Standard concepts for performance improvements in the airport operations areas

Global interoperability

Omar Daniel Martins Netto

Tese para obtenção do Grau de Doutor em

Engenharia Aeronáutica

(3º ciclo de estudos)

Orientador: Prof. Doutor Jorge Miguel dos Reis Silva

Júri:

Prof. Doutor Carlos Alejandro Di Bernardi

Prof. Doutor José Manuel Mota Lourenço da Saúde

Profª. Doutora Maria do Rosário Maurício Ribeiro Macário

Prof. Doutor José Miguel Almeida da Silva

Profª. Doutora Rogéria de Arantes Gomes

Prof. Doutor Francisco Miguel Ribeiro Proença Brojo

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Dedicatory

To my wife for the incredible and unrestricted support and for always trusting me over nearly five decades that we have already spent together.

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Resumo

Tendo em vista o crescimento exponencial do tráfego aéreo e a sua importância na integração dos países, a implantação de melhorias no sistema ATM Global torna-se cada vez mais necessária. Neste sentido a ICAO preconiza, dentro do seu Global Air Navigation Plan (GANP), uma metodologia de fácil entendimento chamada: “Aviation System Blocks Upgrade” (ASBU). Tal metodologia define uma linguagem com abordagem programática, e flexível, visando melhorias de desempenho nos sistemas. E um dos setores onde é procurada uma dessas melhorias de desempenho, conforme preconizado no ASBU, é a área de Operações Aeroportuárias e, em particular, o processo de Airport Colaborative Decision Making (A-CDM).

Esta investigação visou realizar uma revisão do método A-CDM, com base em regulamentos e trabalhos acadêmicos sobre o assunto. Aprofundando teoricamente com base nos diversos sistemas de navegação aérea globais, como os processos empregados pela European Organisation for the Safety of Air Navigation (EUROCONTROL) e pela Federal Aviation Administration (FAA). Também foram pesquisados os posicionamentos a respeito do tema de entidades associativas, como da Airports Council International (ACI), da International Air Transport Association (IATA) e da Civil Air Navigation Services Organisation (CANSO). De forma subsequente realizaram-se estudos de caso de aeroportos e foram realizadas entrevistas com especialistas internacionais conhecedores do assunto. Finalmente realizou-se um inquérito com integrantes do Setor Aéreo de todo o mundo. Sempre com o foco de buscar compatibilidades e oportunidades de melhoria no referido processo, principalmente em termos de ganhos econômicos.

Ao final do trabalho, de acordo com a estratégia sequencial acima exposta, e com base no resultados colhidos, é feita uma análise de cenário e apresentada uma conclusão, a qual visa que o referido sistema possa ser aplicado, não somente em países de grande capacidade de investimento mas também, e principalmente, apresentar uma solução que permita sua aplicação em países, e aeroportos, com médios a baixos recursos financeiros. Sendo este o resultado buscado na pesquisa.

Palavras-chave

International Civil Aviation Organisation (ICAO), Global Air Navigation Plan (GANP), Aviation System Blocks Upgrade (ASBU), Airport Operations, Airport Colaborative Decision Making (A-CDM).

Resumo Alargado

1. Introdução

Este resumo alargado contém, em Língua Portuguesa, uma descrição sucinta da estrutura do trabalho de investigação realizado no âmbito desta Tese de Doutoramento desenvolvida na área das Ciências Aeronáuticas, particularmente no setor de Transporte Aéreo, com foco em Controle de Tráfego Aéreo e Operações Aeroportuárias.

2. Enquadramento e delimitação da Tese

Esta Tese trata dos processos de melhoria, recomendados pela Organização de Aviação Civil Internacional (OACI), aos estados signatários, contidos nas diretrizes mais importantes atualmente editadas, as quais deverão ser adotadas nas próximas décadas pelos membros do Setor Aéreo. Busca esclarecer processos, propondo soluções para melhorias, e padrões, que possam ser aplicados pela diversidade socioeconômica dos países que compõem a Organização.

O assunto aprofunda-se nos Sistemas de Navegação Aérea do Futuro (FANS) e em suas interações globais. Em primeiro lugar, analisa as recomendações do Órgão regulador mundial, por meio do contido no Plano Global de Navegação Aérea (GANP) da OACI e sua aplicação em projetos existentes e relacionados. Mais precisamente, nos processos de aplicação de Decisão Colaborativa em Aeroportos (A-CDM). Os quais envolvem a melhoria do fluxo de tráfego aéreo, em todo o mundo, e suas diversas e benéficas consequências, onde a operação aeroportuária e os sistemas de controle de tráfego aéreo estão diretamente envolvidos. O objectivo final é verificar a aplicabilidade desses casos à realidade econômica das interfaces aeroportuárias a que se destinam.

O trabalho procura responder à pergunta:

- Após identificar as melhores práticas de implantação dos Sistemas A-CDM atualmente aplicados em todo o mundo, mantendo os níveis de eficiência operacional e atendendo às diretrizes da OACI, é possível implantar um A-CDM com reduções substanciais no custo financeiro e no tempo de implantação?

Esta investigação procura uma lógica sequencial de informações, evita a apresentação de padrões de fórmulas e cálculos, e embora não fugindo de seu caráter científico, busca ser didática em sua sequência, visando que o leitor tenha um entendimento crescente. Em uma abordagem sobre trabalhos científicos, o artigo "A estrutura de um artigo de Engenharia", apresentado em 1994, no XXII Congresso Brasileiro de Ensino de Engenharia, em Porto Alegre, Brasil (Pinheiro & Koury, 1994), os autores destacam que o Engenheiro Civil não constrói prédios; o Engenheiro Mecânico não constrói aviões; o engenheiro químico não opera uma indústria. Todas essas atividades são realizadas por suas equipes de trabalho. O Engenheiro produz projetos e relatórios, que precisam ser compreendidos pelas partes interessadas. Portanto, é de vital importância que o aluno de engenharia aprenda, desde o início, a ser didático na apresentação de projetos e na redação de um relatório de engenharia. Na medida em que se possa estabelecer uma ligação entre a academia e o ambiente profissional. Nesse parâmetro de equidade, o trabalho científico ideal, mesmo no contexto matemático da Engenharia, deve ser evidente, preciso, conciso, direto, com o uso correto de linguagem técnica e conter algumas seções essenciais, dispostas em ordem lógica. O leitor deve ter rapidamente uma visão clara e global do propósito, do método usado e das conclusões. A organização deve ser tal que se possa localizar rapidamente qualquer seção para obter mais detalhes. Existem muitos esquemas de organização de trabalhos científicos e, no entanto, o método não atinge os objetivos iniciais, muitas vezes por falta de sequência lógica. O resultado é que o leitor fica muito confuso e perde a visão geral da obra. Muitos trabalhos são uma coleção aleatória de conclusões, problemas, dados, objectivos, procedimentos e discussão. Outro erro sério é um tamanho superdimensionado. É imprescindível que o autor seja capaz de pensar e planear logicamente, relacionar as ideias básicas, ordená-las na ordem adequada e depois começar a montar e detalhar o texto (Pinheiro & Koury, 1994).

O presente estudo, apoiado por acadêmicos e organizações da indústria, e com o suporte de documentos da OACI, considera a contribuição da academia no campo do apoio à decisão e tomada de decisão colaborativa (CDM). Tem relevância prática, científica, metodológica, social e pessoal. A Tese traz em seu conteúdo, diversas informações específicas sobre componentes e estrutura organizacional do Setor Aéreo, visando tornar mais fácil o entendimento, não só da Tese, como do Setor como um todo. Assim, os resultados deste estudo podem trazer maiores informações aos acadêmicos envolvidos em pesquisa na área de transporte aéreo. Também servir como base teórica primária para profissionais de operações aeroportuárias, e de controle de tráfego aéreo, que pretendam iniciar trabalhos recomendados pela OACI em suas áreas de jurisdição. Cientificamente, pode fornecer suporte para pesquisas futuras nas áreas de aeroportos e de controle de tráfego aéreo, as quais podem buscar novas opções de aplicação dos processos de A-CDM.

3. Metodologia

O trabalho orientará sua busca por resultados através do suporte metodológico de vários Estudos de Caso. Seus pressupostos básicos analisados estrategicamente baseiam-se em duas teorias presentes, visando seu desenvolvimento: Teoria dos Sistemas e Teoria da Complexidade.

Com o suporte das teorias mencionadas, serão considerando dados secundários recolhidos da literatura internacional em aviação, livros e artigos que tratam do assunto, dissertações, monografias e dados da OACI e de outras entidades como: European Organization for the Safety of Air Navigation (EUROCONTROL); Federal Aviation Administration (FAA); International Air Transport Association (IATA) e Civil Air Navigation Services Organisation (CANSO).

Todas essas informações, somadas a um estudo de caso múltiplo, entrevistas com especialistas em A-CDM e um inquérito respondido por profissionais internacionais, envolvidos no Setor Aéreo, servirão para balizar um diagnóstico sobre o uso de um modelo que possibilite a implantação de um A-CDM, de forma econômica, o qual seja possível ser aplicado em aeroportos e países com baixa capacidade de investimento.

4. Organização da Tese

A tese está estruturada da seguinte forma:

CAPÍTULO 1: INTRODUÇÃO E METODOLOGIA

Contém uma apresentação geral da tese, delimitação, justificativas, objetivos, enfoques, suportes utilizados, teorias, metodologias e ferramentas de análise.

CAPÍTULO 2: INTRODUÇÃO TÉCNICA

Este capítulo apresenta os fundamentos da tese ao leitor. Situará o assunto sob o aspecto técnico, desde seus fundamentos necessários. Permitindo assim, o início de uma compreensão dos elementos técnicos e operacionais propriamente ditos. Apresenta uma visão abrangente sobre: o Plano Global de Navegação Aérea (GANP) da OACI; os Blocos de Melhorias dos Sistemas de Aviação (ASBU); e as Melhoria das Operações Aeroportuárias com base na Tomada de Decisão Colaborativa do Aeroporto (A-CDM).

CAPÍTULO 3: APROFUNDAMENTO EM A-CDM

Depois de apresentar os fundamentos do GANP e dos ASBU, bem como uma introdução ao conceito A-CDM, este capítulo irá aprofundar a ideia A-CDM em suas áreas de melhorias de desempenho e indicadores. Dando alguns exemplos de implementação da ferramenta, com recomendações das principais entidades representativas da área de aviação, como OACI, CANSO, e IATA. Além disso, trazendo o "modus operandi" de duas das principais organizações que tratam do assunto atualmente em seus territórios, a EUROCONTROL e a FAA.

CAPÍTULO 4: ESTUDOS DE CASO DE AEROPORTOS

Neste capítulo, com base em dados disponibilizados em documentos da EUROCONTROL, são apresentados 8 (oito) estudos de caso de aeroportos Europeus onde o A-CDM já foi implantado com sucesso. Em 2 (dois) deles de forma mais aprofundada e em outros 6 (seis) aeroportos com dados mais compactos.

CAPÍTULO 5: ENTREVISTAS E PESQUISAS

No capítulo 5, entrevistas estruturadas são conduzidas com especialistas em A-CDM, as quais servirão como uma das bases para a elaboração da pesquisa, tais pesquisas realizadas com especialistas internacionais em aeroportos, controle de tráfego aéreo e indústrias relacionadas da Europa e Américas. Na primeira parte, são realizadas entrevistas estruturadas que, além de servirem como suporte para as Análises e Conclusões, também subsidiam a montagem de alguns trechos da pesquisa que se apresenta na segunda parte do capítulo. Esta contém um questionário com questões de múltipla escolha, encaminhado aos integrantes do Setor Aéreo em geral, ou seja, um público mais amplo, não apenas para quem conhece A-CDM.

CAPÍTULO 6: ANÁLISE E CONCLUSÕES

Aprofunda o estudo como um todo, principalmente com base nos capítulos 3, 4 e 5. Ao final são apresentadas as conclusões resultantes do estudo.

CAPÍTULO 7: CONSIDERAÇÕES FINAIS

Neste capítulo final, é apresentada uma síntese da dissertação, as últimas considerações e algumas perspectivas para pesquisas futuras.

Abstract

Because of the exponential growth of air traffic and its importance of integration of countries, the implementation of improvements in the Global ATM system is becoming increasingly necessary. Within this scope, ICAO brings, within its Global Air Navigation Plan (GANP), an easily understood methodology called: "Aviation System Blocks Upgrade" (ASBU). It defines a language with a programmatic and flexible approach, aiming at performance improvements in the systems. And one of the sectors where one of these performance improvements is sought, as recommended in the ASBU, is the Airport Operations Area. In this area is the Airport Collaborative Decision Making (A-CDM) process.

This research aimed to review and improve the A-CDM method to enable its use in airports with lower disbursement capacity. It is based on regulations issued by the International Civil Aviation Organization (ICAO) and academic papers. Theoretically, it went deeper into the various global air navigation systems, such as the processes employed by the European Organization for the Safety of Air Navigation (EUROCONTROL) and the Federal Aviation Administration (FAA). Positions from entities such as the International Air Transport Association (IATA) and the Civil Air Navigation Services Organization (CANSO) were also researched. Subsequently, case studies of airports and interviews with international experts with knowledge on the subject were carried out. Finally, a survey was conducted with members of the Air Sector from around the world. Always focused on seeking compatibilities and opportunities for improvement in the process, mainly in economic gains.

