy and success of such controls at both the technical and social levels. However, sociotechnical theories assert that events are not static and that they have lingering impacts on an organization and its personnel (e.g., psychological effects on the employees and residual costs) (Hrymak & Pérezgonzález, 2007).

A possible explanation for the general stability over time is that the complexity of the sociotechnical environment and its impact on safety is a persistent issue (Reiman & Pietikäinen, 2012), and thus SAIM designers may assume that the personal discretion required for context-sensitive adaptation of SOPs and technical environments is always a necessary precondition for sound-functioning systems (Haavik, Kongsvik, Bye, Røyrvik, & Almklov, 2017). Additionally, the need for consistency and validity in SAIMs may have resulted in the partial removal of risk perception and communication variables, which are bound to subjectivity (Renn, 1998; Sjoberg, Moen, & Rundmo, 2004; Williams & Noyes, 2007; Vasvári, 2015). The latter is likely a result of the risk management rationale's early focus on technical assessments, which resulted in the rejection of social inputs such as fairness or resilience (Renn, 1998).

When the findings of risk perception are compared to those of risk communication and its related variables, it seems as if communication and many of its characteristics have received greater attention. Over time, the results showed an increasing trend in the ratios of risk communication analysis stages, emotional, and environmental factors. Additionally, systemic SAIMs were more comprehensive of all risk communication variables than epidemiological and root cause SAIMs, with the exception of communication channels, which were cited more often in epidemiological SAIMs. It seems that since communication has been recognized as a critical human factor that may have negative effects if not handled correctly (UK HSE, 2018), interest and research in effective communication have grown throughout time (Mearns, 2003; dos Santos, Vieira, & de Morais, 2014; Kim H. , 2018). Additionally, systemic SAIMs have an advantage over the other two types since they place a premium on nonlinear connections and component interactions (Wreathhall, 2009). As a result, they are more conceptually compatible with the acceptance of non-linear communication interactions between actors and system components.

Despite the fact that an increased ratio of risk communication and perception analysis stages was linked with a greater frequency of reference to respective factors in the SAIMs examined, more emphasis should be paid to these two important factors. SAIMs should not be static constructions but rather should develop and be updated in light of new research. This perspective does not necessitate the creation of more SAIMs, but rather the consideration of upgrading current ones and, perhaps, combining their strengths in order to create more inclusive, valid, and representative SAIMs. Several examples of combining SAIMs have previously been proposed, like the combination of Human Factors Analysis and Classification System (HFACS) and Accident Mapping (AcciMap) (Lei, Zhang, Tang, & Lu, 2014). Any new or current 'hybrid' SAIMs may be enhanced to increase their reliability and validity by including both qualitative and quantitative data, since risk comprehension is inextricably linked to successful communication and an understanding of causation across systems (Waterson, Jenkins, Salmon, & Underwood, 2017).

Given that researchers have emphasized the importance of risk perception factors in safety investigations and routine risk assessments (Simon, Houghton, & Aquino, 1999; Houghton, Simon, Aquino, & Goldberg, 2000; Sjoberg, Moen, & Rundmo, 2004; Vasvári, 2015), and that risk communication facilitates the execution of safety processes (Kasperson, et al., 2000; Williams & Noyes, 2007), the anticipation is that this study will increase researchers' and safety practitioners' awareness of risk perception factors when developing, revising, or applying SAIMs. A future study should investigate the impact of existing SAIMs and their theoretical underpinnings on effectively altering different risk perception and communication factors.

5.3. Sub-Study 2 Discussion

Examining at the overall findings of the study of safety investigation reports, it was discovered that the risk perception and communication aspects both contribute with the same frequency. More precisely, environmental variables were found to have the greatest percentages (73 and 77 percent), while emotional and physiological components had the lowest frequencies (1-2 percent) in both aspects. Similarly, the overall picture emerging from safety investigators' interviews indicates that the relative variances between the different risk communication and perception factors follow the pattern established by the investigation reports. Nonetheless, the interviews revealed extensive and broad factors affecting risk communication and perception that are typically not directly linked to these two risk attributes in safety investigation reports due to the fact that the various factors can also affect multiple aspects of human performance. In addition to the results on the particular variables investigated in this research, interviews provided additional insight into investigative methods, revealing that practitioners evaluate risk perception and communication mostly via their experience and heuristics.

Furthermore, risk communication variables were shown to be more often associated with safety incidents than risk perception factors across all flight phases except flight planning. According to the study design, this difference cannot be clearly linked to any claim regarding enhanced susceptibility of risk communication over risk perception during aviation operations. However, the interview findings indicating a significantly higher frequency of references to risk communication than risk perception may suggest that investigators place a greater emphasis on the former characteristic. This, in turn, may be a result of risk communication's more apparent features, which include observable behaviours (e.g., information sharing) and a more systematic approach (e.g., reporting systems), in addition to the internal mental processes involved in risk perception and communication.

When the two risk attributes are distributed across the various flight phases, the results indicate that the flight planning, final approach, and landing phases are more frequently impacted by risk perception issues, whereas the cruise, final approach, and landing phases appear to be more frequently impacted by risk communication issues. While statistical studies (BOEING, 2019; EASA, 2019; Kelly & Efthymiou, 2019) indicate that the flight planning phase is not an attributable period in which problems may result in a safety incident, our study revealed latent risk perception and communication problems. Additionally, safety investigators agreed that planning is a critical step during which operators may misperceive or communicate inadequately, potentially resulting in safety incidents during operational phases.

Although the majority of flying time is spent in cruise, concerns about risk perception and communication have emerged during the approach and landing phases, when human participation is prevalent, workload fluctuates, and situational awareness is affected by changes in operational status (Lin C. J., et al., 2012). Additionally, environmental factors have been shown to interact with an aircraft's attitude during final approach, resulting in potential roll, airspeed, and heading overruns (Xie, Sun, Jiao, & Lu, 2019). In general, final approach and landing have been labelled the most perilous flying phases, since they are when the majority of accidents occur (Hinkelbein, Schwalbe, Neuhaus, Wetsch, & Genzwürker, 2011; UK CAA, 2013; IATA, 2015). Automation may help minimize misperceptions and ineffective communication (ACASA, 2019), as long as it does not interfere with operators (Dehais, Peysakhovich, Scannella, Fongue, & Thibault, 2015).

Table 5-32 presents the quantitative results from this study in comparison with the findings of the first sub-study regarding SAIMs. The combined findings are discussed in the following section per respective hypotheses with reference to relevant literature, followed by the picture regarding investigation practices. As means to enable valid comparisons, the category of environmental factors in Table 5-32 includes both the physical and organisational parameters in alignment with the study on SAIMs. Also, since the percentages per factors from the interviews are relative (i.e. their sum equals 100%) whereas the individual frequencies from SAIMs and investigation reports could take any value from 0% to 100% (i.e. their sum exceeds 100%), the discussions per hypothesis are based principally on the rankings of frequencies per factor and source. Only for the second hypothesis, the comparison of the results between SAIMs and investigation reports considers the original frequencies per factor and not their rankings; in this case, it was considered as significant any difference close to and more than 20%.

Table 5-32: Summary of Quantitative Findings, including those regarding SAIMs

Factors	SAIMs		Safety investigation reports		Interviews	
	Frequency	Ranking	Frequency	Ranking	Frequency	Ranking
Risk Perception						
Emotional	19%	4	20%	3	15.46%	3
Cognitive	53%	2	41%	2	24.74%	2
Physiological	49%	3	2%	4	8.25%	4
Environmental	54%	1	77%	1	51.55%	1
Risk Communication						
Emotional	14%	6	18%	5	15.18%	2.5
Cognitive	56%	2	39%	4	14.28%	4
Physiological	53%	3	3%	6	3.58%	6
Environmental	72%	1	73%	1	42.85%	1
Temporal	52%	4	43%	3	15.18%	2.5
Channel	48%	5	66%	2	8.93%	5

5.3.1. Sub-Study 2 Hypotheses

HYP1: The relative extent to which safety investigators consider and search risk perception and communication factors reflects the extent to which these factors are represented in SAIMs.

The comparison of the ranking of factors for risk perception suggests that there is a similar view on the contribution of environmental and cognitive factors as the most prevalent, and a reverse picture regarding emotional and physiological factors. The former confirms the fact that both organisational and physical environment factors are covered extensively in investigation standards and during respective training with references to specific techniques for their examination. The sample of the interviewees concerned, eight (8) out of ten investigators had undergone the common European and Organisational training (EASA, 2015; ICAO, 2015). Also, widely used classifications of accident factors such as the Human Factors Analysis and Classification System (Wiegmann & Shappell, 2000) refer explicitly to broader environmental and cognitive aspects of human performance. Equally plausibly, causes related to organisational factors (e.g., procedures, training, supervisory policies) and the physical environment (e.g., weather information) are more readily available (MacLean & Read, 2019). Thus, confirmation biases of investigators stemming from their training in specific SAIMs and references in standards as well as accessible data (Lundberg, Rollenhagen, & Hollnagel, 2009) might have played a role in the similar rankings of these factors.

On the other hand, the higher focus of investigators on emotional factors than physiological ones might be attributed to the fact that the physical state of aviation staff, especially pilots, is checked periodically, and, under expected professionalism as well as several guidelines and directives (EASA, 2019; FAA, 2020), any employee must declare when physically unfit for work. Thus, investigators might see physiology as the least probable influential factor subject also to the fact that respective evaluations are mainly undertaken by specialised medical personnel. Regarding emotional factors, although these are the least covered by SAIMs and not explicitly examined through investigation techniques and standards, their consideration more frequently than physiology might be attributed to the personal experiences of investigators during their careers in aviation (i.e. pilots, engineers).

The risk communication concerned, only environmental and channel related factors had the same rankings between SAIMs and interviews. Subject to the explanations provided above about the environmental factors, interviewees also acknowledged the importance of an organisation's involvement in risk communication, through supervision, training, and promotion of a positive safety culture. The communication channels regarding, the ever-increasing reliability of communication technology along with established techniques of the correct use of communication resources (e.g., radio communication) might explain the alignment of investigators with SAIMs. On the other hand, the disagreement between investigators and SAIMs regarding the rankings of cognitive, emotional, physiological and temporal factors, subject to the possible explanations stated above about risk perception for the three former factors, can be allocated to exposure of the investigators to reports and studies on possible psychological issues (i.e. mental health disorders, mood disorders, and suicide risk) in the aviation industry (Pasha & Stokes, 2018) especially under time and workload pressures.

Conclusively, Hypothesis No 1 was only partially confirmed for both risk perception and communication.

HYP2: The frequencies to which risk perception and communication factors are mentioned in SAIMs are comparable to the frequencies these factors have contributed to aviation safety events.

Regarding risk perception, emotional and cognitive factors do not seem to present remarkable differences in their frequencies between SAIMs and investigation reports, indicating adequate alignment between experience from past events and the inclusiveness of respective factors in SAIMs. However, physiological factors are presented in reports with an extremely low frequency both in absolute numbers and when compared to their respective frequency in SAIMs. This may be explained from the fact that operators in critical roles possess medical certifications to work based on a variety of clinical examinations (i.e. respiratory and cardiovascular systems) and run in multiple oversight cycles (EASA, 2019). Therefore, the minimum contribution of physiological factors to safety events seems justifiable. Considering the differences in the frequencies of environmental factors, since these partially include the role of the organisations in the events, their higher frequency in the reports can be attributed to the evolution of safety thinking that prompts investigators to look beyond the operational level and seek deeper and wider factors inside and outside organisations (Dekker S. W., 2014).

The risk communication concerned, the respective frequencies are close enough for the emotional, environmental and temporal factors and markedly different for the channel-related, cognitive and physiological factors. The significant difference in physiological factors can be explained by the argument above about investigating already medical fit personnel. The higher frequency of the channel related factors in reports can be attributed to a mindset of "What-You-Look-For-Is-What-You-Find" (Lundberg, Rollenhagen, & Hollnagel, 2009) considering the intensive address of communication means in aviation training, the Crew Resource Management (CRM) programmes included (Jimenez, Kasper, Rivera, Talone, & Jentsch, 2015; Chidester & Anca, 2019). Hence, it can be easy for investigators to annotate channel-related factors, label as predictable the non-use of communication means, and apply a counterfactual view by highlighting that operators missed opportunities to follow standard operating procedures to communicate. The lower frequency in cognitive factors can be attributed to limited analytical skills concerning the mental aspects of communication. The CRM or other similar training and any communication skillset investigators need to possess to communicate the results of an investigation to each audience effectively (Nixon & Braithwaite,

2018) does not mean that practitioners have the knowledge and skills to interpret in-depth the cognitive aspects of other individuals regarding communication.

Conclusively, Hypothesis No 2 was only partially confirmed for both risk perception and communication.

HYP3: The relative extent to which safety investigators consider and search risk perception and communication factors reflects the extent to which these factors have contributed to aviation safety events.

Concerning risk perception, the rankings of factors between the interviewed investigators and the reports were found identical. On this occasion, the interviews representing the “what/how we investigate” notion were aligned with the investigation reports representing the “what we have found” notion. On the one hand, this alignment suggests that investigators, both the interviewed ones and those who compiled the reports, seem equally aware and inquisitive of the influence of risk perception factors. On the other hand, the similarity of rankings suggests possible effects of confirmation bias and group thinking where investigation teams uncover problems they are more aware of, feel more confident to search or for which they have easier access to respective information.

The rankings of risk communication factors are similar only for environmental, cognitive, physiological and temporal aspects, subject to the possible effects of confirmation bias and group thinking mentioned in the paragraph above. The higher appreciation of channel-related factors and the less reference to emotional factors from the interviewees was discussed in HYP1 above. The appearance of channel aspects with a lower frequency in investigation reports might be due to effective communication media management as a result of technical, training and organisational interventions and developments over time. The higher ranking of emotional factors in reports could be allocated to the effects of various personal experiences and approaches during investigations and respective training with the involvement of team members with diverse backgrounds and viewpoints. Also, despite the prior beliefs of investigators about the role of emotional factors, the information collected during investigations from persons involved in the events of interest might reveal additional emotional parameters.

Conclusively, Hypothesis No 3 was confirmed for risk perception and partially confirmed for communication.

HYP4: There is no statistically significant difference in the distribution of risk perception and communication factors revealed during safety investigations across the various flight phases.

The statistical tests suggested the prevalence of cognitive factors in risk perception during the flight planning phase and risk communication during the cruise phase. The former regarding, cognitive factors mediate the end-user's understanding of the mission and its condition, while the risk-related information communicated comes in a standardised manner (i.e. briefing, checklists). Although the application CRM principles may facilitate a safe flow of information by mandating explicit verbal communication, the question remains as to how many of the problems CRM solves are created due to incomplete risk perception (Hutchins, 2000). Additionally, the flight planning takes place in a relatively controlled environment and is a scheduled activity, a fact that explains the statistically lower frequencies of environmental, timeliness and channel factors of risk communication. During safety events unfolded in the cruise phase, physical and psychological stressors may increase the workload during parallel activities, one of them being communication (Wickens, Gordon, & Liu, Stress and Workload, 2004). Multiple factors have been highlighted as leading to miscommunication, such as quality of audio signals, the accent of pilot or controller, English language proficiency of operator, and failure to use standard phraseology (Molesworth & Estival, 2015), all of them linked to cognition.