According to the sequential strategy exposed above, a scenario analysis is done based on the results obtained at the end of the work. Then, a conclusion is presented, which aims to to apply the referred system, not only in countries with high capacity disbursement but mainly to deliver a solution that allows its application in countries and airports with medium to low financial resources. This solution presented is the goal sought in the research.

Keywords

International Civil Aviation Organisation (ICAO), Global Air Navigation Plan (GANP), Aviation System Blocks Upgrade (ASBU), Airport Operations, Airport Colaborative Decision Making (A-CDM).

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List of Acronyms

ACC: Area Control Centre

A-CDM: Airport Collaborative Decision Making

ACGT: Commence of Ground Handling Operations

ACI: Airports Council International

ACIS: A-CDM Information Sharing

ACISP: Airport CDM Information Sharing Platform

ADES: Aerodrome of Destination

ADS-B: Automatic Dependent Surveillance-Broadcast

AIBT: Actual In Block Time

ALDT: Actual Landing Time

AMAN: Approach Manager

ANSP: Air Navigation System Providers

AN-SPA: Air Navigation System Performance Assessment

AOBT: Actual Off-block Time

AODB: Airport Operational DataBase

APOC: Airport Operations Center

ASBU: Aviation System Blocks Upgrade

A-SMGCS: Advanced Surface Movement Guidance And Control Systems

ATC: Air Traffic Control

ATD: Actual Time of Departure

ATFM: Air Traffic Flow Management

ATM: Air Traffic Management

ATOT: Actual Take-Off Time

BRU: Brussels Airport

CANSO: Civil Air Navigation Services Organisation

CARATS: Collaborative Actions for Renewal of Air Traffic Systems of Japan)

CDF: Central De-icing Facilities

CDG: Paris Charles De Gaulle Airport

CDM: Collaborative Decision Making

CFMU: Central Flow Management Unit

CHG: Message of Change

CISS: Airport Central Information System Schiphol

CONOPS: Concept of Operations

CRM: Crew Resource Management

CTOT: Calculated Take-Off Time

CTRP: CDM Turn-Round Process
DCB: Demand and Capacity Balancing
DECEA: Department of Airspace Control
DLA: Message of Delay
DMAN: Departure Manager
DPI: Departure Planning Information
DSNA: Direction des Services de la Navigation Aérienne
ECOSOC: Economic and Social Council
ELDT: Estimating Landing Time
EOBT: Estimated Off-block Time
ETO: Estimated time Over
EU: European Union
EUROCONTROL: European Organisation for the Safety of Air Navigation
FAA: Federal Aviation Administration
FANS: Future Air Navigation Systems
FIR: Flight Information Region
FRA: Frankfurt Airport
FUM: Flight Update Messages
GANP: Global Air Navigation Plan
GBAS: Ground-Based Augmentation Systems
GDS: Global Distribution Systems
GLS: GBAS Landing System
GNSS: Global Navigation Satellite System
HEL: Helsinki-Vantaa Airport
IANS: EUROCONTROL Institute of Air Navigation Services
IATA: International Air Transport Association
ICAO: International Civil Aviation Organisation
IFR: Instrument Flight Rules
IROPS: Irregular Operations
KNMI: Royal Netherlands Meteorological Institute
KPI: Key Performance Indicators
LA: Latin America
LGW: London Gatwick Airport
MAD: Madrid-Barajas Airport
MTT: Minimum Turn-round Time
NAS: National Airspace System
NASA: National Aeronautics and Space Administration

NEXTGEN: The Next Generation Air Transportation System
NGIP: NextGen Implementation Plan
PANS: Procedures for Air Navigation
PBN: Performance-Based Navigation
PDS: Pre-Departure Sequencer
PIA: Performance Improvements Aviation areas
PICAO: Provisory International Civil Aviation Organisation
PSR: Primary Surveillance Radar
RFPL: Repetitive Flight Plan
SAM: Slot Allocation Message
SAOC: Schiphol Airline Operators Committee
SARP: Standards and Recommended Practices
SBAS: Satellite-Based Augmentation System
S-CDM: Surface Collaborative Decision Making
SESAR: European Community Single Air Traffic Management Program
SLA: Service Level Agreement
SeMS: Security Management Systems
SOBT: Scheduled Off-Block Time
SPA: System Performance Assessment
SRM: Slot Revision Method
SSR: Secondary Surveillance Radar
SXF: Berlin-Schönefeld Airport
TBO: Trajectory-Based Operations
TFDM: Terminal Flight Data Manager
TGS: General Theory of Systems
TLDT: Target Landing Time
TOBT: Target Off-block Time
TSAT: Target Start-up Approval time
TTOT: Target take-off time
TWR: Aerodrome Control Tower
USA: United States of America
VTTC: Variable Taxi Time Calculation

Chapter 1. INTRODUCTION AND METHODOLOGY

1.1 Introduction

This Introduction contains a general presentation of the Thesis, generically, its motivation and objectives. It is followed by a historical summary of the International Civil Aviation Organisation (ICAO), which is the primary documentary support of the work. It also presents other institutions and associations in the airline industry that will provide technical/documentary support.

In the sequence, in 1.2, in Methodology, the theoretical and scientific bases, the methodology used and finally, in 1.3, the organisational structure of the work.

1.1.1 Motivation and objectives

Since 1973 I have worked within the Air Sector. Suppose we compute the previous two years attended at the School of Aeronautical Specialists, preparatory for Air Traffic Controllers, in 2021. In that case, it will be 50 (fifty) years interacting in the vibrant aviation environment. More than half of this time was devoted to Air Traffic Control, and the rest was also adding activities related to Airport Operations. In both events focus on the operational, planning, management and training areas. In this long journey, I was able to verify many successful cases and opportunities for improvement and process refinement, which in most of the cases were operational deficiencies caused by a lack of proper management and poor coordination between sectors and their members.

An aviation environment is made up of a multitude of stakeholders who have different backgrounds and interests. However, at times when the operational side is focused, they must act in concert. Unfortunately, the financial aspect often motivates them to tend to leave the operational and safety issues behind. And anyone working in aviation knows that, above all, safety is always the number one priority.

Thus, due to training and experience, in these two crucial sectors of aviation, Air Traffic Control and Airports, I have listed a theme subject that addresses these two sectors simultaneously, and that may bring some improvement proposal to a process that is already underway, called Airport Collaborative Decision Making (A-CDM). However, it requires some improvement to meet the regional development of several medium-sized countries and airports, where there are deficiencies under the economic aspect.

With this work, I intend to answer the following question:

- *As for the A-CDM process currently in operation in several airports around the world: It is possible to run this process in airports with low investment capacity, implementing an A-CDM with substantial reductions in financial cost, implementation time, maintaining high levels of efficiency operational, safety and meeting International Civil Aviation Organization (ICAO) guidelines?*

Given the answer to the Thesis question, the main objective of this work is to seek solutions that can enable the implementation of this low-cost A-CDM.

And to meet this central objective, the specific goals to be achieved are:

a) In-depth study of the ICAO legislation that regulates the matter;

b) Research and analysis of rules and operational procedures used by the two National Aviation Authorities in America and Europe, the Federal Aviation Administration (FAA) and the European Organisation for the Safety of Air Navigation (EUROCONTROL), when implementing A-CDM at its main airports;

c) Case study of some airports where the process is already implemented;

d) Interview participants in the implementation of A-CDM at airports in some countries; and

e) Conducting an international survey seeking to gather responses from experience, as users, of members of the airline sector.

At the same time, the Thesis seeks to be didactic, as it presents topics from ICAO's organisational and regulatory structure, converging to the specific content of the publications that came to generate the Organisation's guidelines for implementing this process. A methodological and organisational structure will be adopted to achieve this objective, as shown in Figure 1.10 at the end of this chapter.

The present study conducted by academics and primarily supported by ICAO documents considers the academy's contribution in decision support and collaborative decision making, using studies made by Baker et al. (2001). As well as the work of Baltazar, Rosa & Silva (2018) allows measuring the effectiveness of the operational and decision making processes. It has practical, scientific, methodological, social, and personal relevance.

The thesis brings in its content several pieces of specific information about the components and organisational structure of the Air Sector, aiming to make it easier to understand the thesis and the Sector as a whole. Thus, the results of this study can provide more information to academics involved in research in the field of air transport. It will also serve as a primary theoretical basis for airport operations and air traffic control professionals wishing to initiate work recommended by ICAO in their areas of jurisdiction. Scientifically, it can provide support for future research in the civil aviation sector.

1.1.2 Technical delimitations

This Thesis deals with improvement processes, recommended by the International Civil Aviation Organisation (ICAO) to the signatory states, contained in the most critical guidelines today. The recommendations are to be adopted in the coming decades by the members of the Air Sector. It seeks to clarify processes by proposing solutions for improvements and standards which can be applied by the socioeconomic diversity of countries that make up the ICAO.

The subject goes deeper into Future Air Navigation Systems (FANS) and their global interactions. Firstly, its objective is to analyse the recommendations of the world regulatory body through the recommendations of the ICAO Global Plan and its application in existing and related projects. These processes involve improving air traffic flow globally, where airport operation and air traffic control systems are directly involved. The ultimate goal is to verify the applicability of these cases to the airport interfaces economic reality for which they are intended.

It also seeks to answer the question cited in 1.1.1. Which asks the possibility to build a user-friendly, low-cost, easy-to-understand global model? That is, of general applicability and acceptability in all ICAO signatory countries, including those with fewer resources, both human and material.

The technical support, to start this research, is based on the recommendations contained in the document "Global Air Navigation Plan 2018-2030" (ICAO, 2016), which outlines the guidelines to be adopted in the coming years by the primary aviation support: air traffic control and airports. On this tripod made up of aircraft, airspace, and airports, we have the fundamental basis of the airline industry. Thus, within this environment, we have deepened the interfaces between Air Traffic Control and Airports. The aim is to improve the quality of service to its aviation customer and, therefore, to passengers, who are the end customer of service providers.

Before entering the case studies, interviews and survey, this research seeks a sequential logic to support the reader's regulatory basis. It also avoids presenting patterns of formulas and calculations. Regarding the knowledge of scientific works, the paper "The structure of an Engineering article", presented in 1994, at the XXII Brazilian Congress of Engineering Education, in Porto Alegre, Brasil (Pinheiro & Koury, 1994), is still current, since the recommendations are perennially contained therein. In the text, the authors emphasise that the Civil Engineer does not construct buildings; the Mechanical Engineer does not build aeroplanes; the Chemical Engineer does not operate an industry. Their work teams carry out all these activities. The Engineer produces projects and reports, which need to be understood by stakeholders. Therefore, it is vitally important that the engineering student learns to be didactic in presenting projects and writing an engineering report from the beginning. Thus, insofar as one can establish a connection between the academy and the professional environment. In this fairness parameter, the definitive scientific work, even in the mathematical context of engineering, must be evident, precise, concise, direct, with the correct use of technical language and contain some important sections which are arranged in the logical order. The reader should quickly have a clear and global view of the purpose, method used, and conclusions. The organisation should be such that it can quickly locate any section for further details.

Due to a lack of logical sequence, many ways of organising scientific work often do not achieve the initial objectives. The result is that the reader can become confused and lose the overall view of the work. Another serious error that can occur is a large job size. It is essential that the author think and plan logically, relate the basic ideas, organize them in the correct order, and assemble and detail the text (Pinheiro & Koury, 1994).

In this scenario, the research is conducted through documents, case studies, interviews and surveys. It is supported by tools like SWOT analysis, which will highlight key elements of process improvement and the steps that should be taken by member states. Then recommending possible actions to countries with lower disbursement power in the Air Sector. Starting in this first chapter, it seems to be instructive and informative, finding that the understanding of the subject can evolve sequentially and organised.

1.1.3 Thesis supports

1.1.3.1 Aviation

From balloons and flying with the first heavier than air, supersonic, and tragedies such as September 11, aviation is one of the themes that arouses the population's interest. Among the machines currently used by man, aviation is among those that, in this century, has had more technological development and growth in their employment. The air transport industry is growing exponentially.

This growth seeks a follow-up in the same rhythm of the organisations of support to the airline sector.

Figure 1.1 – ICAO logo
Source: ICAO, 2019a

1.1.3.2 The ICAO

With the rapid growth of aviation, borders began to become restrictive factors for air navigation. At the end of World War II, the international community started to develop shared norms, procedures, and standards that would regulate the rapid growth of a revolutionary mode of transportation. This would completely change the distance and time relationship between different locations and significantly contribute to business transactions. In that sense, standards would need to be established to ensure the safety and compatibility of operations between States.

Figure 1.2- International Civil Aviation Conference, Chicago, 1944
Source: ICAO, n.d.1

After several regional meetings held by countries concerned with the issue, on December 7, 1944 (Figure 1.2), representatives of 52 nations met to draw up the Convention on International Civil Aviation (also known as the Chicago Convention). Pending the ratification of the Convention by 26 States, the Provisory International Civil Aviation Organisation (PICAO) was established. It ran from June 6, 1945, until April 4, 1947. On March 5, 1947, the 26th ratification was received. ICAO emerged on April 4, 1947. In October of the same year, ICAO became a specialised United Nations agency linked to the Economic and Social Council (ECOSOC) (ICAO, n.d.2).

The International Civil Aviation Convention sets out the objectives of ICAO:

- WHEREAS that the future development of international civil aviation can significantly help to create and preserve friendship and understanding in the world, between nations and peoples, but their abuse can become a threat to general security;

- WHEREAS that it is desirable to avoid friction and to promote cooperation between nations and peoples on which world peace depends; and
    - THEREFORE, the undersigned governments have agreed on certain principles and arrangements so that international civil aviation can be developed in a safe and orderly manner and that equal opportunities can establish international air transport services and operated soundly and economically; and (then)...

... they have concluded this Convention for this purpose (ICAO, 2006).

In addition to the Chicago Convention, an important document called the Convention on Civil Aviation in English and Spanish, *Convênio sobre Aviación Civil Internacional* and presented by ICAO as Document 7300 (following its internal documentation standards), edited the Standard and Recommended Practices (SARPs). There are nineteen “Annexes to the Convention” and, as the name defines, present the Norms and Practices recommended by the Organisation. There is also a supplementation of the annexes by other documents that regulate and, in some cases, give more amplitude to its content. Thus, the Convention, a significant report, establishes the significant directives of international air transport concentrated among all signatory States. It consists of four parts (Netto, 2011):

- Part I - Addresses the responsibilities of states about the provision of facilities and services related to Air Navigation;
- Part II - Treatment of the Organisation (ICAO) and constituent bodies;
- Part III - Handle aspects related to air transport, obligations/rights of States; and

- Part IV - Final provisions.

The establishment and maintenance of international SARPs and Procedures for Air Navigation (PANS) are fundamental tenets of the Chicago Convention and a core aspect of ICAO's mission and role.

SARPs and PANS are critical for the ICAO Member States and other stakeholders as they provide the fundamental foundation, safety and efficiency for harmonised global aviation in the air and on the ground. As well as worldwide standardisation of functional and operational requirements, provision of air navigation facilities services focusing on the development of air transport. ICAO currently manages over 12,000 SARPs contained in the 19 Annexes and five Procedures for Air Navigation Services (PANS) of the Chicago Convention, many of which are continually evolving. According to the latest innovations and developments. The development of SARPs and PANS follows a structured, transparent and multistaged process, often known as the ICAO "*amendment process*" or "*standards-making process*". This involves many technical and non-technical bodies within the ICAO or closely associated with Organisation. Typically, it takes approximately two years to run an initial proposal to a new or improved Standard, Recommended Practice (or procedure), aiming to be formally adopted or approved for inclusion in an Annex or a PANS. Sometimes, this timescale can be expanded or compressed depending on the nature and priority of the proposal under consideration (ICAO, 2019).

The Annexes to the Convention deal with the provisions contained in each Party, showing how each service should operate through the application of standards and recommended methods. The Annexes include Appendices, which are parts of them, and serve to detail, complement and clarify the implementation of a standard/method.

Documents and Manuals provide guides and information on how to make the standards/methods of the Annexes feasible and operational (the Annexes regulate these Docs).

They are published in the six official languages of the United Nations system, namely:

- English; Spanish; French; Russian; Mandarin; and Arabic.

The following Table 1.1 shows the 19 Annexes and their applications in the air industry.

Table 1.1 - ICAO Annexes index
Source: Own elaboration based on ICAO general documentation

Annexe	Description
ANNEXE 01	Personnel Licensing
ANNEXE 02	Rules of the Air
ANNEXE 03	Meteorological Service for International Air Navigation
ANNEXE 04	Aeronautical Charts
ANNEXE 05	Units of Measurement to be used in Air and Ground Operations
ANNEXE 06	Operations of Aircraft
ANNEXE 07	Aircraft Nationality and Registration Marks
ANNEXE 08	Airworthiness of Aircraft
ANNEXE 09	Facilitation
ANNEXE 10	Aeronautical Telecommunications
ANNEXE 11	Air Traffic Services
ANNEXE 12	Search and Rescue
ANNEXE 13	Aircraft Accident Investigation
ANNEXE 14	Aerodromes
ANNEXE 15	Aeronautical Information Services
ANNEXE 16	Environment Protection
ANNEXE 17	Aviation Security
ANNEXE 18	The Safe Transport of Dangerous Goods by Air
ANNEXE 19	Safety Management

For this research, it is interesting to point out that it identifies all the potential performance improvements available today and details the next generation of terrestrial and avionics technologies deployed around the world. It provides the investment certainty necessary for states and industries to make strategic decisions for individual planning purposes.

The ongoing Air Navigation improvement programs carried out by several of the ICAO Member States – NextGen (The Next Generation Air Transportation System - USA), SESAR (European Community Single Air Traffic Management Program), CARATS (Collaborative Actions for Renewal of Air Traffic Systems of Japan), SIRIUS in Brazil and others in Canada, China, India and the Russian Federation - become consistent given the specific methodology. These States have mapped their planning to the so-called Block Upgrade

Modules to ensure their Air Navigation solutions' short- and extended-term global interoperability. GANP's block upgrade planning approach also addresses support user needs, regulatory requirements and the needs of air navigation service providers and airports. This process ensures a single source for comprehensive planning (ICAO, 2016).

ICAO has 193 (one hundred and ninety-three) state members. Its permanent headquarter is in Montreal-Canada and is supported by seven regional offices established in Bangkok, Cairo, Dakar, Nairobi, Lima, Mexico and Paris. One of its missions is the development of policies and standards, building higher capacity in aviation processes with cooperation among all members (ICAO, 2021).

The Organisation is always seeking and perfecting methodologies that can be adopted by its signatories, albeit from different cultures and economic power.

1.1.3.3 Support and representative organisations

The air sector comprises of the most diverse governmental and non-governmental organisations that regulate, centralise, manage, and represent the aviation industry. Many of them are cited in this Thesis. The most important is the ICAO, which has already been referenced earlier. The others will be presented summarised next:

Figure 1.3– EUROCONTROL logo
Source: EUROCONTROL, 2019a

EUROCONTROL (Figure 1.3), the European Organisation for the Safety of Air Navigation, has 38 Member States: Albania, Armenia, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Malta, Moldova, Monaco, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, the former Yugoslav Republic of Macedonia, Turkey, Ukraine and the United Kingdom and Northern Ireland. EUROCONTROL's mission focuses on harmonising and integrating air navigation services in Europe. The main objective of creating a uniform air traffic management

(ATM) system for civilian and military users is to achieve the safe, secure, orderly, expeditious and economical flow of traffic throughout Europe while minimising adverse environmental impact (EUROCONTROL, 2019a).

Figure 1.4 – FAA logo
Source: FAA, 2019

As stated in the FAA (2019), the Federal Aviation Administration (FAA), (Figure 1.4), a United States government agency, is a division of the Department of Transportation that inspects and classifies civil aircraft and pilots, enforces air safety rules, and installs and maintains air navigation and traffic control facilities. It has the power to regulate all aspects of civil aviation in that country and the surrounding international waters. Its capabilities also include the construction and operation of airports.

Figure 1.5 – DECEA logo
Source: DECEA, 2019

The Department of Airspace Control (DECEA) (Figure 1.5) is the organisation responsible for controlling Brazilian airspace, an air navigation service provider that enables flights and ordering air traffic flow in the country. Reporting to the Air Force Command, DECEA is the Brazilian Airspace Control System (SISCEAB). To plan, manage and execute the scope of the approximately 22 million km2 of airspace under the country's responsibility. DECEA has a robust physical structure and has facilities in more than 100 municipalities in 27 Brazilian federative units. Around 12,000 professionals work during a complex interconnected operational network that comprises of: 5 area control centres; 42 approach controls; 59 aerodrome control towers; 79 airspace control detachments; 90 aeronautical telecommunications stations; 75 telecommunications and air traffic service stations; 170

radars; 50 Instrument Landing Systems. Among other aids to air navigation (DECEA, 2019).

Figure 1.6 – IATA logo
Source: IATA, 2019

The International Air Transport Association (IATA) (Figure 1.6) is the trade association for airlines worldwide. It represents some 290 airlines or 82% of total air traffic. It supports many areas of aviation activity and helps formulate industry policy on critical aviation issues. IATA's mission is to represent, lead, and serve the airline industry. IATA represents the airline industry, improves understanding of the air transport industry among decision-makers and increases awareness of aviation's benefits to national and global economies. Advocating for the interests of airlines across the globe, challenging unreasonable rules and charges, holding regulators and governments to account, and striving for sensible regulation (IATA, 2019).

Figure 1.7 – ACI logo
Source: ACI, 2019

The Airports Council International (ACI) (Figure 1.7) is today the only global commercial representative for airports in the world. Founded in 1991, ACI represents the interests of airports before governments and international organisations such as ICAO. It systematically develops standards, policies, and best practices for associated airports and provides information and training opportunities that allow it to raise standards worldwide (ACI, 2019).

Figure 1.8 – CANSO logo
Source: CANSO, 2016

The Civil Air Navigation Services Organisation (CANSO) (Figure 1.8) is the global voice of air traffic management (ATM) worldwide. CANSO Members support over 85% of world air traffic. Members share information and develop new policies, with the ultimate aim of improving air navigation services (ANS) on the ground and in the air. CANSO represents its Members' views to a wide range of aviation stakeholders, including the International Civil Aviation Organisation, with official observer status. CANSO has an extensive network of Associate Members drawn from across the aviation industry (CANSO, 2016).

1.2 Methodology

This work, using the qualitative method, whose fundamental assumptions must be strategically analysed and based on two theories - Systems Theory and Complexity Theory. It will guide our search for results through the methodological support of existing literature, multiple case studies, interviews, and questionnaires. At the end of the work, such data will be analysed and bring to light the conclusion and the final considerations to be issued.

1.2.1 Qualitative methodology

Using a qualitative method, the present research considers secondary data collected from international aviation literature, books, and articles that deal with the subject, dissertations, monographs, and data from ACI, IATA, ICAO, EUROCONTROL, FAA, among others.

Qualitative research is an approach to exploring and understanding the meaning that individuals or groups attach to a social or human problem. The research process involves emerging issues and procedures, works with data generally collected in the participant's environment, and data analysis building inductively. Ranging from particular to general themes, the researcher makes interpretations of the meaning of these data (Creswell, 2014).

The final written report has a flexible structure. Those who engage in this form of inquiry support a way of looking at research that honours an inductive style, a focus on personal meaning, and the importance of interpreting the complexity of a situation.

All this information supported by multiple case studies, interviews, and surveys will permit analysis and diagnostics about using models and possible enhancement. In the interpretation of data, a SWOT analysis will be carried out.

1.2.1.1 Choosing the correct research method

In the search to find the necessary methodology for the development of the theme under study, it appears that the possible options are different - qualitative, quantitative and mixed, and the mixed can often present tendencies for a further in depth analysis in quantitative or with a more interpretative aspect.

In research related to the exact sciences, mainly in engineering, the quantitative research methodology is mostly used; it is an option of choice for this scientific community. According to Punch (1998), the qualitative methodology in academic works is widely contested in the scientific field.

The option to undertake qualitative research should be aware that there are criticisms (e.g. not strict, descriptive) of its use, particularly by the positivist (Denzin & Lincoln, 2011).

The object of this study is a Complex Organisation, which lives in a complex context, and as stated in a previous item, is supported by the Complexity Theory. The principles of repetition are not always guaranteed; the same causes may not produce the same effects. Especially in aviation, which is subject to a combination of meteorological, operational, administrative, governmental and regulatory origins, most of them of variable order. They may be influenced by many aspects, which may render studies based only on quantitative methods fallible. This feature makes it mandatory to choose a methodology that will help mirror this reality and, as is the sector, be flexible to enable the study of this type of complex reality. Otherwise, it will undermine the research results in terms of theoretical and practical contribution. It should be noted that qualitative or mixed studies are often the basis for quantitative studies.

According to Strauss and Corbin (2008), traditionally, qualitative studies have exploratory aspects, generating hypotheses that can be tested in later studies through quantitative strategies.

Flick (2009) states that it would be naive to think that in the 21st century, there could be completely new situations, justifying the need to always review the literature related to the main topics of study. In addition to the methodological question, the literature review also allowed answering questions such as what is already known about this subject; what theories are used; what concepts are used; what problems are open; what has not been studied yet.

Using inductive reasoning from the dawn of data, mainly from the studied cases, will analyse and study process improvements and standardisation. With the contribution of the SWOT tool, the researcher experience should be considered based on the subject studied. According to Yin (2003), the inductive approach is challenging to use if researchers are inexperienced. There is a risk that they will not have the ability to analyse the obtained data appropriately.

Thus the present research will be based on existing literature, norms, regulations of international, governmental and private organisations, and existing academic literature. It will be contributed by international aviation experts, who will respond to a survey that, after being planned, will add subsidies to the concluding chapter.

The starting point will be the study of the international documentation produced by ICAO, which today has the most significant weight for signatory countries. It will guide and mark the actions taken in the coming decades regarding air traffic and airports: The Global Air Navigation Plan Manual (GANP).