Furthermore, the increased effects of timeliness factors in risk communication during the push back phase can be explained by the involvement of multiple operators and groups (e.g., ground crews, air traffic controllers, pilots) and the relatively short time of this activity compared to the preceding and following flight phases. Communication during push back tasks might be more vulnerable to background noise, variance in operational language fluency and use of visual signals which can create delays in communication (SKYbrary, 2019). Concurrent information and signals may increase mental workload and, consequently, decrease the available window for action by the operators to ameliorate any hazardous situation (Hutchins, 2000).

Conclusively, Hypothesis No 4 was confirmed for:

- Taxi, take-off, and descend regarding risk perception and communication factors.
- Push back and cruise for risk perception factors

and it was disconfirmed for:

- Flight planning
- Push back and cruise for risk communication factors

HYP5: The frequencies of risk perception and communication factors contributed to events as revealed during safety investigations are lower in the most recent time period 2015-2018 considered in the sample.

Interestingly, the results of the statistical tests revealed that in the latest period of 2015-2018, Cognitive (P-COF) and Environmental (P-ENF) factors related to risk perception and Cognitive factors (C-COF) of risk communication were observed less frequently, while the opposite stood for Timeliness (C-TIF) and Channel (C-CHF) factors of risk communication.

Regarding the low frequencies, it can be claimed that the operators could have been less influenced lately by these factors. The developmental course of human factors research and automation in the aviation industry could have provided enough barriers through the years to limit the specific factors (Mouloua & Hancock, 2019). Improvement of human-machine interactions and automation have alleviated the mental workload on human operators, thus decreasing the influence of related cognitive factors (Gawron V. , 2019). However, the consequences of automation should also be considered since they raise other risks, such as complacency due to overreliance to automation (Parasuraman & Manzey, 2010; Merritt, et al., 2019). Also, over time the influences of environmental factors on perception have been studied more thoroughly, providing better proactive measures (IATA, 2016). On the other hand, the increased contribution of C-TIF and C-CHF can be respectively linked to production pressures and saturation or quality of communication media (Ligda, et al., 2015; Kelly & Efthymiou, 2019) despite technological advancements and end-user training on relevant communication aspects.

Conclusively, Hypothesis No 5 was only partially confirmed for both risk perception and communication.

5.3.2. Sub-Study 2 Safety Investigation Practices

The investigators interviewed revealed that they draw from their experience and heuristic capacity to unveil risk perception and communication factors. The participants acknowledged the consideration of the context the investigation is applied with special references to the role of the operators involved, the individual characteristics of the latter, the processes under study and the influence of the wider environment, the prevalent culture included. Regarding especially the search for the contribution of risk communication factors, investigators declared that they rely on discretion, organisational data, lessons learned from past events, and training on communication while trying to comprehend the role of emotions.

Overall, the responses of the participants denote that risk perception and communication of aviation staff are shaped through training and work experience and influenced by the safety culture, indicating that the practices relevant to these attributes might differ significantly from the decisions or judgements made during formal risk management processes at senior organisational levels. Also, the role of emotions in subjective understandings of risk perception and communication practices was seen as determinative. This viewpoint complements research suggesting that neurobiological aspects of emotions are prime factors in the operations of consciousness and different levels of awareness (Izard, 2009) as it proposes additional socio-technical implications of emotions.

Similar to the salient role of emotions reported in this study, Miller and Sinclair (2012), who used focus groups to investigate risk perception in a coal mining community, found that participants responses clearly showed that cognitive judgments about risk and safety practices in the industry were salient, and a strong emotional current was evident throughout the data collected. Their findings indicated that pride was an important aspect of workers' social identity, bolstering a positive in-group identity, and related to personal risk (often physical) associated with their profession. The authors above concluded that experience of risk may strengthen the links between cognitive and emotional responses and that such an experience might also be personal or shared by a family or close community member.

5.3.3. Sub-Study 2 Safety Management Practices

The managers interviewed identified the factors influencing risk perception and communication based on their daily experience. The participants acknowledged the factors' role as disruptive in total, while indicating them as pitfalls needed treatment or safety barriers to achieve daily safe operations. Their main focus was on the safety thinking, sentimental attitude sourcing from conflict between intention and self-capacity, fatigue, intolerable environmental conditions as the pivotal factors regulating safe behaviour from risk perception perspective. Concerning risk communication, the communication culture regulates the vertical communication among the layers of management, supervision and front-liners and the horizontal communication among the personnel within the same level.

Overall, the managers' responses signify that they approach risk perception and communication from a heuristic and empirical angle, drawing from their professional background. Indeed, safety management guidelines (ICAO, 2013) allow this kind of freedom to safety managers. However, this shows a misbalance among personal experiences, organisational policies and safety bodies' guidelines resides within the safety manager's decision-making process, leaning towards the first against the other two. This highlights the gap to investigate a stricter horizontal approach limiting the personal filters of each safety manager, within a standardized intervention behaviour-based framework.

5.4. Sub-Study 3 Discussing the Intervention Frameworks

When the features of the 11 intervention techniques used in this sub-study are considered, the predominance of education as an intervention function across all methods may be explained by its widespread use for developing and enhancing safety-related skills and capacities (Sivaramalingam, et al., 2015; Kirkman, et al., 2015). Interestingly, seven out of the eleven interventions examined were evaluated on the basis of intentions or system outcomes, indicating that the latter are employed as proxies for behavioural changes (Sheeran, 2002; Webb & Sheeran, 2006). In particular, when it comes to intention, the proportion of the intended audience that is aligned with the intervention's objectives has often been seen as an indicator of efficacy (Jensen, et al., 2020). On the other end, less inclined groups have been linked with forgetting to conduct as directed by the intervention, failing to leverage on chances to act as anticipated, reverting to prior or undesirable behaviours, and being noncompliant (Gollwitzer & Sheeran, 2006). Nevertheless, since stated intentions do not guarantee particular behaviours, it seems as if many of the treatments examined are predicated on a hypothetical relationship between behaviours, intentions, and results (Sheeran & Webb, 2016; Hulland & Houston, 2021).

The relatively higher coverage of SHELLO clusters and risk perception and communications factors in "recognition primed decision making” (RPDM), "Netherlands: sustainable safety", "naturalistic decision making" (NDM), INDICATE and "post-training feedback" reflects the inclusion of environmental and individual perception aspects that might facilitate consideration of several interactions amongst people and their social, organizational, technological, and environmental settings. For instance, RPDM and NDM, which have mostly been applied to aviation, have benefited from the systems approach and overcome biases (Johnson, Kirwan, Licu, & Stastny, 2009). On the other hand, the low SHELLO rankings for "enhanced refresher training" and "proactive risk management" may be explained by the inclusion of specific scenarios/cases within each intervention rather than addressing scheme modules and any possible interactions that could result in multiple scenarios. Both interventions seek to enhance training and risk management via the use of particular scenarios in order to reduce avoidable emergency service vehicle accidents (Bui, et al., 2018).

The variations in how SHELLO clusters and risk perception and communication variables are represented across intervention functions may be explained by the change agents' knowledge base and the nature and scope of each function. According to the results, the function appearing with the highest score was “enablement” covering SHELLO and risk perception, while “coercion” and “modelling” appeared in the functions with the lowest coverage of risk perception and communication. In addition, “modelling” was also found with average scores in addressing the SHELLO clusters. The function "enablement" has been shown to be helpful, reinforced through printed material and verbal communication, in educating adults and increasing knowledge retention among professionals (Leppien, Demler, & Trigoboff, 2019). In this manner, it places a premium on information acquisition over skill development (Note, De Backer, & De Donder, 2021), which explains the minimal coverage of risk communication. The insufficient coverage of risk perception and communication factors by "coercion" may be explained by its binding nature of strictly influencing behaviours regardless of the audience's state and volition, which presents an ethical dilemma and a reason for the specific function to be perceived as an abuse (McKeown, Mortimer, Manzini, & Singh, 2019; Asikainen, Louheranta, Vehviläinen-Julkunen, & Repo-Tiihonen, 2020). Additionally, "modelling" focuses only on the end-user without regard for other components (e.g., organization-O, software-S), often aiming at replication via the manipulation of perceptions about advantageous capabilities and talents. As a result, this enables a form of social learning to occur without necessarily addressing informed choices for the targeted behaviours (Carrey, et al., 2019). As such, risk perception and communication factors are unlikely to be visible components of imitation of desired safety behaviours.

The greater coverage of the SLLE and HLLE clusters, the average presence of the LLOE and OLHE clusters, and the low frequency of the LLOE and OLHE clusters across all intervention functions reflect an emphasis on interacting factors closer to the end-user (L), specifically other persons (L), the equipment and tools used to perform tasks (H), the procedures and rules applied (S), and the physical environment (E). The lack of representation of the "O"-organization element may indicate organizations being excluded as distinct system actors. For instance, ISO 31000:2018 on risk management (British Standards Institution, 2018) recognizes the interconnections between the S, H, E, and L components of organizations. However, it considers the latter as primarily a monitoring function rather than as a collection of different elements when developing interventions. Nonetheless, identical treatments may need to be differentiated and tailored to distinct organizational identities in order to adhere to the concept of intervention specificity (Michie, Atkins, & West, 2014).

Additionally, the greater prevalence of risk perception factors than risk communication factors reflects the focus of behavioural interventions on how individuals comprehend their overall environment in order to make informed decisions and act safely, with less emphasis on how end-users communicate their perception to others. Similarly, safety interventions are more concerned with enhancing the safety atmosphere (i.e., perceptions of what is going on around them) than achieving specific goals such as increased safety knowledge (Zohar & Polachek, 2014; Nielsen, 2014; Bronkhorst, Tummers, & Steijn, 2018). This may also account for the increased coverage of cognitive factors associated with risk perception. Various methods used to assess safety culture and climate do not contain clear and visible questions regarding emotions, physiological states, and the natural environment. For instance, neither the Aviation Safety Climate Scale (Evans, Glendon, & Creed, 2007) nor the Integrated Organizational Safety Climate Questionnaire (Brondino, Pasini, & Da Silva, 2013) specifically contain or evaluate any of the topics listed above.

The lack of channel-related risk communication factors from intervention functions may be explained by the end user's limited control over such parameters (e.g., radio and other wired/wireless channels) or may indicate an underestimate of their importance. Additionally, the presence of emotional factors in risk communication at the same low frequency as in risk perception and the presence of temporal factors at comparable low frequencies could be expected, as several communication models and studies take a cybernetics approach and view communication as a controlled or standardised process, executed with readbacks and typical phraseology, without acknowledging a human aspect (Lasswell, 1948; Shannon & Weaver, 1949; Berlo, 1960; ICAO, 2007).

Interestingly, physiological factors received the lowest scores for risk perception and communication, with a coverage rate of just 6% across intervention functions for risk communication. This lack of representation may be explained by the assumption that users would always be physically and mentally fit for work and will report any unfavourable physical or mental health problems. However, research indicates that presenteeism (Karanika-Murray & Cooper, 2018) and mental health problems [e.g., the German-Wings Crash (Soubrier, 2016)] may be undetected as a result of workaholism (Mazzetti, Vignoli, Schaufeli, &

Guglielmi, 2017), performance-based self-esteem (Dahlin, Joneborg, & Runeson, 2007), and increased stress (Maestas, Mullen, & Rennane, 2021).

The findings of a combined ranking of functions based on their inclusiveness of system interactions, risk perception, and communication factors across all intervention methods suggest that combining "enablement," "education," and "environmental restructuring" into a single approach may be the most pragmatic from a cross-industry perspective, based on the experience and knowledge gained by means of their use in a variety of settings to date, independent of the intervention method used. This implies that it would be essential to exchange best practices and insights from interventions in which those functions were used in order to supplement them with the SHELLO clusters, risk perception, and communication aspects that are currently lacking.

Although the combination suggested above does not guarantee effectiveness due to the interaction of several factors (e.g., intervention agents' characteristics, workforce physiological, psychosocial, and emotional capacity, and organizational support), it could serve as a starting point for holistically addressing behavioural interventions. It is worth noting that two of the intervention approaches evaluated, RPDM and "Australia: National Road Safety Strategy: 2011–2020," contain all three of the aforementioned functions, although the former outperforms the latter in terms of inclusion. Thus, in continuation of the preceding argument and from a readiness perspective, RPDM appears to be the intervention method whose practices could be shared across organizations and subsequently enriched with the elements identified as missing in the cross-method analysis: risk perception (environmental factors), risk communication (physiological, emotional, environmental, temporal and channel factors) and system interactions including the organizational element.

In terms of the areas targeted for improvement, they seem to reflect persistent topics of interest and concern throughout the industry. For instance, "situational awareness" has been identified as a key component in the aviation environment due to its impact on all choices and actions made during aircraft operations (Nguyen, Lim, Nguyen, Gordon-Brown, & Nahavandi, 2019). “Fear of punishment”, where causes of events are personified rather than objectified, may foster a culture of poor reporting (De Castro Moura Duarte, Alonso, Gallier, & Prado Mercado, 2018). Biases have long been recognized as significant barriers to efficient communication and contributors to catastrophic judgment mistakes (Thaler & Sunstein, 2008; Kahneman, Thinking Fast and Slow, 2011). Additionally, "fatigue" is a focal point for human factors in general, with fatigue management being one of the efforts targeted at mitigating tiredness and/or its consequences (Bendak & Rashid, 2020).

While the frequency with which the targeted areas appear in the findings may indicate their relative significance for the effectiveness of safety measures, their differences do not necessarily correspond to theoretical core concepts. For example, the increased emphasis on "consciousness" and the decreased emphasis on "distraction" do not imply their interdependence as fundamental notions of cognitive processes (Kaber, Jin, Zahabi, & Pankok Jr., 2016; Taatgen, et al., 2021). Another example is that "fatigue" was shown to be exclusively linked with physiological factors, while mental attributes are often ignored (Gawron, French, & Funke, 2001; SKYbrary, 2020)and neither social fatigue (Fauville, Luo, Queiroz, Bailenson, & Hancock, 2021) nor emotional fatigue (Portoghese, et al., 2020) were identified as areas of change in the sample.

One of the research's limitations was its reliance on an internet search of peer-reviewed studies, which excluded non-digitalised publications, as well as industry/professional papers and reports. Additionally, the sample was restricted to the healthcare and transportation sectors on the grounds of their perceived criticality and the transferability of their paradigms to other domains. This constraint precludes generalisation of the results. Additionally, it is acknowledged that the taken approach with frequencies and additions is linear and does not take into account the weights associated with the individual SHELLO clusters, risk perception, and communication factors, as well as the relationships between SHELLO, risk perception, and communication. Nevertheless, given that this is the first study on the matter, the method followed by the author is adequate to provide important insights and, perhaps, spark further research.