Still, within the scope determined by this document, other recommendations will be made that specify the interaction between air traffic control bodies and airports, aiming to streamline and standardise some processes within the complexity that the environment requires, with a focus on more significant interaction, what is called Airport Collaborative Decision Making (A-CDM). From there, other technical documents from international entities and related academic documentation will be studied. Processes already implemented in some European airports will be studied (Case Studies) to know its advantages and knowhow. Interviews and surveys will complement the data.

1.2.2 Strategies

It is a common domain in the service and business environments that, as a prominent part of management, strategic planning is a tool to assist managers in contributing to the definition of their projects. The current states are continuously being challenged to face the changes required by globalisation and the challenges and significant risks imposed on them in high technology environments, such as the airport environment (Netto, 2011).

According to Vizeu and Gonçalves (2010), the etymological and conceptual origin of the word strategy goes back to the military area. It is from ancient Greece, one of the first civilisations to be interested in its study. The originating strategy term comes from the Greek word strategos. This political and military title was granted to ten tribal leaders in Athens to meet the political reforms proposed by Clístenes, improvements recognised as the first effort of history for a democratic government.

It is coming back to the conceptual part that the strategy probably arose related to military operations. Most of the elements that value it, such as the various types of limitations and uncertainties, are found. Both about the intentions of the opponents and the control of situations, General Sun Tzu pointed out in a document written around the year VI BC (Tzu, 1997), the importance of the strategy not being seen by the enemy. All could look at the tactics he used to achieve, but no one could see the strategy through which total victory is gained. Strategy today is one of the most used expressions in organisational and corporate environments, found abundantly in the specialised literature in this field. In a first analysis, it seems to be a stabilised, consensual and unique concept. Still, according to Chaffee (1985), there is no consensus about its definition because the strategy is multidimensional and has situational characteristics; it varies according to industry or service.

Considering Johnson's, Scholes and Whittington (2007) definition, the concept of strategy is the direction and scope of an organisation in the long term, considering that it will benefit from changes in configurations, resources and skills, changes that aim to meet the expectations of the stakeholders. It can be concluded that in one of the dimensions of the strategy, the organisation establishes a relationship with the environment to seize its opportunities and avoid its threats. In another aspect, the organisation captures resources in the background, develops internal competencies based on technology and innovation, configures its functional structure to meet shareholders' expectations.

In an increasingly globalised world, highly dynamic and continually changing, understanding environmental transformations has become a crucial part of an efficient Strategic Plan. Then it will have a higher probability of anticipating opportunities and threats of an environment in constant change, minimising the risks inherent in this scenario. Organisations, to survive in highly competitive markets, increasingly need to know how to take calculated risks. But to succeed, they must also know how to navigate in dangerous environments, with the objective of capturing the rewards coming from them, for this there is a vital and fundamental factor, the need to develop techniques to reduce risks (Netto, 2011).

For Chatterjee (2006), in whatever sector, the risk will be related to factors such as lack of knowledge of the demand, a threat of competition and a lack of appropriate skills. In this way, to reduce risks, it is necessary to be clear about where they are and, from there, to create alternatives or options to minimise them.

According to Arantes (2017), there is a big difference between planning and putting what was planned into practice. This difference is because the environment in which organisations operate is unpredictable. Thus, as a change occurs in the environment, the organisation needs to review its strategies, build new learning and make other decisions. The managers of an organisation can follow a decision-making model, following a rational sequence of analyses and conclusions, or develop a less systematic model that allows them to adjust their conduct over time.

In an increasingly globalised, highly dynamic, and constantly changing business world, understanding environmental changes has become a key element in realising an effective Strategic Plan. Thus, they probably increase the possibility of anticipating opportunities and threats in a constantly changing environment, minimizing the risks inherent in this scenario [1] (Motta, Netto, & Carneiro, 2011).

Pettigrew (1992) discusses "The Character and Significance of Strategic Processes", stresses the description, analysis, and explanation of recurrent patterns in the strategic management process, along with the exploration of why, when, and how the results are shaped by the characteristics of political processes and contexts. It also emphasises that the particular focus is on action and setting, the critical role of time and history in understanding the emergence, development, decay, and regeneration of crucial people within contexts, the part of teams, institutions, sectors, and political and economic systems.

The research is to capture reality in flight, at the moment of the event, of action, and bring it as the embryo of a method. One can explore the cumulative sequence of a process with different levels of analysis to explain when and why specific results are achieved. These general issues can be useful in analysing the dynamics of the decision-making processes, change, competitiveness, market creation, internationalisation, business strategy, and technology and the role, conduct, and performance of managerial elites in companies and societies (Petigrew, 1992).

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[1] Author's participation in the Theorethical References, Cases and Models of Low Cost Airline Companies, Interview with the COO of Azul Airlines and in the Final Considerations.

All these strategists have always had process improvement as one of their most important goals, like the reference point for strategic planning processes. What can be observed by the scholars is that the concept of strategy has evolved significantly for the application, not only in business but in any segment focused on the provision of services. In the air sector, all these concepts can, and should, be applied, and the strategies to be followed must be carefully analysed to choose and establish the most suitable models to be used. After this choice, the implementation strategies of the model determined for sector management, or of a remote unit, are subsequent steps to assess the activity's success.

1.2.3 Theories

During the development of the work, two theories -which are applied, even if subjectively-should be present to guide and increase the level of understanding of the activities are being explored and deepened. By studying the abstract organisation of phenomena and investigating the principles common to all complex entities. Their models that can be used for their description, systems theory, together with the complexity method, applies to the airport area.

Systems and Complexity Theories will always support the strategy adopted in this research, which is a free system that presents exchange relationships with the environment through a large number of facts. These are based on internal and external actions, which move an Airport System. At the same time, also guided by the theory of complexity, considering that an airport always has occasional input, both internal and external, which tend to lead to **chaos**, such as adverse weather conditions, flight delays, accidents and interdictions on runways and aprons, kidnappings and other factors. These must always have alternative procedures programmed so that **order** is maintained and SAFETY, a preponderant factor in aviation, is not affected. Thus, these two theories must always be considered throughout the research, especially for analysis and conclusions.

1.2.3.1 System Theory

The Systems Theory (ST) is a specific branch of the General Theory of Systems (GTS). This arose with the works developed by the German biologist Ludwig von Bertalanffy (Bertalanffy, 2008). Such a biologist, addressing the evolution of humanity, related to many financial, economic, social and political problems. He mentions that air traffic or even the automobile can no longer be seen only as some vehicles in operation, but forming systems that must be planned and organised. This statement highlights the need for a systemic approach and system specialists who can examine possible solutions and choose those promise to be optimal, with maximum efficiency and minimal cost, in a tremendously complex network of interactions. Thus, complicated techniques and computers are required today, which can solve problems that far exceed the capacity of individual mathematicians. New technologies are represented by computers (hardware and software), automation and cybernetics (Bertalanffy, 2008).

An airport system, as to its nature, can be considered an open system. According to Chiavenato (2003), a free system presents an exchange relations with the environment through many input and output. Transfer of matter and energy with the situation regularly. It is adaptive. That is, it continually needs to be readjusted to the environmental conditions. There is reciprocal play with the environment, and its structure is optimised when the set of elements of the system is organised through adaptive operations. Thus, adaptability is the continuous process of learning and self-organisation. It is predominant in modern times the concept that every organisation is characterised simultaneously by order and disorder. The rule is described to the extent that repetition, regularity, redundancy, and the ability to have self-regulation to preserve stability are brought together. Disorder, because it produces events, disturbances, noises and deviations that lead to processes of instability and change.

Jan Christian Smuts, a South African general, philosopher, and statesman, pioneered the application of systemic concepts to organisational life, coined the term *holistic* and worked with the idea of globality, both in the understanding of natural systems and in the knowledge of social and regulatory policies. It emphasises the existence of subsets within the systems, which can be called in systemic language as subsystems. A system does not exist alone in a vacuum; its performance is influenced by a set of factors within which it is "immersed" and which, on a large or small scale, can affect it (Castor, 2009).

When it happens to the air sector, planning, management, and even researching the industry, it should always bear in mind that it is a great system. Therefore it should be treated as such, with contingency plans prepared to deal with mutations in an environment that are highly influenced by factors of all kinds, such as adverse weather conditions; seasonality (mainly year-end and long-term holidays); technical problems in support equipment; and strikes or other issues related to human factors supporting the activity.

1.2.3.2 Complexity Theory

Whether it is science or philosophy, complexity theory in recent times has been the focus of research and discussion across diverse segments of the academic world: universities, pedagogues, philosophers, and various writers on the subject. In reference to complex organisations or the approach to complexity theory, the immediate propensity is to relate "complex" to "complicated".

According to some of the definitions in the Aurélio Dictionary, the term complex encompasses many elements or parts, observable in different aspects; that is confusing, complicated, intricate (Ferreira, 2005). However, understanding the complexity of a given subject does not mean recognising it as complicated.

In contextualising " complexity ", the French thinker and researcher on the subject, Edgard Morin, in contextualising "complexity", advocate the interconnection of all knowledge by considering that everything in the universe is interconnected. Thus, the study of theory can lead to an understanding of what and how: complicated systems can generate simple behaviour. The complexity is noticed when it is understood that the world is not separated into fragmented parts. All are connected and in cyclical and relational processes. The complexity of the contemporary world is demonstrated by the balance existing in the ecosystem generated by cells, organisms, and society, in short. From chaos, the stability necessary for survival and ordinary life arises (Morin, 1996).

The founder and former CEO of Visa, Dee Ward Hock, considers that the exterminations rates of life on earth have reached catastrophic proportions: every hour, species disappear from the face of the planet, virgin forests are devastated, millions of tons of arable soil are destroyed and, the most significant aggravating factor, thousands of children die of hunger (Hock, 1999). It shows that even with all scientific and technological evolution, the mechanical rationality of today's productive society is generating a tremendous collective catastrophe. Hock defends the fact that organisations are based on erroneous concepts of the seventeenth century, unsuited to the solution of the systemic problems related to social and environmental factors, of which we suffer daily.

As a visionary, he projects a future for organisations based on **"chaordic"** principles, a selfgoverning organisation that could harmoniously combine **chaos and order**, competition and cooperation. These principles are brought from experience acquired throughout his life, which was put into practice when he founded VISA International, an enterprise of the credit card sector considered to be one of the largest in the world. Due to business characteristics, which must transcend cultures and borders and different monetary systems.

And the worldwide success, according to him, is due to its "chaordic" structure, since the cards were owned by twenty-two thousand members banks, which at the time competed with each other for seven hundred and fifty million customers. At the same time, cooperating with everyone, honouring, mutually, the annual transactions of one trillion and two hundred and fifty billion dollars, overcoming borders and differences in monetary systems (Hock, 1999).

Around the 1960s, he began a surprising journey through the American banking network, seeking new organisation concepts. The result was put into practice when he built the VISA network, applying many of the paradigm shifts that the scientific community ratifies today through Theories of Complexity. In this way, he dared to transcend the Newtonian and Cartesian views that determined the functioning of society and its organisations during the industrial era. **Caord,** which has its origin in the junction of ca (of chaos) and ord (order), arose from the necessity of combining the essence of evolution and nature in a single word, which is considered the essence of organisations.

He thought of the adjective chaordic:

- The behaviour of any self-governing organism, organisation or system that harmoniously combines characteristics of order and chaos;
- Arranged so as not to be dominated by chaos or order; and
- Characteristic of fundamental organising principles of evolution and nature.

As the focal point of the research, an airport deals with performance improvements in the interactive process**:** aircraft/air traffic flow management/airports. In observing the three (chaordic) presupposed described above, it can be seen that the airport segment fits within the three. They are parts of the world of diversity and complexity and should be treated as such.

Therefore, as evident as it may seem, an airport cannot be seen within "normal" patterns of urban equipment. The constant challenge is always to command and make a "didactic chaos" like a systematic opportunity for continuous improvement.

1.2.4 Using a research Case Study

For Yin (2010), using a case study as a research method in various situations aims to bring individual, group, organisational, social, political, and related phenomena to the knowledge. The differentiated needs for case studies arises from the desire to understand complex social aspects, as it allows researchers to retain the holistic and meaningful characteristics of real-life events. A case study is preferred when:

a) The type of research question is in the "how" and "why" way;

b) When the investigator's control of events is significantly reduced; or

c) When the temporal focus is contained in contemporary phenomena within the context of real life.

Because the case study has different origins, it has also received many definitions. These definitions, however, are not mutually exclusive. Thus, Gil, Licht, and Oliva (2005) consider when research is defined as a case study, it can be said:

a) That the investigation is qualitative and uses different sources of evidence;

b) That analyses the property of a case or a phenomenon; and

c) Whose purpose is the knowledge of a broader universe of similar units for.

1.2.4.1 Multiple Case Study

According to Yin (2010), case studies can cover multiple cases. They can design a single set of cross-case solutions; he considers that in some areas, several case studies were considered a "methodology" different from single case studies. He presents the advantages and disadvantages concerning the single case study, pointing out that:

a) The shreds of evidence of the multiple case study are often found more vigorous, being then the study seen as more robust; and

b) As for a disadvantage, it is recognised that:

   - The multiple case study cannot be used for analyses that deal with critical, unusual, rare and revealing cases, typical of being studied as unique cases
   - The fact that it may require more resources and time than the single case

It also indicates, within the multiple case study, the use of the logic of case replication, citing that cases should be carefully selected so that they can:

- Predict similar results (a literal replication) or Produce conflicting results, but for predictable reasons (a theoretical replication).