5.5. Sub-Study 4 Discussing the Aviation Personnel Input and the Model's Development

5.5.1. Aviation Personnel's Input

Overall, the aviation personnel's suggestion concerning the intervention function was positive for both risk perception and communication. As such, the sample showed the amount of acceptability of the intervention functions, no matter how hardly achievable, which is a necessary condition for effectiveness of an intervention. Indeed, the content, specific context and quality of intervention may all have various implications for effectiveness. For example, a study to assess the risk of emergency nursing occupational hazards by job safety analysis showed that the implementation of engineering and administrative interventions may have overlapping effectiveness in reducing risks (Zibaei Karizi, Esmaeili, Akhavan, & Halvani, 2020). On the contrary, incentivisation function was estimated with average influence over the aviation personnel. This could be attributed to its nature creating expectations; however, these expectations might not fit the people credited to. For example, even monetary compensation can be a poor motivator as it was shown in a study, which examined the smallest meaningful pay increases in terms of magnitude, behavioural intention, and affective reactions (Mitra, Tenhiälä, & Shaw, 2015). Regardless, honest face-to-face feedback should have been motivating enough for matters of safety, improving task performance (Johnson, Weerasuria, & Keating, 2020). According to Johnson et al. (2020), the reasons constituting feedback as a valuable incentivisation can be real-time interaction, allowing for concurrent assessment, and interpersonal connection, where experience and empathy facilitate motivation and learning. For the aviation personnel questioned in this study, this was not the case.

Furthermore, the results showed that organisations vary their incorporation of education and modelling functions for risk communication, environmental restructuring for risk perception, and enablement for both constructs. The three examined groups in this study adhere to the common principle of airworthiness as the “demonstrated capability of an airborne store to perform satisfactorily and fulfil the mission requirements, throughout the specified life in the prevailing environments with acceptable level of safety and reliability” (Biswas, 2020). As such, all aviation organisations aim to increase their risk reliability, presumably in a universal and systemic manner. However, according to the results there were variations for specific functions. The variations could be attributed to differences among the examined groups (i.e., military, commercial, miscellaneous, other) and the application of the varying intervention functions per context.

Concerning military aviation group, for which the literature is limited, it was associated with the least use among the four groups of environmental restructuring for risk perception. The military aviation environment presumably adheres to military conformity, and this could mean that personalized measures for changing post or work environment are not within reach, given the military rigid structure (Braswell & Kushner, 2012). In addition, the high cost of specialization for aviation officers and non-commissioned officers can be disallowing to relocate someone in terms of invested training time and cost. As such, the mental context is rather limited, thus the link with risk perception. Adjacent, the military aviation group was associated with enablement function for both risk perception and communication, most of the four groups. It is suggested that enablement is most frequent due to use of existing means to facilitate behaviours or removing barriers, and due to the continuous drive for excellence through the acquisition of knowledge and skills (Bekesiene, Meidute-Kavaliauskiene, & Hošková-Mayerová, 2021). Similarly, the same drive could be credited with use of education function for risk communication, third among the groups. In the same vein, presumably the hierchical military structure hampers open communication, regardless the communication standards in aviation (ICAO, 2007; ICAO, 2013). Likewise, although it can be customary to read accident reports during the morning briefings in air force squadrons, the limited room for open communication explains the reason the group was second among the four groups for modelling for risk communication.

Regarding commercial aviation group, it was third out of four groups for environmental restructuring for risk perception. A possible explanation is that specialisation and skills in the modern aviation context can be quite expensive and time consuming for organisations (ATP, 2021; Airgoldcoast, 2018; EU Commision, 2021). In addition, since the economic crisis of 2008 and the infliction of COVID-19 pandemic, many states have been striving to retaliate the consequences as well as industrial fields, such as aviation (Oravský, Tóth, & Bánociová, 2020; Gössling, 2020). In other words, environmental restructuring maybe is seen more as a handicap for risk perception by the aviation personnel, keeping them off the job loop while trying to readjust to their new context. Following, it was third for the two facets of enablement for risk perception and communication. Although enablement is suggested by ICAO as a broad practice for safety (ICAO, 2020; EASA, 2021), risk perception and communication can be dependable on the quality of effort from all the stakeholders tasked to maintain licensing and proficiency, enabling safe performance, and on the quality of effort from the aviation personnel on self-taught practices. In addition, it was second for education for risk communication. This could be attributed to the quality of the education system associated with communication skills. Although communication skills are highlighted within the aviation training (FAA, 2020), are rather limited to a simplistic mode of two-way and linear communication. Also, the technical-knowledge competency emphasis could lead to poor quality of interpersonal communication (Vieira & dos Santos, 2010). Likewise, the same emphasis could be accountable for modelling intervention function’s place as third for risk communication. Meanwhile, the continuous rise of automation (Rungta, et al., 2013) in conjunction with the need to exemplify, or "lead-by-example", in safety demonstration procedures (IATA, 2017) underlines a pendulous conundrum need between technical versus soft skills training.

With regard to miscellaneous group, it was second for environmental restructuring for risk perception. Change and relocation in general aviation (SKYbrary, 2020) can be easier due to the standard required training level and the on-going build-up of specialised skills, where the special limitations of the "commercial" and "military" groups are not absolute. Likewise, it was second for enablement for both risk perception and communication. Due to the local hiring trait of general aviation, most aviation personnel may be employed as freelancers, which makes it easier for an enablement scheme to be applied since the aviation professional is not bound to specific organisation long-term (Jorens, Gillis, Valcke, & De Coninck, 2015; Zadik, Bareket-Bojmel, Tziner, & Shloker, 2019). Based on the aforementioned traits of the miscellaneous group and in combination with the discussed assumptions, the first position among the four groups for risk communication education and modelling functions may stem from the same traits, as already discussed. Seemingly, the atypical employment status in aviation may have a direct impact of the interventions chosen for the last decade, while it is a concerning issue for the aviation industry where, for example, 'pay-to-fly' pilots are just outsourced for a short period to be "educated" (education function) and briefly shown the "know-how" (modelling function) (ECA, 2015; Gorbačovs, 2016; Brannigan, et al., 2019).

Concerning other aviation activities group, it was first for environmental restructuring for risk perception. Within this group are also included ground operations, such as ground handlers. With regard to the low amount of highly specialised personnel in aviation equipment, it can be easier to provide with more relocation solutions concerning the working context and the job duties. However, there are still challenges to consider, such as familiarity with equipment (Linton, 2016). Following, it was fourth for enablement for both risk perception and communication. The assumption is that behavioural support by the increase of means for assisting aviation personnel is less from the other groups due to the prioritization the organisations dedicate for the purposes of airworthiness, which either refers to the technical aspects of the aircraft or the fitness of the flying personnel (Richardson, 2010; SKYbrary, 2020). Similarly, it was fourth for education and modelling functions for risk communication. A probable cause can be the variety of specialties within the groups, other than directly related to airworthiness, not allowing resources to be invested in this kind of interventions. However, it is known for years that communication skills are holistically important for the safe flow of operations at all levels (Vieira & dos Santos, Communication Skills: A Mandatory Competence For Ground And Airplane Crew To Reduce Tension In Extreme Situations, 2010).

Concerning the resistance of aviation professionals towards specific intervention functions, assuming them as a challenge to their professional autonomy (Michie & Lester, 2005), it was confirmed for incentivisation and coercion functions. Increased experience may come with ambition and increased need for recognition, and aviation personnel like everyone can also be affected by ego and the need to protect it, which may work as a buffer for work-related stressful events (Renger, Miché, & Casini, 2019). Therefore, incentivization may be unsuitable depending the kind of incentive given. For example, monetary incentives have limits due to the organisational capacity for expenses and that money is not motivational for everyone, as it is already discussed earlier. Likewise, coercion may be insulting and diminishing for an experienced professional due to its nature.

Concerning the derivation of intervention functions from various existing frameworks (Michie, van Stralen, & West, 2011), the prevalence of training and education over their scored opposites, coercion and incentivization, suggest the suitability of their respective frameworks for risk perception and communication. Depending on the organisational challenges and routine, the aviation context is constantly developing technically and socially (Kim, Lee, &

Ahn, 2019; Walker, Bergantino, Sprung-Much, & Loiacono, 2020; Papanikou, Kale, Nagy, & Stamoulis, 2021). Modern needs such as climate change and the recovering from COVID-19 may pose the need for aviation industry to sustain a zero-carbon footprint, balance environmental and economic aspects of air transportation, and incorporate more advanced health safety protocols against viral pandemics. Therefore, the aviation context has invested more on education and training rather than simply forcing obedience (coercion) or spending resources one anyone's personal goals (incentivisation).

Moreover, training and restriction functions were significantly different between their respective facets for risk perception over communication, regardless the assumption of similarity of functions based on the Capability-Opportunity-Motivation-Behavior (COM-B) model's associations with the interventions (Michie, van Stralen, & West, 2011). Supposedly, when applying an intervention to similar behaviours or behaviours with two or more facets it would be more sufficient the same intervention function to affect them due to their closeness. Surely, this has the advantage of gaining time and resources over the targeted outcome. However, the criterion of specificity during interventions may have interfered in these cases, resulting to the noted differences. In addition, restriction function due to its nature of reducing engagement, it resonates that it was less associated with communication.

5.5.2. Comparing Investigators, Managers, and Personnel

The comparison among those who enact safety policies (Safety Managers), those who control the mishaps (Safety Investigators), and those who routinely employ safe behaviours (Aviation Personnel) allowed to highlight their traits and reflect on their situated understandings of their own contexts (Torrence, 2008). Therefore, the following comparisons may reflect the presence of phenomena within the investigated context for the finalisation of the model (Ritchie, Lewis, McNaughton, & Ormstrom, 2014).

This sub-section addresses the comparison of qualitative findings among the three samples. This comparison highlights the gaps and similarities among the professionals who enact safety policies (safety managers), those who confirm the application of these policies, should operations fail (safety investigators), and those who employ the safety policies during operations (aviation professionals). The comparisons crossmatch the themes and sub-themes of the samples.

5.5.2.1. Comparison Between Safety Managers and Investigators

Concerning risk communication, safety managers and safety investigators agreed in four sub-themes and disagreed in three. First, they agreed that the lack of versatility of communication means inhibits the reach of communication to the right audiences, thus limiting the organisation's systemic capacity to communicate risk effectively. Ensuing, they highlighted the importance of emotional management for emotions, such as fear to communicate and internal conflicts, as an inhibitor. Furthermore, they stressed the influence of cognitive aptitude to manage the available resources and barriers to communicate (i.e., experience, information overload, complacency, biases, training). Additionally, physiology was agreed to disrupt risk communication when the psychosomatic limits are surpassed, or the end-user's resilience is not matched with the corresponding workload.

Turning now to the dissimilarities, the two samples disagreed upon how the organisational factors disrupt risk communication. Managers highlighted the trust among hierarchy levels, while investigators stressed the role of the unreliable communication network in the organisation. Adjacent, managers conveyed that timeliness disrupts risk communication due to wrong circulation of information among involved end-users, while investigators pointed out the time congruency to exchange the information. Moreover, managers indicated the environmental disruption due to the limitations of protective equipment and ineffective policies, while investigators stated nothing.

Risk perception concerned, safety managers and safety investigators agreed in three sub-themes and disagreed in two. Both samples highlighted the disruptive role of fear and internal conflict on the hazard's estimation. Next, they stressed the disruptive role of the organisation's culture as per the amount and pressure of involvement. Furthermore, they agreed on the disruptive role of physiological limits not being matched to the corresponding workload. Regarding the differences, managers allocate the disruptive role of cognitive factors on internal barriers (i.e., biases), while investigators allocate it on personal limits (i.e., knowledge). Additionally, managers pointed out standard workspace environmental disruptive factors (i.e., noise, temperature), while investigators stressed spontaneous events leading to tunneling effect.

With regard to their practices, managers and investigators agreed on drawing from their experiences and the use of heuristics for risk perception. On the risk communication side, they both highlighted their roles, the managers as mediators to support effective communication and the instigators as points of reference of events to suggest solutions and changes.

5.5.2.2. Comparison Between Aviation and Safety Professionals

Comparing the aviation professionals' inputs with those of managers and investigators produced interesting findings. Concerning risk perception, professionals agreed with investigators on external factors limiting effecting cognitive hazard processing. Adjacent, professionals acknowledged the organisation's involvement only as enabling them, in contract with both managers and investigators. Likewise, professionals differed from managers and investigators disregarding fatigue as delimitating factor of fitness to operate and resilience to workload. Similarly, professionals contrasted the other two samples by disregarding the emotional disruption on risk perception.

Regarding risk communication, all samples agreed on the disruption caused by systemic communication lack of flexibility and ineffective reporting culture. Following, professional agreed with investigators on the disruptive role of organisational-environmental complexity, the lack of a uniform communication mindset as versatility inhibitors, preventing accurate and effective risk communication. Furthermore, professionals disagreed with the other two samples because the latter focus on the end-user's aptitude regardless of the received training. Moreover, professionals agreed with investigators on the disruption caused by the lack of accurately circulated information. In addition, all samples agreed on the disruptive role of emotion as a stressor incapacitating accurate information circulation. Similarly, there was an agreement on the disruptive role of the health status hindering effective risk communication.

5.5.3. The Strategic Communication Insight

According to the previous findings and the followed methodology, the development of the StratCom part of the model is described in the following paragraphs. For the second phase specifically, the guidelines suggested by Michie et al. (2014) for the goal-setting, the action and response strategies, and the communication for a behavioural intervention were followed. Furthermore, steps 8-9 of StratCom planning were not examined as they are extending beyond the thesis' scope.

For the first phase, the situation analysis returned interesting results. The findings present the following obstacles. According to sub-study 1, risk perception and communication factors align with the application of a most recent systemic SAIM within an aviation organisation. Hence, there is not a strict approach on the use of systemic models. Per se, this obstacle could turn into an opportunity through the motivation on using recently published systemic SAIMs. Additionally, emotional factors were underrepresented in sub-studies 1-3, which contradicts the importance of emotional factors conveyed by the safety investigators and managers. This contradiction can turn into an opportunity for the model by implementing the targeting of emotional factors for risk perception and communication. Furthermore, the variation of intervention functions among categories of aviation organisations poses a challenge. However, the variations were located in intervention functions other than Training (i.e., Environmental RestructuringRP, EnablementRP, EducationRC, ModellingRC, EnablementRC). Likewise, Training was found to be more helpful for risk perception than risk communication. Nonetheless, due to the fact that the statistical tests yielded small effect sizes and that Training has been prevalent as intervention function over the rest, it is considered dominant to employ within the model. Another contradiction is that Education was prevalent against the other functions across the scoped behavioural intervention methods, while Training was found fourth.

What is more, the following opportunities were located. According to sub-study 1, environmental factors play the central role within SAIMs above the other factors concerning risk perception and communication. Likewise, in sub-study 2 the environmental factors were prevalent within the safety investigation reports, the safety investigators' and managers' interviews, and the aviation personnel survey results. In addition, the systemic behavioural intervention frameworks RPDM, "Netherlands: sustainable safety", NDM, INDICATE and "post-training feedback" were the intervention methods that appeared most inclusive of system interactions and risk perception and communication factors. Moreover, the aviation personnel regarded as most helpful the Training intervention function for risk perception and helpful for risk communication. Following, the aviation personnel regarded behavioural specificity as a challenge to their professional autonomy for Education and Enablement, and not for Training and the other intervention functions. Additionally, the variation of intervention functions based on the theoretical framework they derive from was confirmed.

Following, the organisation analysis focused on the organizational inputs included in the previous sub-studies' findings. The communication environment of an aviation organisation as conveyed by the findings is depicted divided in first-liners and supervision level, with the latter to enact various kinds of pressure to the first, while inhibiting effective and timely circulation of information. Indeed, indifferent communication management and reporting culture at all levels concerned all three samples. Furthermore, the detailed organisational factors considered for the model, have been listed in Tables 4-22, 4-24, and 4-31.

In addition, the target audience analysis received inputs from the demographics and the specific factors indications of the previous sub-studies. The enablers for the model to have an effect on the aviation personnel were allocated on the face of safety managers, reliable supervision, facilitating workspace, flexible organisational culture, for both risk perception and communication. On the other hand, the limiters for the model's application were spotted on the complacency sourcing from physiological-mental fitness to operate, the end-user's capacity to perceive and communicate hazards effectively, and the instability caused by the lack of training on emotional management.

Concerning the second phase, the goals were based on the three samples' specific factors. Table 5-33 summarizes the specific factors referenced as directly disrupting risk perception and communication, which were common among the three samples. Regarding the formulation of the model's goals, the factors from the aviation professionals were used as the "end-user" recipient and the model's target audience. In retrospective, these are the factors which will be targeted by the model.

Table 5-33: Summary of common specific factors among the three samples.

Risk Perception Factors	Managers	Investigators	Aviation Professionals
Cognitive	Experience	Experience Knowledge	Experience Knowledge
Emotional	Fear	Fear	Fear
Physiological	N/A	Somatic Fitness	Somatic Fitness
Environmental Organisational	N/A	N/A	N/A
Environmental Physical	N/A	N/A	N/A
Risk Communication			

Risk Perception Factors	Managers	Investigators	Aviation Professionals
Factors			
Cognitive	Experience Training Knowledge	Experience	Experience Training Knowledge
Emotional	Fear	Fear	Fear
Physiological	N/A	N/A	N/A
Environmental Organisational	Complex communication network	Complex communication network	Complex communication network
Environmental Physical	N/A	N/A	N/A
Channel related	Availability of means	Language barriers	Availability of means Language barriers
Timeliness	Availability of means	Availability of means	Availability of means

Figure 5-24: A Diagrammatic Model of Risk Perception and Communication Influence on Behaviour

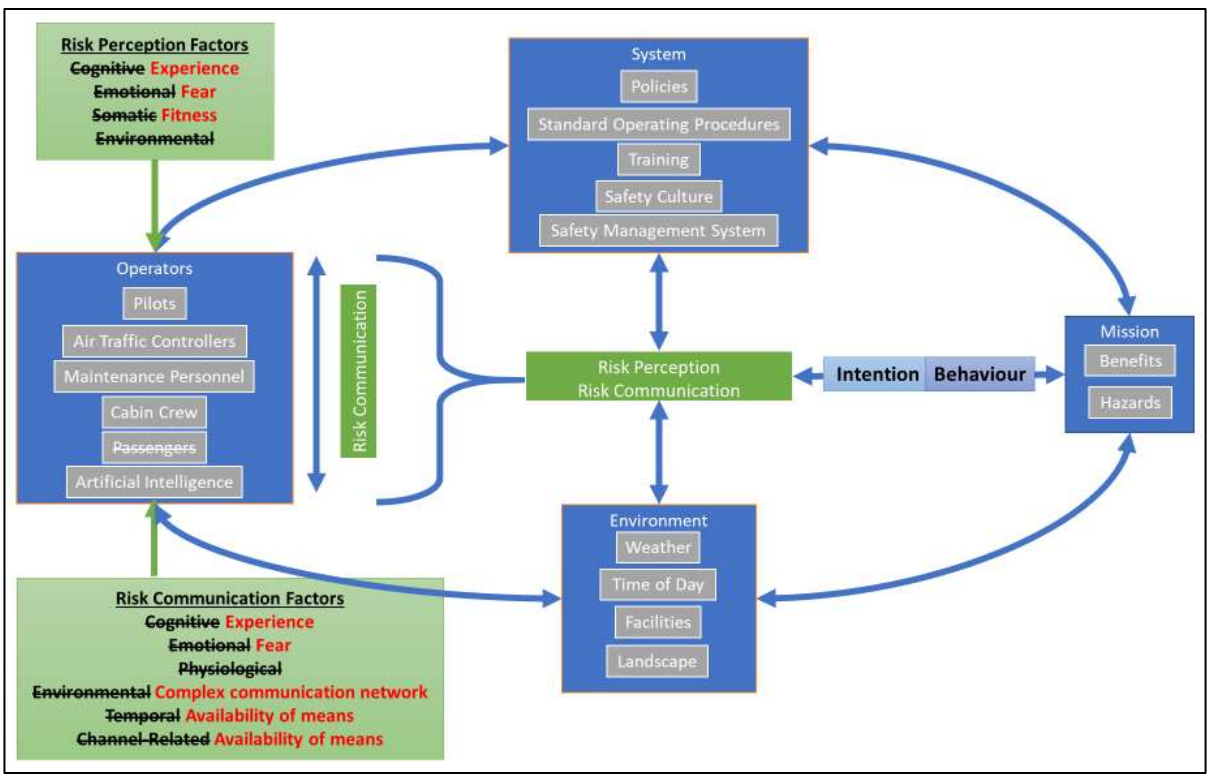
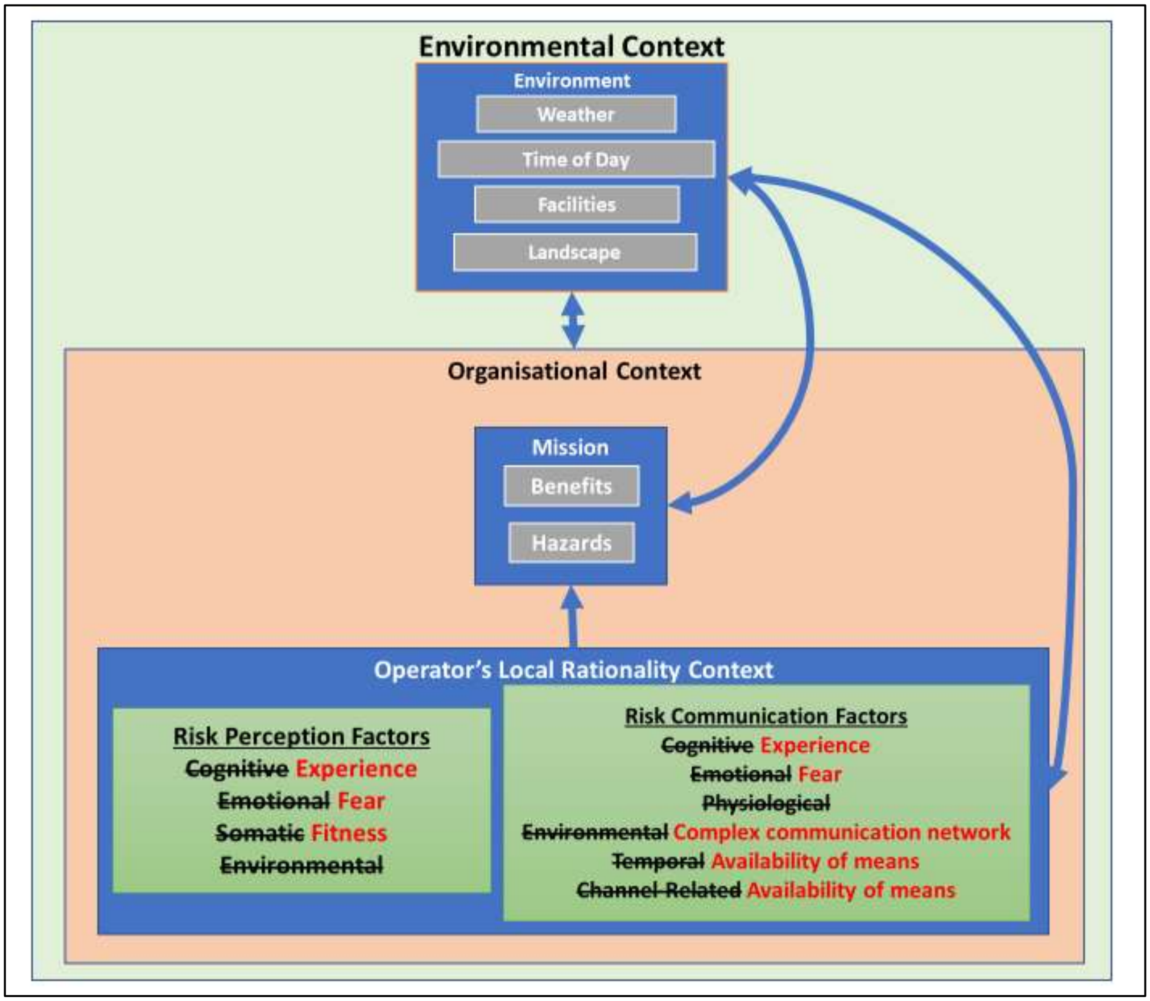


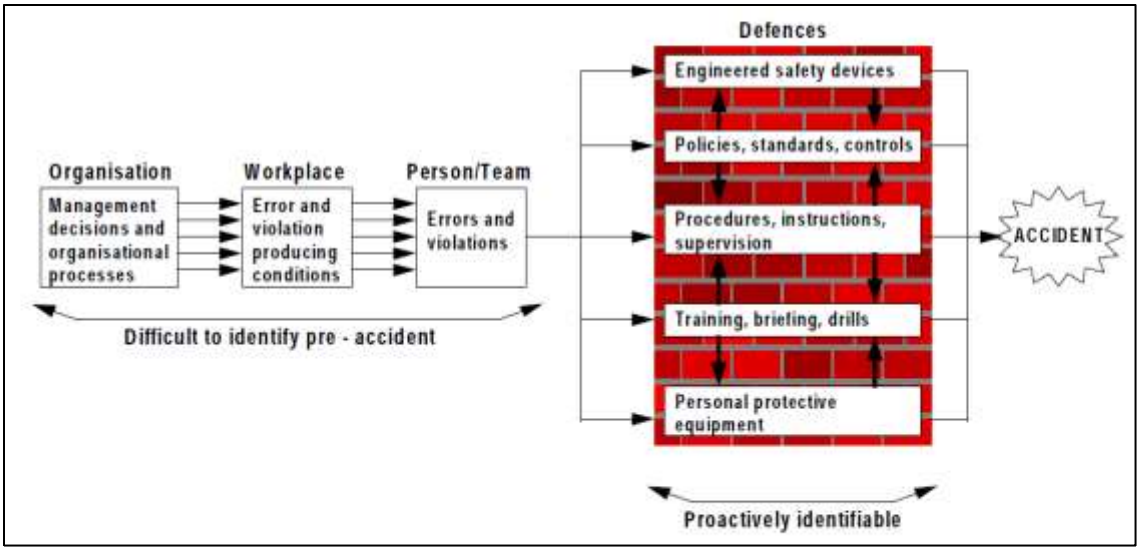
Figure 5-25: Contexts as Variables Influencing Risk Perception and Communication



The action and response strategies derived from the scoping review's findings. Specifically, among the frameworks found in the scoping review, INDICATE framework is the most suitable since it comes from the aviation context, it includes the intervention functions with the highest meta-ranking.

Based on the measurability of a system's defences, unforeseeable and latent hazardous cues can be more precisely determined (Figure 5-26). Moreover, Edkins (1998) suggested INDICATE to encourage better vertical communication between first liners and the management, to unveil critical areas for safety (e.g., training), to provide a framework for feedback, to provide a baseline for safety management decisions, and to provide cost-effectiveness. Specifically, the results from the initial trial study showed that the application of INDICATE made the aviation personnel perceive the same risks as less severe and less likely.

Figure 5-26: Proactive defence evaluation model **(Edkins, 1998)**.



Based on the above, the INDICATE framework was integrated with the resulted intervention setting. For an elaborate depiction of this integration, the edited framework was tabulated with its former steps and the additions, as follows:

Table 5-34: Initial INDICATE Steps with suggested additions to fit in the model

INDICATE Steps	Additions
Step 1: First, the intervention should focus on the main operational areas (flight operations, maintenance, ground operations).	Here, the application of communication/marketing policies may help the appropriate target audience (TA) provide the unique identity of risks through a strategic scope. The capacity to engage in a specific hazard should be considered, and the motives and beliefs towards that specific risk to perceive it and communicate it.
Step 2: Second, for each hazard, the staff should determine the defences in place to contain the hazard.	The safety standards should be appreciated for the support they provide to each TA. What is more, the defences should provide physical and social means of influence towards perceiving and communicating risks.
Step 3: Third, the staff should evaluate the	The TA should be given chances to

INDICATE Steps	Additions
effectiveness of these defences.	broaden skills and its capacity to engage in mental processes. The educational/persuasion means should be communicated effectively for a successful effect.
Step 4: Fourth, the staff should suggest additional defences.	The TA should be given a trusted and facilitating environment to make impactful suggestions about adding or adjusting safety defences. The aviation staff should possess the skills to perceive risks realistically, the communication skills to bring up their suggestions, physical means to communicate, motivation to act in this way, and a matching belief concerning the betterment of the safety status with their contribution.

The plan for effective/niche communication of the model was based on the target audience analysis as deriving from the three samples' inputs (safety managers, safety investigators, and aviation personnel), the set objectives and the scoping review's findings. Specifically, the suggested plan the thesis' model aims at communicating effectively the factors depicted in Table 4-32, combined with the most effective intervention framework (i.e. INDICATE) and intervention function (i.e. "education").

In the light of the above, the thesis' framework aims at factors influencing risk perception for the aviation context, which were cognitive (Experience) and emotional (Fear) factors. Concerning risk communication, it aims at cognitive (Experience), Emotional (Fear), Environmental Organisational (Complex communication network), Channel related (Availability of means, Language barriers), and Timeliness (Availability of means) factors. From this behavioural analysis, education intervention function was selected to improve knowledge and understanding of mental-sentimental-physical management and enhance communication skills.

Following, the INDICATE (Identifying Needed Defences In the Civil Aviation Transport Environment) with the incorporation of suggested additions in Table 5-34, is transcribed as Identifying Strategic Requirements for Risk Awareness (ISRRA), with the following steps:

1. Consider the operational area and the involved personnel based on their face-to-face interactions conditioned by beliefs and motives for the risks.
2. Provision of socio-technical facilitating means/aids for risk perception and communication.
3. Level of all personnel's education level upon the effectiveness of risk-taking behaviour barriers.
4. Provision of an enabling communication context, promoting risk awareness knowledge and communication skills.