1.2.5 Interviews and Surveys

Interviews will be conducted with aviation experts and specialists in the A-CDM process.

The written interview is structured in a sequence of topics that the interviewee should address. The answers will guide the theoretical framework and support the research. The research will be conducted through a structured questionnaire, and its results, together with the interviews, corroborate or refute the theoretical foundation. Aiming to contribute on how to run the questionnaire, the interviews answers will be analysed before their final elaboration. Thus, the interviews and the questionnaire will be one of the contributing parts for the analyses and conclusions.

Empirical reality exists only in human experience and appears in the way humans view truth. From the methodological point of view, the best way to grasp reality is to enable the researcher to put himself in the role of the other, seeing the world through the viewpoint of the respondents (Godoy, 1995).

1.2.6 SWOT Analysis

1.2.6.1 Background of the tool

According to Hofrichter (2017), the origin of the SWOT analysis technique can be attributed to Albert Humphrey. He conducted a research project at Stanford University in the 1960s and 1970s, using data from leading companies. The focus was to identify why corporate planning had failed. The resulting research identified many essential areas, and the tool used to explore each of the critical areas was initially called SOFT analysis. Humphrey and the original team of researchers used expressions defining that:

a) What is good in the present is Satisfactory, good in the future is an Opportunity;

b) Bad in the present can be a Failure, and bad in the future is a Threat.

1.2.6.2 Using the tool

The SWOT analysis tool is excellent for developing and understanding an organisation, or situation, or the decision making process of all types of business, at a corporate or personal level. It is a planning tool that helps you understand the Strengths, Weaknesses, Opportunities, and Threats involving a project or a company. SWOT analysis headers provide an excellent framework for reviewing a company's strategy, positioning, direction, product, project, or person (career). Conducting a SWOT analysis may be relatively straightforward; however, the strengths lie in its flexible and experienced application. Data collection represents only part of the picture. It means specifying the purpose of the company or project and identifying the internal and external factors that can support or hinder the achievement of that objective. SWOT is often used as part of a strategic planning process. SWOT is the acronym used for "Strengths, Weaknesses, Opportunities, Threats". There are several ways to represent this graphically in an array or grid of analysis (Hofrichter, 2017).

1.2.6.3 Tools application at work

As can be seen in Figure 1.9 and subsequent explanations (Hofrichter (2017), due to the eclectic nature of the SWOT tool. It can be of great value for application in the Air Sector, as a valuable aid for assessments, planning and general decision-making processes in stakeholder analysis involved in work within this critical segment.

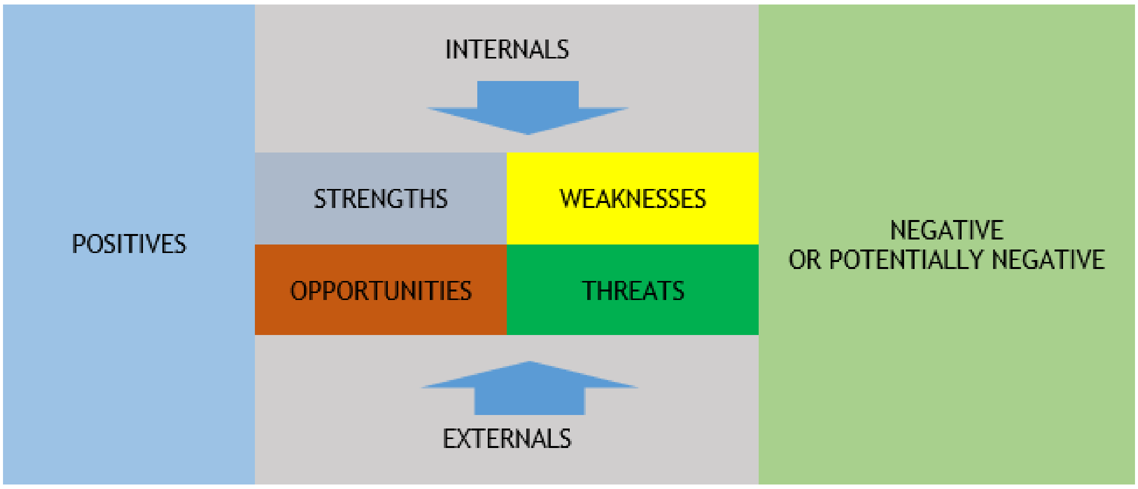

Figure 1.9 - SWOT Matrix
Source: Own elaboration based on Hofrichter (2017)

STRENGTHS: Tangible and intangible positive attributes internal to an organisation.

- *They are under the control of the organisation.*

WEAKNESSES: Factors under the organisation's control but which undermine its ability to reach the goal.

- *What organisation areas could be improved?*

OPPORTUNITIES: External attractive factors that are the reason an organisation exists and develops.

- *Which opportunities exist in the environment that can propel the organisation? Identify them by their "deadlines".*

THREATS: External factors beyond the control of an organisation that could jeopardise the organisation's mission or operation.

- *The organisation can benefit from contingency plans to address them as they occur.*

1.2.7 Technical operational methodology

ICAO presents an easily understood method among the methodologies recommended in the Global Air Navigation Plan: "Aviation System Blocks Upgrade" (ASBU). This methodology defines a flexible language with a programmatic approach to systems, which will serve as the necessary tool for all the diversity of contracting states.

In the next chapter 2, the ASBU concept will be detailed. In subsequent chapters, there is a deep understanding of one of the performance improvement areas that the States must implement: Airport Operations. Within this vital area, we will go deeper into one of the recommended modules, the A-CDM.

The Airport Collaborative Decision Making (A-CDM) is a process that, as the name implies, is about partners working together and making decisions based on more accurate and higher quality information, where each word has precisely the same meaning for each partner involved. The more efficient use of resources and improved event punctuality and predictability are the desired results. In the absence of A-CDM, operational decisions may be incorrect or not made. Partners may make conflicting decisions due to lack of information or the receipt of data that has different meanings for different partners (EUROCONTROL, 2017a).

1.3 Thesis organisational structure

The Thesis is structured as follows.

CHAPTER 1. **INTRODUCTION AND METHODOLOGY**: This first chapter contains a general presentation of the Thesis, the motivation and objectives. A historical summary of the International Civil Aviation Organisation (ICAO), which is the primary documentary support to the work. It also presents other institutions and associations in the airline industry that will provide technical/documentary support. In the sequence, the methodology used and the theoretical and scientific bases, finally, the organisational structure of the work.

CHAPTER 2. TECHNICAL INTRODUCTION: This chapter 2 introduces the fundamentals of the Thesis to the reader. It will situate the subject under the technical aspect from its necessary foundations, allowing the beginning of an understanding of the technical and operational elements themselves. It presents comprehensive insights on the Global Air Navigation Plan (GANP), Aviation System Block Upgrade (ASBU), Airport Operations Improvement based on Collaborative Airport Decision Making (A-CDM), which is the domain in which this Thesis is focused.

CHAPTER 3. DEEPENING INTO A-CDM: After presenting the basics of GANP, ASBU and an introduction to the A-CDM concept, chapter 3 will deepen the A-CDM idea in its areas of performance improvements and indicators. We are already giving some examples of implementation of the tool, with textualising recommendations from major entities representing the aviation area, such as the International Civil Aviation Organisation (ICAO), Civil Air Navigation Services Organisation (CANSO), International Airport Council (ACI) and the International Air Transport Association (IATA), also, bringing the "modus operandi" of two of the leading organisations dealing with the subject currently in their territories, EUROCONTROL and the Federal Aviation Administration (FAA).

CHAPTER 4. AIRPORTS CASE STUDIES: In chapters 4, 8 (eight), case studies of European airports, collected in the EUROCONTROL documentation, are presented. Airports where A-CDM has already been successfully implemented. In 2 (two) of them, in greater depth, and another 6 (six) airports with compact data. This analysis aims to know how many and what types of advantages occur after an A-CDM deployment. This study determines the desirability of improving the system or despising it.

CHAPTER 5. INTERVIEWS AND SURVEY: In chapter 5, structured interviews will be conducted with industry experts who will serve as the basis for the survey elaboration. Chapter 5 will present interviews and surveys with international experts in airports, air traffic control, and related industries from Europe and the Americas. In the first part, structured interviews will be carried out with specialists in the sector, which will serve as one of the beacons of the Analyses and Conclusions and support the construction of some parts of the survey presented in the second part of the chapter. The second part contains a survey sent to members of the Air Sector with multiple choice questions; this is for a wider audience, that is, not only for those who know A-CDM.

CHAPTER 6. ANALYSIS AND CONCLUSIONS: Chapter 6 deepens the study as a whole and present the resulting conclusions. According to the established sequence, Conclusive analyses will be carried out on the content of the Thesis, maintaining the analysis strategy on the three pillars: Documental Support, Practical Support (Case Studies) and Research Support (Interviews and Questionnaires).

CHAPTER 7. FINAL CONSIDERATIONS: In this FINAL chapter, a synthesis of the dissertation, lines of action, conclusive evidence, and the last considerations and perspectives of future research will be presented.

Figure 1.10 shows the Thesis's methodological (left column) and organizational (right column) structure. The preparation and consolidation of the INTRODUCTION lead to Chapters 1 and 2 of the Thesis. The stage of DEEPENING ON THEME THEORY feeds the INTRODUCTION to help in the theme contextualising eventually. A DEEPENING ON THEME THEORY naturally leads to Chapter 3 of the Thesis. The approach (preparation and development) to the CASE STUDY shows in Chapter 4. An essential part of the work is how Stakeholders should be chosen, approached, introduced to the theme and questioned about a sensitive subject of Airport Management.

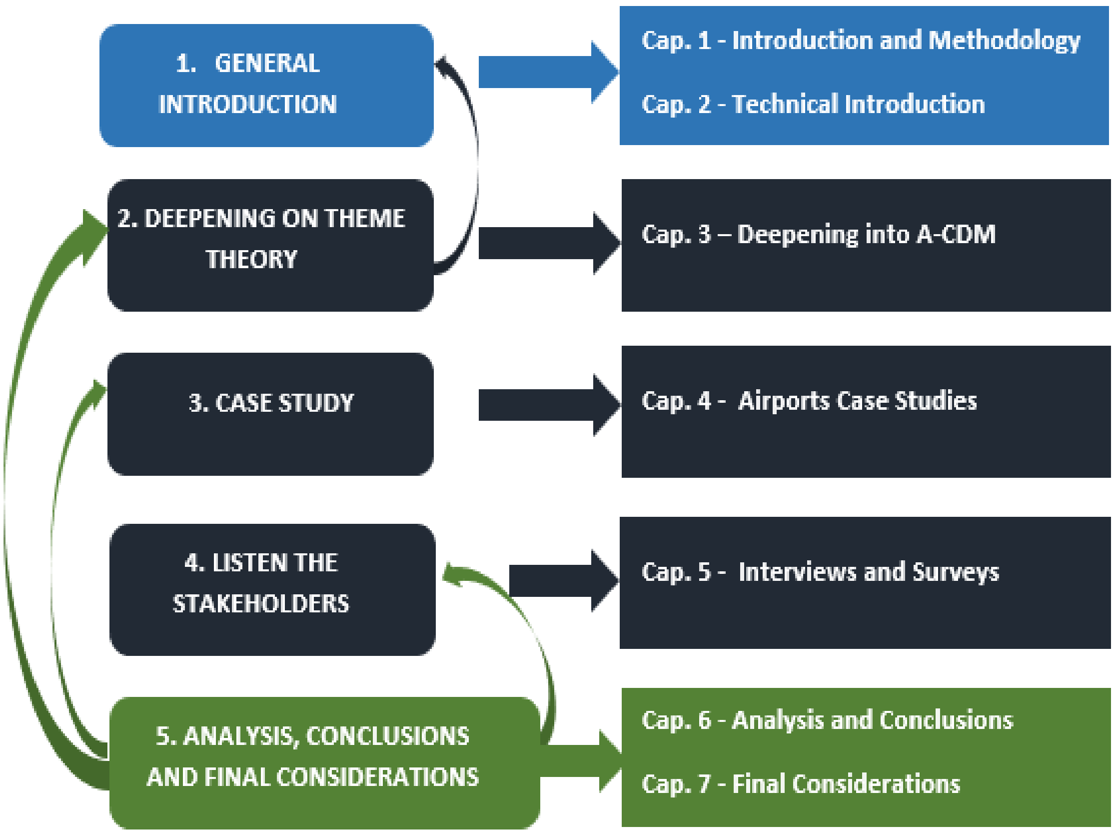

Figure 1.10 - Methodological and organisational structure
Source: Own elaboration based on the logical connection of chapters

Thus, the phase of LISTEN THE STAKEHOLDERS corresponds to Chapter 5 of the Thesis. FINAL ANALYSIS AND CONCLUSIONS lead to chapters 6 and 7 of the thesis. To give consistency to the development of the work, it was necessary to rethink the approach to some of the Stakeholders based on Conclusions that were not very consistent with what was expected.

Likewise, the FINAL ANALYSIS AND CONCLUSIONS phase allowed the feedback of the DEEPENING ON THEME THEORY and CASE STUDY phases, as it was necessary to adjust them from some of the conclusions obtained that were not very consistent with what was expected to.

So it can be said, in other words, that the structure of the Thesis, as a whole, is constructed and supported by three fundamental pillars like the above representation:

(I) **INTRODUCTION**

Chapter 1: Introduction and Methodology
Chapter 2: Technical Introduction

(II) **SUPPORT** (*for analysis, conclusions and final considerations*)

Chapter 3: Deepening into A-CDM
Chapter 4: Airport Case Studies
Chapter 5: Interviews and Survey

(III) **FINAL ANALYSIS, CONCLUSIONS AND CONSIDERATIONS**

Chapter 6: Analysis and Conclusions
Chapter 7: Final Considerations

With this sequence of subjects, this structure was strategically planned to allow the researcher and the readers a logical and sequential development to the research. The objective is to delimit, in the introductory part, the regulatory organisations that can bring theoretical contributions to the research.

The second part presents the deepening of the A-CDM theme from the technical-operational point of view of Central Agencies and regulatory bodies, as well as case studies and research in the form of interviews and structured questionnaires.

With all this support established, the final two chapters are intended for analysis, conclusions and final considerations.

Chapter 2. TECHNICAL INTRODUCTION

2.1 Introduction

2.1.1 General delimitation

This chapter introduces the fundamentals of this Thesis to the reader. As specified in the List of Publications, it is based on the article: The ASBU as facilitators for the implementation of the Future Air Navigation Systems, and its interfaces with airport operations and A-CDM [1](Netto, & Silva, 2018).

It presents general insights about the Global Air Navigation Plan (GANP), Aviation System Blocks Upgrade (ASBU), Airport Operations Improvement based on Airport Collaborative Decision Making (A-CDM) that is the domain under which this Thesis is focused.

2.1.2 Historical delimitation

Since the completion of the work of the Special Committee on Future Air Navigation Systems (FANS) in October 1993, the ICAO has made significant progress in the development of material necessary for the planning, implementation, and operation of the Communications, Navigation and Surveillance/Air Traffic Management (CNS/ATM). Since then, ICAO Document 9750, receiving scheduled and systematic implementation deadlines, has established a Global Air Navigation Plan from 2016 to 2030. From the main world civil aviation body, this document determines all procedures adopted regarding air traffic services by member countries [2](Netto, Baltazar & Silva, 2019).

To meet the requirements of this publication, the ICAO signatories have drawn up their respective strategic projects: the NextGen (USA), SESAR (Europe), CARATS (Japan), SIRIUS (Brazil), as well as others, such as in Canada, China, India, and the Russian Federation. The aviation routes are already and will be influenced entirely by these projects regarding air traffic and airport operations in the coming decades. Still, according to GANP, technology never stands still, so there is a need for a strategic path to achieve a globally harmonised system. There will be a workable solution for the twenty-first century by bringing together the states and stakeholders from all aviation sectors.

[1] Author's participation in the preparation of: Sections 2 (Literature Review) and 3 (A-CDM Operations).

[2] Author's participation in the preparation of: Sections 2 (Literature Review) and 3 (Unmanned Operations).

The Aviation System Blocks Upgrade (ASBU) methodology and its Modules define a language with a programmatic and flexible approach to systems. It allows all countries to advance their air navigation capabilities based on specific operational requirements. This methodology will enable all States and stakeholders to achieve harmonisation, capacity building and efficiency, which new air traffic growth requires, in all regions worldwide (ICAO, 2016).

According to DOC 9854 - Global Air Traffic Management Operational Concept, aerodromes will play a key role in the overall system performance. While the ATM system's challenge will be to ensure that all available capacity is utilised fully and efficiently, the main problem for aerodrome operators will be to provide the capability that is "full" enough to meet all demand (ICAO, 2005).

For achieving this goal, a fundamental process emerges as an essential tool, aiming to eliminate any impediment to the correct operation of Air Traffic Flow Management (ATFM), the Collaborative Decision Making (CDM). When used in the Aiport, such a method, particularly the ATFM Airport interaction, is called the Airport Collaborative Decision Making (A-CDM). All the operational parts involved in sharing relevant flight and other information with each other. This results in the more efficient treatment of ground processes at the airport and an improved flow of information (ICAO, 2014).

The Collaborative Decision Making (CDM) process, when associated with the Air Traffic Management (ATM), is an operational management tool that can be applied in tactical and pretactical planning scenarios. This function can also impact pretactical planning until one day before take-off, where actions can be taken, while considering the predicted impact on infrastructure and even changes in weather conditions (Fregnani, 2015).

The FAA and EUROCONTROL have established a protocol for cooperation, formalised through the State of Harmonisation document. NextGen and SESAR collaborate on demonstration activities to show the global public the interoperability of new or updated technologies and procedures and the performance gains that can be achieved. The scope of these demonstrations can cover all phases of flight (planning, surface, departure, enroute and arrivals), with joint tests mainly focusing on flights between North America and Europe. As part of this activity, the work consists of discussing joint projects, shared or in support of *joint* projects objectives, accelerating the development and/or implementation of *specific* technologies and operational procedures contributing to interoperability in support of the ICAO GANP and implementation of ASBUs (SESAR/FAA, 2018).

2.2 Literature Review

2.2.1 ASBU Methodology

According to the Global Air Navigation Plan (GANP) 2016-2030 (ICAO, 2016), the ASBU methodology is an approach that aims to facilitate and, thus, enable all member states to advance in all its Air Navigation resources based on each of their specific operational needs. This system of blocks will allow the sector to achieve global harmonization, increase capacity, and improve environmental efficiency. These improvements are requirements imposed by the growth of air traffic in all regions of the world. In light of these needs, ICAO has developed such a comprehensive system of block improvements. Firstly, to ensure that aviation safety and security are maintained enhanced, and ATM improvement programs can be sufficient to be harmonised and not put any barrier to future aviation efficiency. And add it to environmental gains and a reasonable cost of implementation (Figure 2.1).

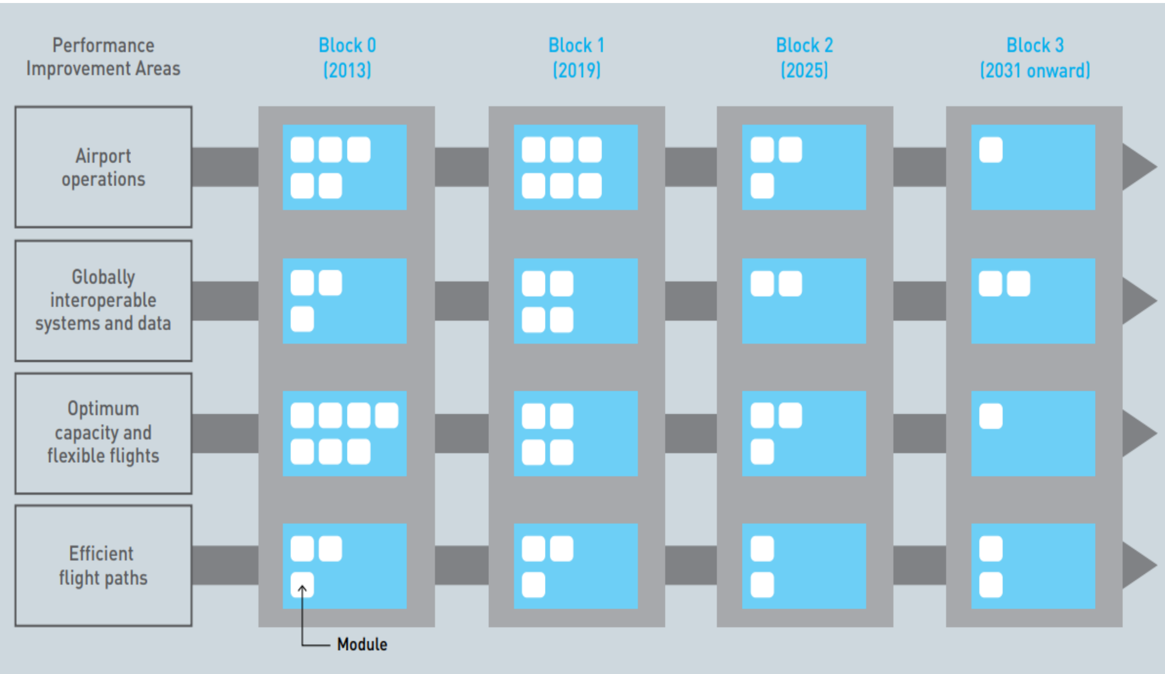

Figure 2.1 - The ASBU standard
Source: ICAO, 2016

These ASBUs incorporate a long-term perspective, as recommended in the ICAO air navigation planning documents:

a) Global Air Traffic Management Operational Concept (Doc 9854);

b) Manual on Air Traffic Management System Requirements (Doc 9882); and

c) Manual on Global Performance of the Air Navigation System (Doc 9883).

The documents (ICAO, 2016) establish clear operational objectives based on aircraft and ground services along with the avionics, data link and ATM systems requirements to achieve them. The overall strategy provides industry transparency and essential safety for operators, equipment manufacturers and Air Navigation System Providers (ANSP).

ASBUs are not comprehensive, just as they are not a global system. Yet, flexible modules remain that can be used by signatory States according to the specificity of their individual operational needs. One of the characteristics of ASBUs is that they define the technologies and procedures that are calculated to improve operational performance, especially when a need comes for an operational problem to be solved. The ultimate goal is to achieve global harmonisation and interoperability of air navigation (Abeyratne, 2014).

The primary (essential) foundation of the concept is linked to four specific issues and interrelated areas of performance improvement:

a) Airport operations;

b) Interoperable systems and data at the global level (Fig. 2.3);

c) Optimum capacity and flexible flights; and

d) Efficient flight paths.

These four (4) performance improvement areas (Figure 2.1) and the so-called ASBU modules associated with each were organised into a series of four blocks (Block 0, 1, 2 and 3) based on timelines for the variable which contain, as illustrated in Figure 2.2., where they are represented only by Blocks 0 and 1. The characteristics inherent to Blocks 0 and 1 will be presented in subsection 2.2.2 (Tables 2.1 and 2.2). They refer to availability schedules for a group of operational improvements.

The ASBU framework is an approach used by ICAO systems engineering to achieve interoperability and harmonisation of global Air Traffic Management (ATM). ASBUs is the product of inclusive and extended collaboration between ICAO, ANSPs, member states and industry stakeholders worldwide. Upgrades present target implementation deadlines for sets of operational improvements referred to as modules. A single module defines an available resource (operational improvement), its necessary technologies and procedures. Each block update was organised into a set of unique modules linked to one of the four Performance Improvements Aviation areas (PIAs) (CANSO, 2013).

The technology and the procedures for each Block were organised into some Single Modules based on their respective Performance Improvement Areas. Not all states will need to implement each Module. In systems engineering developed by the ICAO team for its Member States, they only need to consider and adopt the appropriate Modules to their operational needs. Within ICAO, ICAO will be working with its Member States to support and guide, to determine -precisely according to their operational requirements and which capacities they should have in each of their systems (ICAO, 2016).

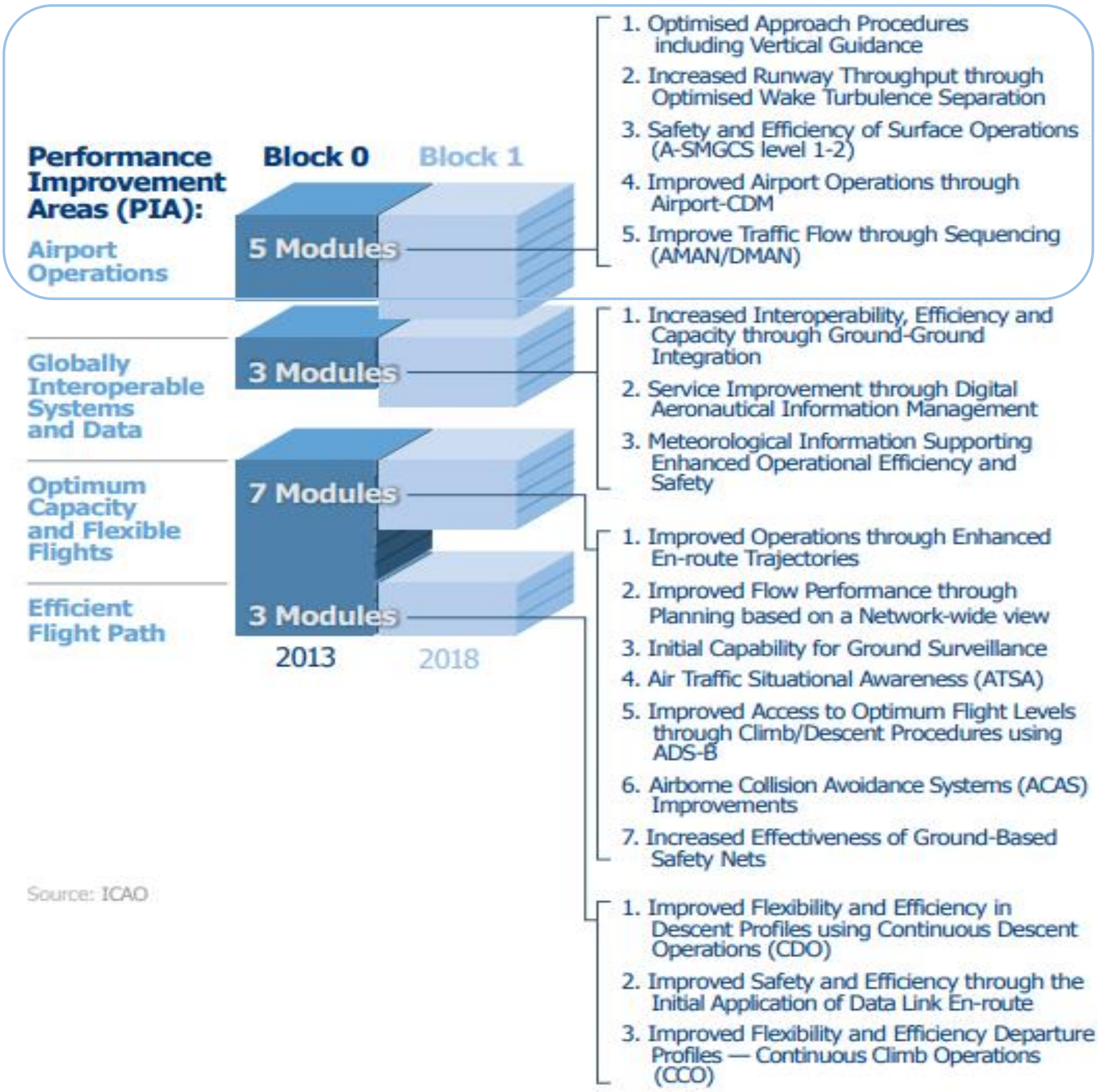

Figure 2.2 - BLOCK 0 - MODULES
Source: Introduction to the aviation system block upgrade (ASBU) modules:
Strategic planning for ASBU modules implementation (CANSO, 2013).