Following, to deliver the intervention functions the model needs communication tactics. Based on education as the chosen intervention function, the most appropriate tactics are a) communication/marketing, b) guidelines, c) regulation, d) legislation, e) service provision (Michie, van Stralen, & West, 2011). These tactics should employ the operational narrative format[10] when creating messages to audiences (Karlsson & Westenkirchner, 2018). Based on the APEASE criteria (affordability, practicability, effectiveness/cost-effectiveness, acceptability, side effects/safety, equity), changing regulations and legislation are appropriate after consideration of the aviation authorities rather the organisations. Therefore, the tactics appropriate for the thesis' model are communication/marketing, guidelines, and service provision. Similarly, the mode of delivery which satisfies the APEASE criteria is face-to-face communication, individually and in groups, rather than distance media (e.g., broadcast and print media) since aviation personnel are unlikely to have uniform access to phones, computers or others forms of media whilst working.

[10] a) the problem-threat, (b) causes of the problem, (c) what needs to be done about the problem-threat, (d) what needs to be avoid (conditional), (e) the end-state

5.6. Summary

The purpose of this chapter was to discuss the findings of four sub-studies which followed a sequential design and an exploratory approach. First, the presence of risk perception and communication factors in Safety Aviation Investigation Methods (SAIMs) was discussed showing various presence within this particular context. Adjacent, the role of these factors was appraised within the aviation operational context from an ad hoc approach, through safety investigation reports and the input of safety investigators, showing that risk perception and communication are present but not thoroughly or always acknowledged for their importance and contribution in safety events. Likewise, the safety management level incorporates methods to ensure that risk effective perceived and communicated but not in a systematic manner. Moreover, the existing intervention frameworks showed that although there is an attempt to behaviourally influence towards safe behaviour, this is not yet systematically done for risk perception and communication. Furthermore, the aviation personnel recognized intervention functions applied on their practice and that there is a substantial effect on their risk perception and communication appraisal and incorporation of safe behaviours.

6. Chapter 6: Conclusions

6.1. Introduction

The results of this mixed methods research were discussed in the previous chapter. This final chapter includes an overview of this study, the presentation of the created model through an everyday example, and limitations of the study. Finally, theoretical, methodological and practical contribution to knowledge and suggestions for further research are iterated.

6.2. Study Description

The purpose of this study was to create a model which would enable workers from all levels in an aviation organisation to regulate their own others' risk perception and communication. For this end, the model should enclose the factors influencing risk perception and communication of workers in the aviation context during operations. Therefore, this research assessed the ways safety is applied by safety managers, the broad aviation workforce and audited by safety investigators. In addition, this research scoped on the theoretical aspects of safe behaviour as applied by theoretical models of safety and as manifested through safety events databases. Moreover, this research scoped on applied behavioural intervention frameworks and functions to estimate the suitability of the type within the aviation context.

Risk perception and risk communication can be described as "recognizing the veracity and gravity of an incoming hazardous cue" and "being able to communicate the veracity and gravity of an incoming hazardous cue", respectively. The goal is to possess the ability, or at least evolve it, to understand an incoming hazard and being able to share that information effectively. Some of the most widely known tools, such as Decision Trees (Utgoff, 1989), the Bowtie Method (De Ruijter & Guldenmund, 2016), or the Risk Matrix (Ristić, 2013), are designed to assess and manage risk, and the performing elements affecting it. However, they aim at the subject and the surroundings of the end-user, rather taking a systemic approach and consider the end-user as part of the equation and aim at antecedents of risk behaviour, such as perception and communication.

The plan of the study included parallel processes. First, the safety aviation investigation methods (SAIMs) were assessed, showing that emotional factors are underrepresented and that SAIMs have the potential to evolve. Adjacent, two groups of safety subject matter experts in aviation were interviewed to acquire the two opposite ends of safety's modus operandi in aviation daily practice. Their interviews provided the notions, modalities and specifics concerning their practices with risk perception and communication factors. In parallel, a scoping review provided the most suitable intervention framework for risk perception and communication factors for use in aviation. Adjacent, using the SMEs input and the intervention functions a questionnaire was formulated to acquire feedback from the general aviation workforce, in an attempt to triangulate the input for risk perception and communication factors, their influence and suitable ways to exploit their use. Based on that triangulation, a model was synthesized to enable the exploitation of risk perception and communication as regulator in favor of safe behaviour.

6.3. The Strategic Aviation Risk Intervention Model

Aviation organisations need to maintain a paramount level of safety through implementing a safety management system. However, end-users at all levels within the organisations are not ideal "risk managers". The begin by complying to safety policies and guidelines and continue by improving daily their safety cultures. As the organisation 'learns' to manage risk the expectations rise in terms of quality and accuracy of decision-making. Therefore, risk management tool research is motivated to evolve 'smarter' and cost-effective tools. However, the tools require a certain level of skills and knowledge, they build upon the result of a subjective interpretation, or quickly become nebulous.

The primary reason for developing SARIM was to introduce a model aiming at antecedents of risk behaviour that are not widely handled by other tools, models or techniques. More specifically, the risk behaviour control proactive measures should include risk perception and communication, and their respective factors influencing these two elements. In short, the goal is to manage the risk perception and communication factors influencing the end-users in each context, not just adjust the safety policies.

An additional goal was to provide guidance to the users into automating the process of being motivated against risk behaviour. Risk management policies just echo ‘not to do this again’, while sometimes they lack or provide a vague explanation as well. A third goal is that it can be used at any time within or out of the work process. Therefore, the three goals mentioned in 1.6.2. section were fulfilled and reflected within the answers to the research questions.

The main research questions were posed in 1.6.4 section and may now be answered.

1.Which are the risk perception factors that can influence aviation operators’ risk behaviour?

As provided through the whole processed data within the sub-studies, the risk perception factors that can influence the aviation operators’ risk behaviour are experience, fear and fitness to perform.

2.Which are the risk communication factors that can influence aviation operators' risk behaviour?

Following, the risk communication factors that can influence the aviation operators' risk behaviour are experience, fear, the presence of a complex communication network, and the availability of means.

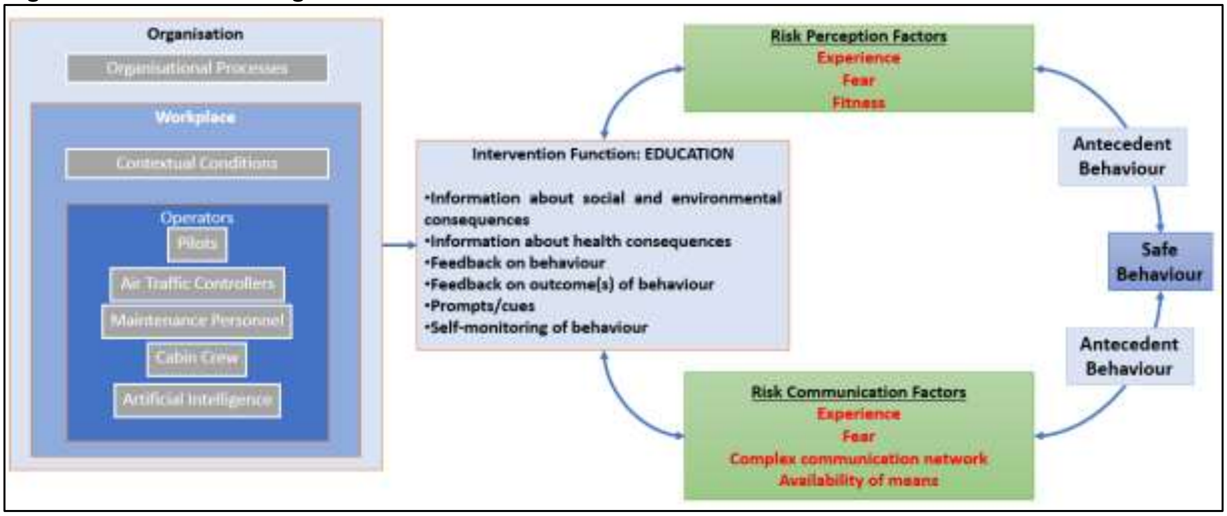
3.Which behavioural intervention model(s) can be applied to influence the enhancement of aviation operators' risk perception and communication factors?

Regarding the third research question about which behavioural intervention model(s) could be applied to influence the enhancement of aviation operators' risk perception and communication factors, the proposition is for an updated version of the INDICATE (Identifying Needed Defences In the Civil Aviation Transport Environment) model as the Identifying Strategic Requirements for Risk Awareness (ISRRA). ISSRA uses INDICATE as basic foundation while adding a broader scope of interactions in the workspace, accumulating a holistic perspective through all four steps, keeping the end-user at the centre of the socio-technical work context.

6.3.1. The Strategic Aviation Risk Intervention Model Process

The model includes the next building blocks to deliver the end-user a tool capable to increase his/hers risk perception, better his/hers risk communication and in-whole condition his/hers behaviour towards safety. The end-user should be able to acknowledge, thus to perceive and communicate, adverse effects; situations where can be actual harm or loss, and near misses, where it is recognised that something went seriously enough wrong. In addition, the model broadens the spectrum for risk perception by including the 'weak signals', as various small indications and signs that something is out of order, individuals behaving out of consistency, and gravity not as much to be sufficiently clear and obvious to most people (Weick & Sutcliffe, 2007).

Figure 6-27: The Strategic Aviation Risk Intervention Model



In total, the proposed model as depicted in Figure 6-27, aims to lead to safe behaviour by influencing risk perception and risk communication by increasing experience, managing fear, regulating fitness to operate, simplifying the complex communication networks and increasing the availability of means to communicate. SARIM incorporates the mentioned antecedents to influence safe behaviour in two steps:

1. Identify the strategic requirements for risk awareness (thus the ISRRA tool described in 5.5.3. section):

   a. Consideration of the operational area and the involved personnel based on their face-to-face interactions conditioned by beliefs and motives for the risks.

   b. Provision of socio-technical facilitating means/aids for risk perception and communication.

c. Level of all personnel's education level upon the effectiveness of risk-taking behaviour barriers.

d. Provision of an enabling communication context, promoting risk awareness knowledge and communication skills.

2. Employ education intervention function techniques through forms of face-to-face communication, using all or choosing among:

a. Sharing information about social and environmental consequences of the behaviour's outcome.

b. Sharing information about health consequences of the behaviour's outcome.

c. Sharing feedback on past behaviour.

d. Sharing feedback on outcome of behaviour.

e. Sharing prompts, enrich communication.

f. Instilling self-monitoring of behaviour.

The aviation context where the above are integrated is the organisational environment as driven by its processes, which in turn defines the workspace limited within the contextual conditions of each specialty and operation, where in turn are confined the five categories of end-users, regardless of managerial position but only based on their specialty background: pilots, air-traffic controllers, maintenance personnel, cabin crew, and the artificial intelligence (AI). Especially for the model, the AI is considered an additional actor within the job context, with the limitations of co-dependence to other end-users and the lack of the need for sentimental management.

SARIM is defined in this final chapter using a simple example of a stairway. The hazard involved is falling on stairs, and the risk is exposure to of a human to a potentially dangerous context, such as the lack of using handrails. The staircase in the example possesses functional and 'graspable' handrails, providing the end-user the ability to grasp it quickly, easily and firmly. The hand should be able to run smoothly along the surface, along the entire length, without the user having to adjust the grip. To even simplify the example, the assumption is that there is effective visibility, optimal stair dimensions and angles, and non-slippery surface. The end-users' identity is ground-crew during a turn-around for medium sized commercial flight.

6.3.1.1. Employing the Identification of Strategic Requirements for Risk Awareness

The first step in SARIM is to identify the strategic requirement for risk awareness to determine the socio-technical boundaries of the context in terms of information flow effectiveness. Based on the scenario, the operational area is limited between the level joint by the staircase and the ground crew. For the example, the assumption is that all ground crew members consider the use of the staircase not worth noticing in much detail, while they are very mindful for the turnaround. Concerning the socio-technical facilitating means, the staircase walls have highly visible signs at both ends of the staircase and in the middle for "Never run on the stairs without holding the handle", "Always hold the handle", and "Mind your step and hold the handle". Additionally, the staircase design has the ideal angles and non-slippery surfaces. The ground crew sees and understands with ease the warning signs as they are at their view spectrum. The safety manager has provided the personnel with an informative A4 size poster at the lower side of the staircase, showing with a cartoon-like style the hazard of falling due to slipping, running and not holding the handle properly.

The identified strategic requirements for risk awareness can now be assessed. Regarding the scenario's context, the ground crew shows complacency regarding the risk of not using the handle of the staircase properly, minimising that input due to allocation of attention resources to the turnaround (salience bias). Also, the aids used (i.e. signs) have been over-used for a single source of hazard, while the construction of the staircase provides the users with certainty that they have few chances to slip and fall. Following, the poster used is small enough for the users to take time noticing while they are in haste.

6.3.1.2. Employing the education intervention function techniques through forms of face-to-face communication (F2FC)

Performing the first step of SARIM provides the strategic requirements for risk awareness, provides the necessary ‘weak points’ of the system, where the perception and communication for risk behaviour is influenced. Following, the elemental factors of risk perception and communication as depicted in SARIM’s layout (Figure 6-27) should be matched with the located systemic weaknesses, propose actions, and highlight the aimed antecedent behaviour. Therefore, a tabulated form may be used to ease the process of matching the elements of the process (Tables 6-35, 6-36).

Table 6-35: Matching systemic weaknesses with risk perception factors

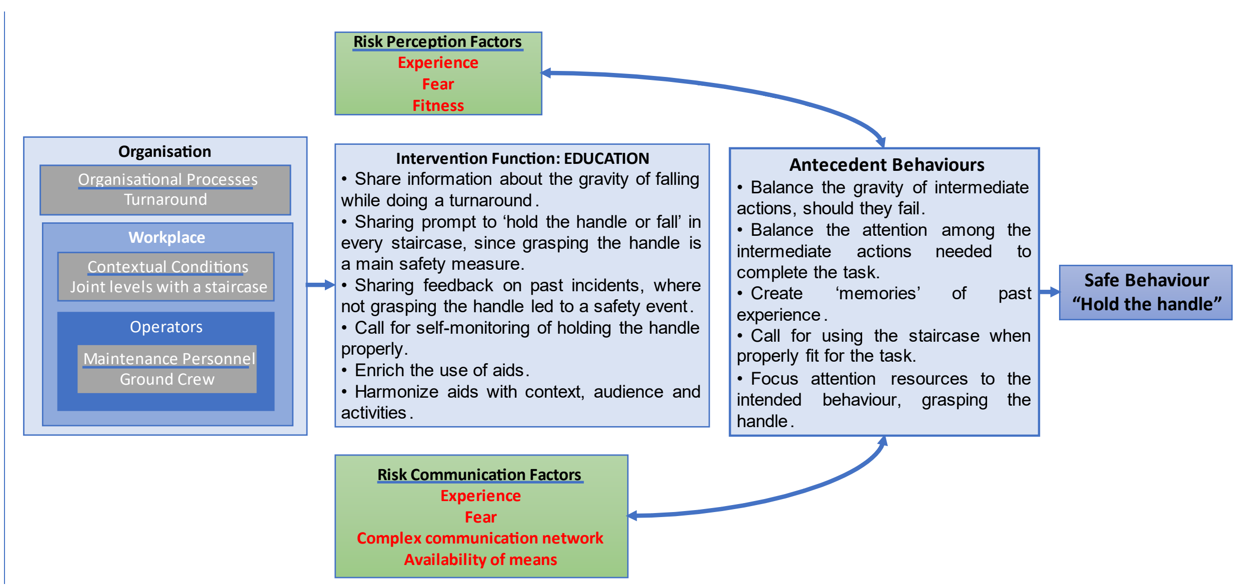
Systemic Weaknesses	Risk Perception Factors	Action (F2FC)	Aimed Antecedent Behaviour
Complacency (salience bias)	Fear	Share information about the gravity of falling while doing a turnaround.	Balance the gravity of intermediate actions, should they fail.
Complacency (stair construction)	Fear	Sharing prompt to ‘hold the handle or fall’ in every staircase, since grasping the handle is a main safety measure.	Balance the attention among the intermediate actions needed to complete the task.
Visual Saturation (visual aids)	Experience	Sharing feedback on past incidents, where not grasping the handle led to a safety event.	Create ‘memories’ of past experience.
Aid incompatibility (visual aids)	Fitness	Call for self-monitoring of holding the handle properly	Call for using the staircase when properly fit for the task.

Table 6-36: Matching systemic weaknesses with risk communication factors

Systemic Weaknesses	Risk Communication Factors	Action (F2FC)	Aimed Antecedent Behaviour
Complacency (salience bias)	Fear	Share information about the gravity of falling while doing a turnaround.	Balance the gravity of intermediate actions, should they fail.
Complacency (stair construction)	Experience	Sharing feedback on past incidents, where not grasping the handle led to a safety event.	Create 'memories' of past experience.
Visual Saturation (visual aids)	Complex communication network	Enrich the use of aids.	Focus attention resources to the intended behaviour, grasping the handle.
Aid incompatibility (visual aids)	Availability of means	Harmonize aids with context, audience and activities.	Focus attention resources to the intended behaviour, grasping the handle.

Considering the previous analysis, the SARIM adaption for the aimed behaviour "grasp the handle", in alignment with the operational narrative format, is depicted in Figure 6-28.

Figure 6-28: An example of SARIM model for a safe behaviour



6.3.2. Considering the Degradation of SARIM's Influence over Time

A final point in SARIM is to consider how the adaptations for any safe behaviour could degrade over time and to prepare for it. The triggers for degradation could be identified and mitigated as the safe behaviour is being established. For example, if one or more antecedent behaviours does not manifest in the field or is becomes redundant, a new one should be put into its place. Surrogate antecedent behaviours might also include internal surveys, granting the personnel a stage to voice their opinion into the organisational ecosystem. Over time, end-users may become again complacent and create a new baseline for the SARIM adaptation, signaling in this way the need to reconsider it and plan anew.

Along with the gradual systemic monitoring for the results measurement, the SARIM adaptation should be renewed when a systemic element changes; for example, the number of workers, the policies. In addition, the quantitative results should be adapted as well at realistic levels; for example, when someone goes up the staircase with the hands full, it is only natural not to account this as incompliance to "hold the handle".

6.4. Limitations

This research set out to develop a comprehensive model of understanding erroneous risk perception and communication and use coaching techniques to regulate these two elements. However, it was proven in the process that a behaviour-based approach (Wilder, Austin, & Casella, 2009; Yeager, Dahl, & Dweck, 2017) to influence risk perception and communication factors as antecedents of safe behaviour, would lead the end-user closer to safe behaviour.

In addition, during the analysis of SAIMs only the 100 most recent were gathered in the sample, while maintaining almost equal sizes per category (i.e. root-cause, epidemiological, systemic), due to time limitations. Furthermore, the assessed safety investigation reports refer only to factors contributing to the events, without documenting what the investigators looked for. As such, it was not possible to estimate the degree to which safety investigators examine risk perception and communication, regardless of their contribution to events. Following, although 140 reports were selected out of 415 through random sampling for the analysis, it is possible that the findings are not representative enough of the whole aviation environment. Also, the depth and quality of accident investigation processes and the derivative reports can vary within and across aviation authorities and investigation teams and across time periods, for example due to experience and team composition. Hence, the inclusion of reports from 22 countries within a ten-year period provides confidence for sufficiently representative results, added the differences revealed for risk perception and communication factors. Especially, only a third of the final dataset analysed included NTSB reports, regardless the slightly more than half of the initial sample of reports of investigations were conducted by NTSB.

Moreover, the interviewed safety investigators and managers possess various personal skills and field experience in investigation and daily safety management practices. However, the assumption was that all aviation authorities and organisations work with professional integrity, choosing properly experts for each duty. In this vein, the inter-raters had relevant experience in aviation safety and analysis from law and psychology backgrounds, while another one was highly experienced in aviation safety with academic and industry backgrounds. Consequently, the inter-raters' composition was adequate to ensure sufficient control of effects of biases, regardless of minor differences in the interpretations findings from the interviews.

Regarding the safety behavioural intervention frameworks and functions, the sample came exclusively from online search of peer-reviewed studies, excluding non-digitalised publications and industry/professional articles and reports. In addition, the generalisation of these findings is not allowed due to scoping of healthcare and transportation sectors, based on the presumption of their criticality and the transferability of their paradigms to other domains. Also, a linear approach was adopted which does not account for weights of the individual SHELLO clusters and risk perception and communication factors as well as between SHELLO, risk perception and communication.

Furthermore, the StratCom steps could not be fully applied at this stage of the model's cycle. One should acknowledge that policies and practices of safety take time to adjust and fully be applied. Therefore, experimenting with such an intervention within an air-carrier organisation engulfed high risk and was practically impossible at this point and with the resources available, even for a doctoral research, and not due to the lack of reaching out to organisations to cooperate on such bold endeavor.

6.4. Contribution to Knowledge

Behaviour based interventions on safety behaviours can be a challenging task, enclosing insecurity for the designer, as discussed from one of the interviewed safety managers, and inconclusive results, as discussed from one of the interviewed safety investigators. The first has been observed in the course of conducting this study. The complexity of socio-technical systems in aviation safety heeds for a need to develop a simple and easy to use tool for efficient behaviour modification. One of the motivations of this study was to contribute to narrow the gap of theory and practice in aviation practice. This has been achieved through the product of this study, which was not only to map the risk perception and communication factors responsible for regulating safe and unsafe behaviour, but also to develop a comprehensive model as a tool for regulating antecedent behaviours and lead finally to the aimed safe behaviours. The following sections present the contribution of this study to the Aviation Safety subject matter in theoretical and practical ways, and in research methodology, through the lens of the presented model.

6.4.1. Theoretical Contribution of Research

Current theoretical approaches on investigation methods neglect residual psychological effects, sourcing mostly from emotional interactions within the socio-technical context, while focus on wider environmental parameters. Therefore, regardless of the evangelized systemic approach and Safety-II mentality, parameters of the persons involved in safety investigations and risk management, remain undiagnosed, while technical aspects are overly highlighted (Renn, 1998). Also, widely used classifications focus explicitly to environmental and cognitive aspects of human performance, rather to the emotional state of the involved personnel, such as the Human Factors Analysis and Classification System (Wiegmann & Shappell, 2000).

In addition, root-cause, epidemiological and systemic SAIMs regardless of publication period, sustain the underrepresentation of risk analysis stages in a succinct and cyclical manner. Also, through the results SAIMs appeared to focus almost consistently on cause-effect controls, neglecting individual and team perceptions and processes, which regulate the efficiency of controls at a socio-technical level. In this vein, this research has also confirmed the emphasis on plans and actions and the underestimation of control and improvements (Rasmussen, 1997; Washington, Clothier, & Silva, 2017; Dallat, Salmon, & Goode, 2019).

As such, this research revealed that SAIMs appear to acknowledge events as static, not having residual effects in organisations and their personnel. This issue indicated the need for new, merged or ‘hybrid’ SAIMs. Addressing this issue, SARIM’s contribution is the different view of the socio-technical environment in its real dynamic character, drawing from the contextual conditions, defined by the target behaviour and linked antecedent behaviours, the audience, and the requirements for risk awareness.

This research has confirmed the high alertness of the aviation industry regarding risk perception and communication (Harvey & Stanton, 2014). Also, it confirmed the high association of education intervention function with frameworks with high coverage of risk perception and communication factors confirms the trend in the aviation to learn from incidents (Clare & Kourousis, 2021) and increase understanding (DiClemente & Jackson, 2017; Chatzi, Martin, Bates, & Murray, 2019).

In addition, the model transfers the focus from the individuals to the actions/behaviours and the ways needed to achieve safety. Also, it overcomes disciplinary bias by acknowledging only the limits of local rationality as contextual limits. Risk perception and communication manifest as systemic processes, at the heart of safety culture, generated within the work context by the end-user, thus confirming theories (Sullivan-Wiley & Short Gianotti, 2017; Heath, Lee, Palenchar, & Lemon, 2017; Hicks, et al., 2017; Bergstra, Brunekreef, & Burdorf, 2018). Although the model has a systemic approach, it considers directly the behavioural manifestations in the socio-technical context, allowing for optional synchronization with social phenomena, such as affiliation bias, social proof driven conformity, or other social traits of the decision-maker(s) (Tajfel & Turner, 1979; Ellemers & Haslam, 2012; Nemeth, 2012; Sohrab, Waller, & Kaplan, 2015; Klumpe, Koch, & Benlian, 2018; Warkentin, Sharma, Gefen, Rose, & Pavlou, 2018).

The model has specified the link of risk perception and communication factors with risk behaviour through antecedent behaviours. It considers both task and not-task related risk cues through its systematic view, highlighting that there is no necessity for a set barrier in investigating risk perception, primarily, and communication (Brewer, Weinstein, Cuite, & Herrington Jr, 2004; Sullivan-Wiley & Short Gianotti, 2017). Also, it overcomes the self-serving bias barrier (Myers, 2015) through exploitation of fear as risk perception and communication factor.

Furthermore, SARIM follows a vertical and horizontal approach reaching all stakeholders within an organisation, regardless of level of expertise or position. Also, it overcomes the need to quantify risk meticulously (Hohenemser, Kates, & Slovic, 2000), resulting in positive or negative bias, by using factual and contextual information for each targeted behaviour. Nonetheless, the model could not avoid the logistic approach to enlist risks (Hansson & Aven, 2014). However, the model converges the gap of Risk-as-Imagined and Risk-as-Deployed, through the exploitation of factual and contextual information for each targeted behaviour, which also overcomes the barrier of the negative or positive notion through the prescription of exactly how a task should be done (Hollnagel, 2017).

6.4.2. Practical Contribution of Research

This research has revealed that safety investigators acknowledge the effects of emotional and cognitive biases. Also, the role of context is acknowledged for the examination of risk perception and communication factors, which are suggested being shaped by the organisational practices, mainly through training, supervision and organisational culture. Especially, concerning safety investigation practices this research has contributed by revealing to consolidate knowledge from the operational field and academia to take full advantage of inclusiveness and lessen the investigators' fears of unfairness due to subjectivity when searching risk perception and communication. In addition, the model contributes to deeper understanding the role of risk perception and communication during safety investigations. Also, crisis communication consideration during the design of the intervention coincides with the practical knowledge need for Health Safety duties for more effective safety management.

The practical contribution of SARIM is that the end-user applying it considers fear, an emotional factor, regulating risk perception and communication, and has to exploit the opportunities presented in the given work context to facilitate behaviours, through education intervention function techniques.

Furthermore, the generated model is fused with the Strategic Communication approach. This gives the advantage for wide use from small to large air-carrier civil and military aviation organisations, while it mandates conformity and diffusion of activities-policies from and through all levels within an organisation (Hallahan, Holtzhausen, van Ruler, Verčič, & Sriramesh, 2007; Thomas & Stephens, 2015; Macnamara, 2018; Macnamara & Gregory, 2018; Zerfass, Verčič, Nothhaft, & Werder, 2018). The generated model's integration with StratCom provides practical implications to create internal and external campaigns targeting safe behaviours. In addition, the StratCom notion of the "Strategic Corporal" offers the capability for a worker from any level to apply the model to his/her context of work. The alignment of StratCom serves as a barrier holding all users to the organisational narrative about the targeted safe behaviour, and the workers become their own educators.

Following, this research highlighted the lack of instruments used to evaluate safety culture to include items about emotions, physiological conditions and the natural environment, such as the the *Aviation Safety Climate Scale* (Evans, Glendon, & Creed, 2007) and the *Integrated Organisational Safety Climate Questionnaire* (Brondino, Pasini, & Da Silva, 2013). In addition, this research has shown that the combination of "enablement", "education", and "environmental restructuring" intervention functions could be the most effective to influence behaviours.

SARIM may be used reactively, to assess an event after it happened to shed light into the probable causes and links that led to the event. It can be used proactively, through the planning phase of operations, addressing unsafe behaviours to mitigate or safe behaviours to achieve. Also, it can be used predictively to plan ahead accounting for the strategic requirements within an organisation to make it and its personnel risk aware.

6.4.3. Methodological Contribution of Research

The main methodological contribution of this study is the contribution to safety research the use of mixed methods, which are not necessarily a trend. Another methodological contribution lies in the experience of converging the fields of Psychology, Engineering/Human

Factors, and Communication. This experience my prove useful for future studies on the adoption of interdisciplinary initiatives in aviation organisations and authorities, primarily for research purposes and transcend even further to daily application.

Finally, to the author's knowledge, there were two novelties more. A methodological contribution relates with the use of Strategic Communication Paradigm in the safety field, the integration of behaviour-based interventions within risk management, as well a uniform investigation of risk perception and communication factors, regardless of level within an organisation or specialty. The mentioned applicability of integrated methods has been questioned from the interdisciplinary point of view, as manifested from the job description of human factors specialists indicating mainly engineers and not psychologists. Therefore, the successful employment of the applied methodology shows that the current job descriptions should adjust to a more interdisciplinary reality and a comprehensive approach.

6.5. Future Research

A different approach on achieving safe behaviour was presented. It is only the beginning for this strain to develop with additional techniques and hopefully other alternatives and improvements. New ideas are surely needed to confront the new challenges ahead on aviation safety. SARIM's full potential will be demonstrated in future studies that will consider initially the layout of behaviours as targets for intervention, and their propagation from a perspective of antecedent behaviours regulated by risk perception and communication factors. While SARIM is currently a static model, future research may add a dynamic dimension to it.