One of the most specific and valuable features of the ASBU strategy is flexibility. It allows the various member states to evaluate different modules to implement the selected ones, each according to their specific operational requirements. Not all modules will be needed in all parts of the world. The implementation is based on several factors, including needs, resources, and level of readiness (Abeyratne, 2014).

Another critical point to emphasise about using ASBUs is that while the improvement of operations involves many challenging actions, like Interoperable systems (Fig. 2.3), the process can be much less costly than technological solutions. In the case of the ASBU, improved operations represent a win for the industry, a quest for corporate responsibility and a victory for the environment. The result is an actual example of finding a balance between these two goals, often opposed. The ASBU is a work in progress and will need to be carefully monitored for successful implementation and to verify how the methodology can facilitate compliance with sustainability goals and be compatible with economic growth. It should probably be consolidated as a "learning by doing" process, depending on the flexibility embedded in policy implementation (Lutte & Bartle, 2017).

Figure 2.3 - Interoperable systems
Source: EUROCONTROL, 2019b

2.2.2 Airport Operations

As can be seen on the previous page, in Figure 2.2 (CANSO 2013), the "Performance Improvement Area" in Airport Operations is composed of 05 (five) modules in BLOCK 0 (the period from 2013 to 2018). BLOCK 0 (2013 to 2018) is the most important, and we are using it as an example and reference as it is the starting point of all the process that has been refined successively to each block, 2019 to 2024 (BLOCK 1 – Table 2.2) and so on. The latest updates from GANP and ASBU are the result of the Thirteenth Air Navigation Conference, held in Montréal, Canada, from 9th to 19th of October 2018. These updates are part of the activity carried out by the committees that integrate these conferences. Thus, some changes and refinements in the BLOCKS processes may be implemented in upcoming conferences, mainly for the future. (BLOCKS 2 and 3) (Annexe 1).

Table 2.1 shows the last actualization in ASBU procedures. Relative to actions recommended being applied in a BLOCK 0 phase (2013), according to the previous actualization in GANP (ICAO, 2019).

Table 2.1 - Recommended actions for MODULES A-CDM included in Block 0
Source: Own elaboration based on ICAO (2019b)

Block 0 (B0) – A-CDM MODULES	
A-CDM B0	**A-CDM-B0/1 Airport CDM Information Sharing (ACIS)**
	○ **Main Purpose:** To generate everyday situational awareness, which will foster improved decision making within aerodromes, by sharing relevant surface operations data among the local stakeholders involved in aerodrome operations. ○ **New Capabilities:** Stakeholders will be able to collaborate and take actions towards the achievement of a set of defined milestones by being aware of the status of a specific flight measured against known target times and milestones. ○ **Description:** This element represents the first collaboration step among stakeholders involved in aerodrome operations. It consists of the definition of common specific milestones for several flight events taking place during surface operations. The stakeholders involved have to, based on accurate operational data, achieve the agreed milestones.
	A-CDM-B0/2 Integration with ATM Network function
	○ **Main Purpose:** Airport CDM operations will be enriched by enhanced arrival information from the ATM network and, at the same time, network operations will benefit from more accurate departure information from CDM airports. ○ **New Capabilities**: To connect airport operations to the ATM network. ○ **Description:** This element consists of feeding arrival information from the network into A-CDM and, at the same time, coordinate specific departure milestones. The involved stakeholders have to, based on accurate operational data, achieve the agreed milestones.

Table 2.2 shows the last actualization in ASBU procedures, relative to actions recommended to be applied in a BLOCK 1 phase (2019 to 2024), according to the last actualisation in GANP (ICAO, 2019).

Table 2.2 - Recommended actions for MODULES A-CDM included in Block 1
Source: Own elaboration based on ICAO (2019b)

<table>
<tr><th colspan="2">Block 1 (B1) – A-CDM MODULES</th></tr>
<tr><td rowspan="4">A-CDM B1</td><td>A-CDM-B1/1 Airport Operations Plan (AOP)</td></tr>
<tr><td>○ Main Purpose: To enhance the planning and management of airport operations and allow their full integration in the ATM network and enhance collaboration between airport stakeholders.
○ New Capabilities: Airport stakeholders will be able to better communicate and coordinate among themselves to develop and maintain dynamically joint plans and execute those in their respective areas of responsibility.
○ Description: This element consists of a collaborative airport operations plan (AOP) that encompasses “local” airport information and shared information with the ATM network to develop a synchronized view for the integration of local airport operations and aircraft operations into the overall ATM network. The AOP includes an airport performance framework and steers with specific performance indicators and targets aligned with the regional/national performance frameworks, building upon A-CDM. Information on resources and aircraft operation plans is available to the different operational units at the airport and elsewhere in ATM. The AOP may be managed and monitored by the Airport Operations Centre (APOC).</td></tr>
<tr><td>A-CDM-B1/2 Airport Operations Centre (APOC)</td></tr>
<tr><td>○ Main Purpose: The integration of all stakeholders, both landside and airside, into a coherent decision making entity/process (and team), using the shared information and capabilities provided through the AOP.
○ New Capabilities: Airport stakeholders will be able to better communicate and coordinate among themselves to develop and maintain dynamically joint plans and execute those in their respective area of responsibility.
○ Description: The APOC is an additional but essential means by which the efficiency of the overall airport operations will be further enhanced. This will be achieved by bringing all stakeholders together in a physical facility, using the shared information and capabilities of the AOP (ensuring thereby a coherent overall airport performance monitoring), decision making and steering process, addressing all phases of operations.</td></tr>
</table>

Table 2.3 shows the last update in ASBU procedures relative to actions recommended to be applied in a BLOCK 2 phase (2025 to 2030), according to the last update in GANP (ICAO, 2019).

Table 2.3 - Recommended actions for MODULES A-CDM included in Block 2
Source: Own elaboration based on ICAO (2019b)

Block 2 (B2) – A-CDM MODULES	
A-CDM B2	**A-CDM-B2/1 Total Airport Management (TAM)**
	○ **Main Purpose:** Total Airport Management (TAM) is an approach that takes a holistic view of airport performance management, integrating all stakeholders, including the ATM network, local ATM, passenger terminal operations, service providers, passenger and baggage management and ground transportation. All stakeholders are integrated into a coherent planning and collaborative decision making process using shared information and capabilities. ○ **New Capabilities:** TAM is an enhancement of the APOC with the integration of the landside management aspects to support further improvement of the efficiency of the overall airport operation, including passenger management. This will be achieved using the shared information and capabilities of the AOP, APOC and landside management, thereby ensuring a coherent overall airport performance monitoring, decision making and steering process, addressing all phases of operations (strategic planning, through operation to post operations). All essential airport processes from passenger check-in to aircraft turn-round work collaboratively with the common goal of ensuring that each departure meets its agreed 4D-trajectory. The airport is considered as one node of the overall air transport network. In order to ensure an overall Quality of Service (QoS) of an airport to the customers and the air transport network, the integrated APOC concentrates on the initial strategic and pre-tactical planning phases using the most accurate information available, followed by the monitoring (and when required, reactive planning) of the tactical working process. ○ **Description:** TAM will bring stakeholders together as a physical entity (team), enabling them to better communicate and coordinate, to develop and dynamically maintain joint plans which are executed in their respective areas of responsibility at an airport. Its main information source will be the Airport Operations Plan with the level of predictability allowed by Trajectory-Based Operations (TBO) as well as Landside Management including Passenger management, which integrates information from the appropriate process monitors, collating it into consistent, timely and reliable knowledge for the airport's various operational units, in particular the APOC. TAM will be equipped with a real-time monitoring system, a decision support system and will apply a set of collaborative procedures that build upon the capabilities of the APOC. This will ensure that the management of landside and airside airport processes will be fully integrated.

Table 2.4 shows the last update in ASBU procedures relative to actions recommended to be applied in a BLOCK 3 phase (2031 onward), according to the last update in GANP (ICAO, 2019).

Table 2.4 – Recommended actions for MODULES A-CDM included in Block 3
Source: Own elaboration based on ICAO (2019b)

Block 3 (B3) – A-CDM MODULES	
A-CDM B3	**A-CDM-B3/1 Full integration of A-CDM and TAM in TBO**
	○ **Main Purpose:** To use the integration of A-CDM in the overall synchronisation of the ATM network, to contribute to ento-end stable, consistent and robust trajectory-based operations providing an adequate level of performance. ○ **New Capabilities:** A-CDM is fully synchronised with TBO. ○ **Description:** All stakeholders are fully connected. All tactical decisions are fully synchronized and operations are fully trajectory-based. Aerodrome operations are considering the en-route to enroute view with the turn-round process, agree on, and subsequently manage the flights on the surface, to deliver expected surface event times with known impacts to the ATM system, and to ensure that the agreed trajectory is consistent with the Airport Operations Plan. A-CDM is contributing to the networkbased, efficiently-converging coordination process as a subcomponent of the overall ATM network synchronisation process.

2.2.3 The adoption of the CDM and A-CDM improving air traffic flow

2.2.3.1 Collaborative Decision Making (CDM)

According to the ICAO documentation "Manual on Collaborative Air Traffic", the collaborative decision-making process (CDM) defines a method focused on how to decide on an articulated course of action between two or more members of the community (ICAO, 2018). An overview of ICAO will be further detailed in Chapter 3.

Whenever people involved in any decision-making process, they need to choose between alternative actions, like the stakeholders involved in collaborative decision-making processes. They should keep in mind that the alternatives that support the presented information are often inadequate to defend or explain such recommended actions. Thus, the priority in decision making is to establish the identification of decision-makers and stakeholders in the process; this action may reduce a possible disagreement about the definition, requirements, objectives, and criteria of the problem (Baker et al., 2001).

2.2.3.2 Airport Collaborative Decision Making (A-CDM)

Collaborative decision making at airports (A-CDM) is a process that provides a complete response to the problem of congested airports. In recent years, it has become an essential element process supported by the Civil Air Navigation Organisation (CANSO), the International Civil Aviation Organisation (ICAO), the International Airport Council (ACI) and the International Air Transport Association (IATA).

There are current documents related to the A-CDM and associated standards, which integrate the Operational Concepts (CONOPS), associated with GANP, of each member state. Each developed a vision according to their specific needs and context. The A-CDM is a change of mindset and working methods involving key stakeholders at an airport. This includes, at a minimum, ANSP, the airport operator, land and air carriers. The goal is to improve the performance of airport operations and provide better overall predictability by allowing stakeholders to work together as a team for mutual benefit. This process is based on transparency and Information Sharing among critical stakeholders, starting with establishing collaborative work methods and practices (CANSO, 2016).

2.3 Conclusions

The ASBU framework represents today a new approach to the modernisation of air navigation around the world. To increase safety, address sustainability and become a globally interoperable system, further operational improvements will result in new roles and essential responsibilities placed on aviation professionals (Lutte, 2015).

The knowledge of the fundamentals that will guide aviation in the coming years in the Global Air Navigation Plan is vital for those working in the Air Sector, mainly for the occupants of management positions in the air traffic services and airport sectors. The operational areas of airlines must also have this knowledge to interact operationally with air traffic control bodies and airports.

Thus, to achieve the objectives set in processes of performance improvements, such as in Airport Operations. This theoretical basis is essential and understanding the importance, diversity, and flexibility of applying the ASBU in signatory countries. It is also necessary to have an overview of how to use this end of operational line process and the use of one of the recommended modules, such as the well known internationally available A-CDM process (Figure 2.4).