Overall, considering the findings of this research, risk perception and communication constitute a strong interpretational framework through which risk management could be researched deeper. Several future prospects were considered:

- Examine the effects of current Safety Aviation and Investigation Methods (SAIMs) and their associated theoretical backgrounds on shaping the various risk perception and communication factors successfully. Also, mapping of specific factors, and not just their types employed in this study, would allow gaining a deeper and more detailed picture of their reference in SAIMs and support respective improvement initiatives.
- Employ longitudinal studies on the change of attitudes towards factors affecting risk perception and communication, possibly separately for commercial, general and military aviation. Further exploration could focus on the mechanisms by which self-stereotyping amongst aviation personnel works in retrospection of safety events. Another point of focus could be a systematic assessment of how safety and accident investigation methods affect the approach to and examination of risk perception and communication factors.
- Prospective analyses could focus on experimental studies on the evolution of attitudes toward risk perception and communication variables in commercial, general, and military aviation, perhaps separately. The relationships between personality traits and risk perception and communication in aviation are also areas that need to be investigated further. Moreover, it would be useful to search the influences of the various consecutive or parallel activities during different flight phases on risk perception and communication. Furthermore, communication training for aviation personnel at the operator level could enhance risk literacy when such training is fused effectively with current programmes such as CRM. Also, an inclusive framework for evaluating risk perception and communication factors during investigations could support the aviation efforts to better understand safety events and improve future safety performance.
- The scientific community could consider the findings from this research to (re)design current methods/functions or when developing new ones to ensure the maximum possible coverage of the underrepresented aspects mentioned above and enhance

the effectiveness of interventions. Despite the latter's influence by other variables (e.g., skills and knowledge of intervention agents, organisational climate), more complete interventions regarding system interactions and risk perception and communication would be necessary even under ideal conditions.

- Field practical simulation studies have to be employed. The integration of the model within the daily aviation routine will allow the identification of weak and strong points, with appropriate application.
- The exploration of the effects from the employment of safety managers' and investigators' proxy-teams within all levels in aviation organisations, in a comprehensive approach, supporting effective communication of their daily experience based on their specialty and safety concurrent post.

6.7. Summary

The purpose of this chapter was to present the final form of the initially proposed conceptual framework concerning the influence of risk perception and communication factors, how this could be exploited through creating a model where the operators could employ and influence these factors retrospectively to establish safe behaviours. In addition, suggestions for future research were presented.

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Appendix 1: Sub-Study 1 Sample Details

Table A-1-37: SAIM Quantitative Data

Group of Independent Variables	Values	Sample Size (*N*)	Model Type			Risk Communication Stages (N)						Risk Perception Stages (N)			
			R	E	S	0%	20%	40%	60%	80%	100%	0%	33%	67%	100%
Time Period	≤1994	24	9	9	6	6	12	3	1	2	0	9	11	3	1
	1995-1999	24	10	7	7	4	15	2	2	1	0	9	9	5	1
	2000-2007	28	8	9	11	3	11	8	2	2	2	7	8	8	5
	≥2008	24	5	9	10	1	10	7	3	2	1	10	6	3	5
Model Type	Root	32				5	16	7	1	3	0	15	8	6	3
	Epidemiological	34				5	15	7	2	3	2	12	11	5	6
	Systemic	34				4	17	6	5	1	1	8	15	8	3
Risk Communication Stages	0%	14										0	14	0	0
	20%	48										27	12	9	0
	40%	20										8	6	5	1
	60%	8										0	2	3	3
	80%	7										0	0	2	5
	100%	3										0	0	0	3

Table A-1-38: Research Sample by SAIM Full Title

Time Periods	SAIMs					
≤1994 (n=24)	APHAZ (Aircraft Proximity HAZards)	CAIR (Confidential Aviation Incident Reporting)	CAP (Comprehensive Assessment Plan)	CDR (Critical Design Review)	COGnET (Cognition as a network of Tasks)	DO-y78B (RTCA/EUROCAE ED-ynB DO-y78B)
	Expert Judgement	FHA (Functional Hazard Assessment) according to JAR-n5	Human HAZOP or Human Error HAZOP (Human (Error) Hazard and Operability study)	LOSA (Line Observation Safety Audit)	Modelling	OMAR (Operator Model Architecture)
	OPSnET (Operations network)	ORM (Operational Risk Management)	PHL (Preliminary Hazard List)	SA-SWORD (Situational Awareness Subjective Workload Dominance)	SAGAT (Situation Awareness Global Assessment Technique)	SART (Situation Awareness Rating Technique)

	Sensitivity Analysis	Swiss Cheese Model	TKS (Task-Knowledge Structures)	TOPAZ (Traffic Organisation and Perturbation AnalyZer)	Uncertainty Analysis	What-If Analysis
	AcciMapping	ATSAT (Aviation Topics Speech Acts Taxonomy)	Code Analysis	CTD (Cognitive Task Design)	FDD (Fault Detection and Diagnosis)	FOQA (Flight Operations Quality Assurance)
	Formal Methods	Hazard Analysis	HEA	HPRA	In-Depth Accident Investigation	Interface Analysis
1995-1999 (n=24)	LISA (Low-level Interaction Safety Analysis)	Markov Latent Effects Tool	Ofan	Partitioning	Performance and Usability Modelling in ATM	RHA (Requirements Hazard Analysis)
	RIF diagram (Risk Influencing Factor Diagram) or RIA (Risk Influence Analysis)	Safety Review or Safety Audit	SPAM (Situation-Present Assessment method)	THEA (Technique for Human Error Analysis)	TRACEr (Technique for the Retrospective Analysis of Cognitive Errors in Air Traffic Management)	TRIPAC (Third party Risk analysis Package for aircraft ACcidents around airports)
	ACCC (Air Carrier Configuration Checklist)	ARIA (Aerodrome Runway Incursion Assessment Tool)	ASIAS (Aviation Safety Information Analysis and Sharing)	CAHR-VA (Connectionism Assessment of Human Reliability - Virtual Advisor)	CARA (Controller Action Reliability Assessment)	ConDOR (Constructed Dynamic Observation Report)
2000-2007 (n=28)	E-OCVM (European Operational Concept Validation Methodology)	EATMP SAM (European Air Traffic Management Programme Safety Assessment Methodology)	Emergency Exercises	FAST Method (Future Aviation Safety Team Method)	FHA (Functional Hazard Assessment) according to EATMP SAM	Hazard Crystallisation
	HCAS (Hazard Classification and Analysis System)	HERA or HERA-JAnUS (Human Error in ATM Technique)	HERTES (Human Error Reduction Technique for the Evaluation of Systems)	HESRA (Human Error and Safety Risk Analysis)	HFA	IRP (Integrated Risk Picture)

	LOS (Level of Safety)	RBRT (Risk Based Resource Targeting)	SAFMAC (SAFety validation framework for MAjor Changes)	SDCPn (Stochastically and Dynamically Coloured Petri nets)	sequenceMiner	SESAR SRM
	SoTeRiA (Socio-Technical Risk Analysis)	SRG CAP 760 (Safety Regulation Group CAA Publication 760)	STAR (Safety Target Achievement Roadmap)	Trend Analysis		
≥2008 (n=24)	ACOP (Air Carrier Oversight Profile)	ADI (Assessment Determination and Implementation Tool)	ATOS Random Inspections (Air Transportation Oversight System Random Inspections)	ATSAP (Air Traffic Safety Action Program)	CAnSO Common Safety Method	CAST (Causal Analysis based on STAMP)
	CATT (Corrective Action Tracking Tool)	CEDAR (Comprehensive Electronic Data Analysis and Reporting)	European Aviation Safety plan Method to Assess Future Risks	FOSA (Flight Operational Safety Assessment)	ISAM (Integrated Safety Assessment Model)	nextGen Future Safety Assessment Game
	OPT (Outsource Oversight Prioritization Tool)	OSP (Oversee System Performance)	RAM	RAT (Risk Analysis Tool)	RCFF (Regulatory-based Causal Factor Framework)	Safety Scanning
	SAME (Safety Assessment Made Easier)	SARD (Strategic Assessment of ATM Research and Development results)	SAS (Safety Assessment Screening)	SRMTS (Safety Risk Management Tracking System)	STPA (Systems Theoretic Process Analysis)	TARAM (Transport Airplane Risk Assessment Methodology)

Appendix 2: Participant's Information Sheet and Consent Form

Risk in The Aviation Context: Investigating Risk Perception and Risk Communication from A Behaviour Based Approach

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

You are invited to take part in a research study about part of a PhD thesis focused on risk perception and risk communication. The thesis aims to explore risk perception and risk communication of professionals in the aviation context. In order to do that we intend to assess data deriving from respondents who will cooperate for the following interview. The results from this thesis will provide directions for a more accurate approach on risk management training and promote safety culture.

This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the research. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

(2) Who is running the study?

The study is being carried out by Dimitrios Chionis who a PhD candidate of Psychology at Bolton University is currently. This study is self-funded by Dimitrios Chionis. This study does not involve any potential/actual conflicts of interest for researchers, sponsors and/or institutions involved in the project. This study will not provide any financial benefits to the researcher, participants or involved institutions.

(3) What will the study involve for me?

Regardless of your specialty, you will be asked to participate in a live interview with the researcher through a live session using electronic means if necessary, after filling the consent form.

(4) How much of my time will the study take?

It should take about 40 minutes of your time at most.

(5) Who can take part in the study?

This study will involve safety investigators from the aviation context.

(6) Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate will not affect your current or future relationship with the researcher, your institution or your employer.

If you decide to take part in the study and then change your mind later, you are free to withdraw at any time. You can do this by asking the research to end the interview during in vivo conversation or use the tools of the electronic platform in use to terminate the session at any time. The incomplete interview will be disregarded as not for use for this research. The researcher or the University of Bolton are not responsible for any current or changed terms of use regarding the used electronic means.

Completing the interview is an indication of your consent to participate in the study. Once you have completed the interview, you will be given a unique code not connected with your personal details. After the interview you are able to withdraw your data by contacting the researcher and submitting the code you were given. The unique code ensures that your contact details will not be connected to your digital imprint and due to anonymity, we will not be able to tell which one is yours. This choice will be available until the submission of the thesis.

(7) Are there any risks or costs associated with being in the study?

- The interview does not include sensitive information about participants or organizations. Your name or organisation's name is not attached to your responses.
- None of the conclusions will namely expose any issues about individuals or organizations. All responses will be compiled together and analysed as a whole.
- Overall, this study does not involve invasion of privacy, threat on dignity and self-respect, deception, unnecessary withholding of information, and discomfort.
- Any original quotes that may possibly be used in text, figure or table format of the thesis will respect the participants' privacy and anonymity.
- All records will be destroyed after the thesis will be approved and graded. We will keep hold of anonymised summarised data from the questionnaire.
- Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study.

(8) Are there any benefits associated with being in the study?

We cannot guarantee that you will receive any direct benefits from being in the study. However, you have the opportunity to contribute in a scientific study which will promote the quality of training and improve knowledge in the area.

(9) Can I tell other people about the study?

Yes, you are welcome to tell other people about the study, and we encourage you to share further to professional pilots, air-traffic controllers, cabin crew, and maintenance personnel of your acquaintance by sharing this information sheet.

(10) What if I would like further information about the study?

When you have read this information, Dimitrios Chionis will be available to reach through e-mail and will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact Dimitrios Chionis.

(11) Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. You may contact Dimitrios Chionis through e-mail dc1res@bolton.ac.uk requesting a summary report – these will be available not before March 2020.

(12) What if I have a complaint or any concerns about the study?

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the supervisor using the details outlined below. Please quote the study title and researcher.

THANK YOU VERY MUCH FOR YOUR HELP!

APPROVED BY THE UNIVERSITY OF BOLTON RESEARCH ETHICS COMMITTEE

Informed Consent Form

Risk in The Aviation Context: Investigating Risk Perception and Risk Communication from A Behaviour Based Approach

Name and contact details of researcher: Dimitrios Chionis PhD Candidate
00306983526798
dc1res@bolton.ac.uk, dchionis10@yahoo.com

Please tick box to confirm consent:		YES	NO
1.	I confirm that I have read and understood the information sheet for the above study and have had the opportunity to ask questions.	☐	☐
2.	I understand that my participation is voluntary and that I am free to quit at any time, without giving any reason.	☐	☐
3.	I agree to my data being used for research purposes.	☐	☐
4.	I understand that my raw data (recordings) will be kept until the researcher's research is completed.	☐	☐
5.	I agree to the interview being audio recorded.	☐	☐
6.	I agree to the interview being video recorded.	☐	☐
7.	I agree to the use of anonymized quotes in publications.	☐	☐
8.	I understand that consent forms will be retained for five years.	☐	☐
9.	I understand that any personal information that I have provided is in confidence.	☐	☐
10.	I agree to take part in the above study.	☐	☐

<u>Please sign by filling in your name and resent to the researcher</u>

______________________	____________	______________________
Name of Participant	Date	Signature

______________________	____________	______________________
Name of Researcher	Date	Signature

Appendix 3: Safety Investigators' Semi-Structured Interview Guide

The following questions were posed to safety investigators:

1. Do you follow a specific model or taxonomy during investigations?
   a. How did you choose the specific model or taxonomy for your practice?
   b. How would you describe the use of models and taxonomies during your years of practice as a safety investigator?
   c. What would be your advice to new safety investigators concerning the choice of models or taxonomies during their practice?
2. How do you assess risk perception of the involved operators during investigations?
   a. What criteria do you use to understand how the involved personnel in an event processed risk?
   b. How would you describe the process of risk perception based on events you have investigated?
   c. How would you suggest new safety investigators should investigate to comprehend whether and how involved personnel processed risk effectively?
3. How do you think emotional conditions, cognitive status, physiological status, and environmental factors influence the operators' risk perception?
   a. How does emotion influence an operator's risk perception? How can an investigator unveil that case?
   b. How does the personal information process influence an operator's risk perception? How can an investigator unveil that case?
   c. How do the bodily functions influence an operator's risk perception? How can an investigator unveil that case?
   d. How does the environment, including organisational factors, influence an operator's risk perception? How can an investigator unveil that case?

e. Have you located a specific pattern of contributing factors that are involved in safety events where risk was not effectively perceived?

4. How do you assess risk communication of the involved operators during investigations?

a. How do the models or taxonomies you use in your practice assist you to assess risk communication of operators?

b. Based on your experience, how would you describe the process of risk communication?

c. How would you suggest new safety investigators should investigate to comprehend whether and how involved personnel communicated risk effectively?

5. How do you think emotional conditions, cognitive status, physiological status, environmental factors, timeliness of communication, and the channel of communication influence the operators’ risk communication?

a. How does emotion influence an operator’s risk communication? How can an investigator unveil that case?

b. How does the personal information process influence an operator’s risk communication? How can an investigator unveil that case?

c. How does the bodily functions influence an operator’s risk communication? How can an investigator unveil that case?

d. How does the environment, including organisational factors, influence an operator’s risk communication? How can an investigator unveil that case?

e. How does the timeliness of exchanging information influence an operator’s risk communication? How can an investigator unveil that case?

f. How does the communication channel of exchanging information influence an operator’s risk communication? How can an investigator unveil that case?

g. Have you located a specific pattern of contributing factors that are involved in safety events where risk was not effectively communicated?

6. Where do you attribute the absence, if any, of the aforementioned factors during investigations?

a. Has the model or taxonomy you use a specific reference to any of the aforementioned factors?

i. If yes, what arguments are supporting it?

ii. If not, what is the closest reference?

7. What would you change to address these factors?

a. Do you think we need a change of safety thinking?

b. How would you implement a change in the way safety investigators assess risk perception and risk communication?

8. Is there anything else that you would like to add?

Appendix 4: Safety Managers' Semi-Structured Interview Guide

The following questions were posed to safety managers:

1. Do you follow a specific model or a conceptual framework during every day practice, application, and training for safety?
    a. How did you choose the specific model or conceptual framework for your practice?
    b. How would you describe the use of models during your years of practice as a safety manager?
    c. What would be your advice to new safety managers concerning the choice of models during their practice?
2. How do you use the models to assess risk perception of the operators?
    a. What criteria do you use to understand how the personnel process risk?
    b. How would you describe the process of risk perception based on your daily practice?
    c. How would you suggest new safety managers should act to facilitate processing risk effectively?
3. Based on the model or conceptual framework you are using, how do you think emotional conditions, cognitive status, physiological status, and environmental factors influence the operators' risk perception?
    a. How does emotion influence an operator's risk perception? How a safety manager is able to intervene in this case?
    b. How does the personal information process influence an operator's risk perception? How a safety manager is able to intervene in this case?
    c. How does the bodily functions influence an operator's risk perception? How a safety manager is able to intervene in this case?

d. How does the environment, including organisational factors, influence an operator's risk perception? How a safety manager is able to intervene in this case?

e. Have you located a specific pattern of contributing factors that are involved in everyday practice where risk could have been perceived more effectively?

4. Based on the model or conceptual framework you are using; how do you assess risk communication of the involved operators during your daily operations?

   a. How do the models or conceptual frameworks you use in your practice assist you to assess risk communication of operators?

   b. Based on your experience, how would you describe the process of risk communication?

   c. How would you suggest new safety managers should act to facilitate that risk is communicated effectively?

5. Based on the model or conceptual framework you are using; how do you think emotional conditions, cognitive status, physiological status, environmental factors, timeliness of communication, and the channel of communication influence the operators' risk communication?

   a. How does emotion influence an operator's risk communication? How a safety manager is able to intervene in this case?

   b. How does the personal information process influence an operator's risk communication? How a safety manager is able to intervene in this case?

   c. How do the bodily functions influence an operator's risk communication? How a safety manager is able to intervene in this case?

   d. How does the environment, including organisational factors, influence an operator's risk communication? How a safety manager is able to intervene in this case?

e. How does the timeliness of exchanging information influence an operator's risk communication? How a safety manager is able to intervene in this case?

f. How does the communication channel of exchanging information influence an operator's risk communication? How a safety manager is able to intervene in this case?

g. Have you located a specific pattern of contributing factors that are involved in everyday practice where risk could have been communicated more effectively?

6. Based on the model or conceptual framework you are using, where do you attribute the absence, if any, of the aforementioned factors during every day practice and training?

   a. Has the model or conceptual framework you use a specific reference to any of the aforementioned factors?

      i. If yes, what arguments are supporting it?

      ii. If not, what is the closest reference?

7. What would you change to address these factors?

   a. Do you think we need a change of safety thinking?

   b. How would you implement a change in the way safety managers facilitate ways to ensure that risk perception and risk communication are effective among operators?

8. Is there anything else that you would like to add?

Appendix 5: Sub-Study 3 Findings

Table A-5-39: List of Scoped Resources

Study	Discipline/ Field	Model(s)/Framework(s)	Intervention Function(s)	S-L-H-E	S-L-L-E	L-L-O-E	O-L-H-E	S-L-O-E	H-L-L-E	Risk Perception Factor(s)	Risk Communication Factor(s)	Reported change	Score
(System Theory and Safety Models in Swedish, UK, Dutch and Australian Road Safety Strategies)	Road Safety	Sweden: Vision Zero	-Education -Modelling	No	No	Yes	Yes	No	No	Cognitive (cognitive capacity)	Organisational (responsibility)	Not reported	4
(System Theory and Safety Models in Swedish, UK, Dutch and Australian Road Safety Strategies)	Road Safety	United Kingdom: Tomorrow's roads: safer for everyone	Restriction	Yes	Yes	Yes	No	Yes	Yes	Physiological (drug abuse)	Emotional (sensitisation/ awareness)	Not reported	7
(System Theory and Safety Models in Swedish, UK, Dutch and Australian Road Safety Strategies)	Road Safety	Netherlands: Sustainable Safety	Environmental restructuring	Yes	Yes	No	No	Yes	Yes	-Emotional (aggression) -Cognitive (lack of experience, distraction) -Physiological (fatigue, drug abuse, illness) -Environmental (anticipation of hazardous behaviours)	Organisational (homogenous communication)	Not reported	9
(System Theory and Safety Models in Swedish, UK, Dutch and Australian Road Safety Strategies)	Road Safety	Australia: National Road Safety Strategy: 2011–2020	- Environmental restructuring -Enablement -Education	Yes	Yes	No	No	Yes	Yes	-Environmental (anticipation of hazardous behaviours) -Physiological	Emotional (sensitisation/ awareness)	Not reported	7
(Recognition Primed Decision Making and the Organisational Response to Accidents: Überlingen and the Challenges of Safety Improvement in European Air	Aviation Safety	Naturalistic Decision Making	Education	Yes	Yes	Yes	Yes	Yes	Yes	-Physiological (fatigue) -Organisational (high workload, poor training)	Timeliness (timely information circulation)	Not reported	9

Study	Discipline/ Field	Model(s)/Framework(s)	Intervention Function(s)	S-L-H-E	S-L-L-E	L-L-O-E	O-L-H-E	S-L-O-E	H-L-L-E	Risk Perception Factor(s)	Risk Communication Factor(s)	Reported change	Score
Traffic Management)													
(Recognition Primed Decision Making and the Organisational Response to Accidents: Überlingen and the Challenges of Safety Improvement in European Air Traffic Management)	Aviation Safety	Recognition Primed Decision Making	-Education -Environmental restructuring -Enablement	Yes	Yes	Yes	Yes	Yes	Yes	-Cognitive (experience, confirmation bias) -Physiological (fatigue) -Environmental (social impact)	Cognitive (confirmation bias)	Not reported	10
(How Can We Improve Safety Culture in Transport Organisations? A Review of Interventions, Effects and Influencing Factors)	Multiple Transportation Means Safety (Used Air Transportation)	INDICATE (Identifying Needed Defences In the Civil Aviation Transport Environment)	-Education -Persuasion -Training -Enablement	Yes	Yes	Yes	Yes	Yes	Yes	-Cognitive (cognitive accuracy) -Emotional (emotional accuracy)	Timeliness (accuracy in communication)	Improved Safety Culture. Improved reporting rates. Lower hazard perception. More actions taken on identified hazards.	9
(Improving Young Drivers' Speed Management Behaviour Through Feedback: A Cognitive Training Intervention)	Road Safety	Post-training feedback	-Education -Training	Yes	Yes	No	No	Yes	Yes	-Cognitive (skill perception) -Physiological (injury avoidance)	-Cognitive (skill perception) -Physiological (injury avoidance) -Timeliness (feedback delivery)	Performance and Finance Feedback (1st effective), Performance Feedback (2nd effective), Summative Feedback (3rd effective)	9
(Interventions and Controls to Prevent Emergency Service Vehicle Incidents: A Mixed Methods Review)	Road Safety	Enhanced and Refresher Training	Education	No	No	No	Yes	No	No	Cognitive factors	Unclear	Reduced crash rates by 19-50%.	2
(Interventions and Controls to Prevent Emergency Service Vehicle Incidents: A	Road Safety	Mentoring	-Education -Modelling	Yes	Yes	No	No	Yes	Yes	Environmental	Environmental	Reported changes in driving behaviours and	6

Study	Discipline/ Field	Model(s)/Framework(s)	Intervention Function(s)	S-L-H-E	S-L-L-E	L-L-O-E	O-L-H-E	S-L-O-E	H-L-L-E	Risk Perception Factor(s)	Risk Communication Factor(s)	Reported change	Score
Mixed Methods Review)												habits and increased situational awareness	
(Interventions and Controls to Prevent Emergency Service Vehicle Incidents: A Mixed Methods Review)	Road Safety	Simulations	-Education -Coersion	Yes	Yes	Yes	Yes	Yes	Yes	Cognitive (penalty avoidance)	Emotional (fear)	Reported reductions in overall collusions (12%) and intersection collisions (38%)	8
(Interventions and Controls to Prevent Emergency Service Vehicle Incidents: A Mixed Methods Review)	Road Safety	Proactive Risk Management	Restriction	No	No	Yes	Yes	No	No	Unclear	Timeliness (accuracy)	58% reduction in Emergency service vehicle incidents (ESVIs)	3
(Relationship between Human Error Intervention Strategies and Unsafe Acts: The Role of Strategy Implementability)	Aviation Safety	Human Factors Intervention Matrix (HFIX)	Restriction	Yes	Yes	Yes	Yes	Yes	Yes	Cognitive (enhancing supervisors' awareness, AI assist)	Cognitive (enhancing supervisors' awareness, AI assist)	23% mitigating decision error, 19% mitigating skill-based error, 39% mitigating perceptual error, and 21% mitigating violation	8
(Development and Evaluation of an Intervention to Reduce Rip Current related Beach Drowing)	Leisure Activities Safety	Communication Campaign (A/B Testing)	Persuasion	No	Yes	Yes	No	No	Yes	-Cognitive (increased awareness) -Emotional (fear of death)	Emotional (fear of death)	Not reported	6
(Evaluation of a High Visibility Enforcement Project Focused on Passenger Vehicles Interacting with Commercial Vehicles)	Road Safety	Ticketing Aggressive Cars and Trucks (TACT), Communication Campaign (A/B Testing), Click It or Ticket (CIOT) is part of Selective Traffic Enforcement Programs (sTEPs)	-Education -Persuasion -Coersion -Restriction	Yes	Yes	No	No	Yes	Yes	-Cognitive (increased awareness) -Emotional (fear of punishment)	Emotional (fear of punishment)	Crash Risk was rated significantly lower, Behavior was rated as less intentional, Behavior was rated as less illegal, Behavior was rated as less intimidating	7

Study	Discipline/ Field	Model(s)/Framework(s)	Intervention Function(s)	S-L-H-E	S-L-L-E	L-L-O-E	O-L-H-E	S-L-O-E	H-L-L-E	Risk Perception Factor(s)	Risk Communication Factor(s)	Reported change	Score
(The Effects of Social Interactions with In-Vehicle Agents on a Driver's Anger Level, Driving Performance, Situation Awareness, and Perceived Workload)	Road Safety	Use of in-vehicle software agent to mitigate effects of driver anger on driving behaviour	Persuasion	Yes	Yes	No	No	Yes	Yes	-Cognitive (tunnelling bias, information workload) -Emotional (anger)	-Cognitive (information workload) -Emotional (anger)	decreased driver workload, reduced angry state, improved SA	8
(Risk Attitudes and Behaviour Among Norwegian Adolescents: The Effects of a Behaviour Modification Program and a Traffic Safety Campaign)	Road Safety	Change in attitudes toward traffic safety and behaviour due to type of intervention (behaviour modification program & attitude campaign)	Education Persuasion	Yes	Yes	No	No	Yes	Yes	Environmental (social norms)	Timeliness (timely report of unsafe behaviours)	there was a significant decrease in how often the respondents in this group reported risky behavior in traffic.	6
(Mechanisms of Health Behavior Change in Persons With Chronic Illness or Disability: The Health Action Process Approach (HAPA))	Health	Health Action Process Approach (HAPA) as a self-regulation framework for health behaviour change	Persuasion	No	Yes	No	No	No	Yes	Emotional (motivation)	Cognitive (behaviour outcome awareness)	Pretenders with high risk perception were much more likely to develop higher intentions over time than pretenders with low risk perception.	4

Appendix 6: Broad Aviation Workforce Questionnaire

Part 2: Profile Information

What is your age?

How long have you worked in aviation?

What type of company/organisation do you currently work with?

- ○ Commercial/Passenger airline
- ○ Cargo airline
- ○ Business aviation
- ○ General aviation
- ○ Flight Training
- ○ Military Air Force
- ○ Search & Rescue
- ○ Off-shore Helicopter Operation
- ○ Maintenance and Repair Organisation (MRO)
- ○ Airport Operator
- ○ Air Traffic Management
- ○ Outsourcing company
- ◉ Other (Please specify) [ ]

What is your current or most recent role/position?

Part 3: Risk Perception Factors

Please provide the five most important factors which influence the way you detect and perceive safety risks during your work activities.

Factor 1:
Factor 2:
Factor 3:
Factor 4:
Factor 5:

Part 4: Intervention Methods for Risk Perception

Based on the table bellow, please rate the degree to which the following organisational practices have helped you to improve your perception about safety risks; Please rate only those you have experienced during your professional career.

1-very unhelpful
2-not helpful
3-unsure
4-helpful
5-very helpful

Provision of knowledge or understanding
Communication to persuade me
Promise of a reward
Warning about penalties
Provision of training to develop skills
Application of restrictions
Change of the physical or social environment
Provision of positive examples
Increase of my capabilities and opportunities in general

Part 5: Risk Communication Factors

Please provide the five most important factors which influence the way you communicate safety risks with others in your organisation.

Factor 1:

Factor 2:
Factor 3:
Factor 4:
Factor 5:

Part 6: Intervention Methods for Risk Communication

Based on the table bellow, please rate the degree to which the following organisational practices have helped you to improve the ways you communicate safety risks; Please rate only those you have experienced.

1-very unhelpful
2-not helpful
3-unsure
4-helpful
5-very helpful

Provision of knowledge or understanding
Communication to persuade me
Promise of a reward
Warning about penalties
Provision of training to develop skills
Application of restrictions
Change of the physical or social environment
Provision of positive examples
Increase of my capabilities and opportunities in general

Appendix 7: Summary of Research Steps and Outputs

The following Table depicts the roadmap of the steps taken for this research summarising the studies undertaken with cross referencing to the relevant findings.

Steps	**Main Output**
Choice of Research Paradigm	Pragmatic paradigm
Sub-study 1: To find the inclusiveness of SAIMs concerning risk perception and risk communication factors	The environmental factors were found in 72% of the sample.
Sub-study 2: To find the inclusiveness and consistency of risk perception and risk communication factors from accidents/incidents, and SMEs (safety investigators and safety managers)	Risk perception and communication environmental factors were those met more frequently. Safety investigators highlighted the organisational risk perception and risk communication factors. Safety managers highlighted risk perception cognitive factors and risk communication organisational factors.
Sub-study 3: To acquire a behaviour based intervention model in which the risk perception and risk communication factors can be integrated.	INDICATE was the most appropriate model. Enablement was the most inclusive intervention function, followed by education, environmental restructuring, and training.
Sub-study 4: To acquire the input by the general aviation workforce and hence lay the foundation for the model according to triangulated data (i.e. SMEs, accident reports, general aviation workforce), based on the output from the sub-studies and strategic communication.	The general aviation workforce found training as the most helpful type of intervention function. Also, they highlighted the communication channel related factors, regarding risk communication, and the cognitive factors, regarding risk perception.