Figure 2.4 - Elements to get the A-CDM implementation process in motion
Source: Airport Collaborative Decision making - Optimisation Through Collaboration (CANSO, 2016)

Chapter 3. DEEPENING INTO A-CDM

3.1 Introduction

3.1.1 General delimitation

This chapter introduces the fundamentals of this Thesis to the reader. It is based on the articles: A-CDM description and operational implementation challenges [1](Netto, O.D., Baltazar, M. E. & Silva, J., 2019); The Airport A-CDM operational implementation: description and challenges [2](Netto, O.D., Silva, J., & Baltazar, M. E., 2020).

After getting to know the bases of GANP, ASBU and an introduction to the A-CDM concept, this chapter will deepen the A-CDM idea in its areas of start operations. It presents the basic concepts from major entities representing the aviation area, such as ICAO, CANSO, ACI, and the IATA, bringing the "modus operandi" of two leading organisations dealing with the subject currently in their territories, EUROCONTROL and FAA.

The A-CDM process is a typical example of the reality of Systems Theories and Complexity. According to Chiavenato (2003), an airport system, by its nature, can be considered an open system and a free system that presents exchange relationships with the environment through different input and output. A living system with constant tendencies to disorganize and become chaotic is complex, and the theory of chaos and order applies to it. Because even with all the external factors that tend to disorganise it, such as meteorological influences, accidents, terrorist threats in lounges and aircraft, various stoppages by stakeholders. It must always maintain organizational standards in the face of chaos (chaord) and, above all, it must never deviate from safety standards, a primary assumption of the Air Sector. According to Hock (1999), organisations could harmoniously combine chaos and order (subchapter 1.2.3).

3.1.2 Historical delimitation

Among the areas of performance improvement advocated by ICAO in GANP, to be implemented in the coming decades, and to integrate the projects of each signatory country, Airport Operations and Airport Collaborative Decision Making (A-CDM), appear as items of significant importance for Air Traffic Flow Management (ATFM).

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[1] [2] Author's participation in Sections 2 (Literature Review) and 3 (A-CDM Operational Implementations and Characteristics) elaboration's.

All decision making in this type of activity always seeks safety and efficiency; however, the effects of these decisions based on the individualistic behaviour of each air traffic control agency or airport may have some kind of impact on the effectiveness of other entities. Thus, the A-CDM concept began more than a decade ago in Europe and its counterpart. Surface-CDM (S-CDM) in the US established a new way to optimise aircraft operations at airports through more efficient collaboration between all stakeholders. This new approach is now a well documented concept with solid support and accepted worldwide for concrete results at various airports based on transparency and information sharing.

According to Steiner, Stimac, and Melvan (2014), in the current ATM concept, when traffic demand exceeds available capacity at an enroute airport or control centre, aircraft are retained at the airport, causing a lot of delays and ATFM slot troubles. A-CDM is predicted like an innovative concept of proactive decision making in the air traffic system. Its aims are to replace the current centralised air traffic management system with collaborative decision-making regarding the airport's airside operations. Establishing such a system is necessary to connect all stakeholders involved in the air transport and provide timely information to all users. The main stakeholders in this system are the ATC, Airports and Airlines (Figure 3.1).

Figure 3.1 - A-CDM bases
Source: EUROCONTROL, 2019b

Rajapaksha and Jayasuriya (2020) highlight the A-CDM process as one of the components of an Intelligent airport. They claim that the concept of smart airports is the best solution for optimal use of limited airport resources, including terminal, air side and earth side. Smart airports can introduce real-time data systems to predict peak hours at the terminal and propose the best resource allocation arrangements. Additionally, labour allocation can effectively manage and reduce staff involvement in automated passenger processes. Robot technology, custom mobile phone directives, intelligent information dashboards, and A-CDM systems can optimise limited available resources.

This chapter seeks to describe and highlight the main characteristics and points that involve the operationalisation of an A-CDM, bringing the vision of the system's main implanters today, such as Europe and the USA, representatives of associations of the air sector such as CANSO and IATA, and academics. Besides, it considers the contribution that the academy has given in the field of decision support and collaborative decision-making by using studies by Baker et al. (2001), as well as the work of Baltazar and Silva (2018), which show us how to measure the effectiveness of the operational and decisionmaking processes. In practice, the results of this study can clarify and mark actions to academic members, mainly the involved in transports research that doesn't know the subject, and members of the Air Sector as the primary theoretical basis for those who should start work with ASBU and A-CDM.

The decision analysis process is a systematic procedure that makes it possible to transform a problematic situation into an action plan through a sequence of steps. For him, the centre of this process is composed of three dimensions: 1. The definition of the alternatives that the decision-maker has; 2. The critical data and information for analysing the alternatives; and 3. The preferences that the decision-maker has. Regarding the alternatives, if they are not easily perceived, a meeting can be held with people related to the problem to bring out strategies to support the decision [1](Arantes, Baltazar, Netto & Silva, 2021).

3.2 Literature Review

3.2.1 CDM - Collaborative Decision Making concept

The A-CDM concept is based on a general idea about collaborative actions, called Collaborative Decision Making (CDM). From this concept, the ICAO starts to apply it in aviation.

[1] Author's participation in Sector 2.1: The airport concession in Brazil

3.2.1.1 CDM - ICAO overview

According to ICAO documentation (DOC 9971) dealing with the subject (ICAO, 2018), Collaborative Decision Making (CDM) defines a process focused on the decision making process on a course of action articulated between two or more members of the community. Through this process, all members of the ATM community share information related to that decision, interact, establish their daily choices and then apply the decision making approach and principles.

The overall objective of all the processes is to improve the performance of the ATM system and balancing the needs of members of the ATM community. It defines the following CDM as a process applied to support other activities, such as the balance of demand and capacity. CDM can be well used in the timeline of events, from strategic planning (for example, investments in infrastructure) to operations in real-time.

CDM is not a simple objective but a way to achieve the performance objectives of the processes it will support. These performance objectives must be agreed upon collaboratively. Since the implementation of CDM is likely to require investment, they will need to be justified according to the performance-based approach and:

- Although Information Sharing is an essential facilitator for CDM, simple Information Sharing is not sufficient to fully achieve CDM objectives;
- The CDM also requires predefined and agreed-upon procedures and rules to ensure that collaborative decisions are made quickly and equitably.

Finally, the correct use of the CDM ensures that decisions are made transparently based on the best available information provided by the participants, which must be carried out in a timely and accurate manner (ICAO, 2018).

3.2.2 A-CDM – Airport Collaborative Decision Making concept

The CDM establishes a basis for building an airport operational communication protocol to show the performance of operations to partners; it allows the use of data across airspace, airport and ground operations, both in real-time operations, but also as a post-analysis tool to review the performance of operations, as well as to propose or monitor control actions. Increasing the view of the operational situation and performance as a whole by analysing this data information, not just at the airport but among aviation partners, is crucial (Zuniga & Boosten, 2020).

According to CANSO (2016), A-CDM is a change of mindset and working methods to improve the performance of airport operations and provide better overall predictability, allowing the stakeholders to work together as a team for mutual benefit. The process is based on transparency and sharing of information among key stakeholders, starting with establishing collaborative work methods and practices. It is a process that provides a positive response to the problem of congested airports. It is supported by the ICAO, CANSO, ACI, and IATA. Today, manuals dealing with Future Air Navigation Systems (FANS) such as the Single European Sky Air Traffic Management Program (SESAR), the USA's Next Generation Air Transportation System (NextGen) and Japan's Collaborative Actions for Renovation of Air Traffic Systems (CARATS), already incorporate several variants of A-CDM. Each of these organisations and projects has developed a vision according to their specific needs and context.

The A-CDM approach, which involves ATC and Airports, is one of the fundamentals that will guide aviation in the coming years contained in the GANP. They are vital for those in the Air Sector, especially who hold management positions in the air traffic services, airports and operational areas of airlines, to interact operationally with the air traffic control organs and areas of airport operations. Thus, to achieve the objectives set in performance improvements, such as in Airport Operations. This theoretical basis is essential and the understanding of the importance, diversity, and flexibility of its application (Netto & Silva, 2018).

According to Steiner, Stimac and Melvan (2014), the implementation of Airport-CDM involves a change in procedures and a cultural shift in all the interested parties involved. They further state that the system is based on two main elements:

a) Predictability of events - would result in the optimisation of each process related to aircraft and airport operations; and

b) On-time performance of operations - which would influence the increase in capacity of the airport and ATC on one side and, more directly, the efficiency of airlines and the use of aircraft on the other.

CDM at congested airports has demonstrated that the air transportation agents could gain considerable improvements at the coordinated airports without sacrificing internal objectives and the means for different operators to achieve them. The goals of A-CDM are to reduce delays and improve system predictability while optimising the utilisation of resources and reducing environmental impact. When the following concept elements are applied, an airport is considered a CDM airport (Marzuoli, Laplace & Féron, 2013): A-CDM

Information Sharing (ACIS); CDM Turn-Round Process (CTRP); and Variable Taxi Time Calculation (VTTC).

In addition to improving the ATFM service, Lozano C. F. (2020) considers that the following objectives of the A-CDM familiar to all users are:

a) Improve air traffic forecasting;

b) Improve performance in real-time;

c) Reduce the cost related to ground movements by aircraft;

d) Optimize the resources of handling operators;

e) Optimize the use of airport infrastructure and reduce congestion;

f) Optimize the use of stands, boarding gates and airport terminals;

g) Reduce ATFM slot losses;

h) Get a flexible take-off plan;

i) Reduce congestion on taxiways and on the platform.

3.2.3 A-CDM - The ICAO Normative Measures

According to ICAO (2018), collaborative decision making at the airport (A-CDM) is a set of processes developed from the philosophy of collaborative decision making in aviation and is applied to operations at airports. The A-CDM allows airport and aircraft operators, air traffic controllers, ground handling agents, pilots, and traffic flow managers to exchange operational information and work together to manage airports. A-CDM can also improve the planning and management of en-route operations. A-CDM defines the rules and procedures used by aerodrome participants to share information and collaborate. These, in turn, help optimise the use of all aerodrome resources, reduce arrival and departure delays, and improve predictability during regular and irregular operations. A-CDM enables all stakeholders to streamline their operations and decisions collaboratively, considering their preferences, known constraints, and the predicted situation. The decision-making process is facilitated by sharing accurate and timely operational information through a standard set of tools and applying agreed procedures. Therefore, the primary objective of the A-CDM is to generate a shared situational awareness that will foster better decision making. A-CDM, however, does not dilute or eliminate the responsibilities associated with decisions. Decisions are still made, and A-CDM partners remain accountable for their actions. They are, however, taken collaboratively and, as a result, are better understood and applied.

The Manual mentioned above (ICAO, 2018) still presents the difference between the implementation of Block 0 (as initially described in Chapter 2, Section 2.2, of this Thesis) and Block 1, as recommended in the ICAO documentation:

- The first block (Block 0) belonging to A-CDM is entitled Enhanced Airport Operations through Airport-CDM. This module is defined to implement collaborative applications that will allow the sharing of surface and operation data between different stakeholders at the airport. This will improve surface traffic management, reducing delays in the areas of movement and manoeuvring and thus increasing safety, efficiency, and situational awareness. The module is applicable locally for an already established airport surface infrastructure;
- Block 1, an evolution concerning the previous Block 0, is called Optimized Airport Operations through Total Management of Airport A-CDM. This module is designed to improve the planning and management of airport operations and allow its full integration with ATM using performance targets compatible with those of the surrounding airspace. This implies the implementation of a collaborative airport with operations planning and, when necessary, an airport operations centre (APOC). The module is applicable for airport planning and used at all airports (the sophistication will depend on the complexity of the operations and their impact on the network).

From what has been said in the referred ICAO documentation, we can briefly conclude that for that Organisation, transparency and Information Sharing serve as the basis for the A-CDM. Information Sharing is the element that unites stakeholders in their objective to coordinate and efficiently manage operations. Such sharing supports the involvement of actors and stakeholders. However, achieving good Information Sharing can vary from a simple A-CDM dialogue system to a more advanced information-sharing platform. These procedures will depend on the technical possibilities of the airport and its stakeholders.

The latest edition of the GANP (ICAO, 2019) includes in its sixth edition a new process recommended by the Organisation, the so-called System Performance Assessment (SPA). Through the so-called Six-steps Method (Annexe 2), such a tool makes it possible to identify where operational improvement proposals, in this case, A-CDM, should be applied cost-effectively.

The appropriate way to utilise the GANP is to apply a performance-based approach. A performance-based approach is results-oriented, helping decision-makers set priorities and determine appropriate trade-offs that support optimum resource allocation while maintaining an acceptable level of safety performance and promoting transparency and accountability among stakeholders (ICAO, 2019).

Although several ways to apply a performance-based approach, ICAO advocates for a globally harmonised performance management process based on six well-defined steps. This Six-steps cyclical method has as its ultimate goal to identify optimal solutions based on operational requirements and performance needs so that the expectations of the aviation community can be met, improving the performance of the air navigation system and optimising the allocation and use of the available resources. This process can be applied at global, regional and local levels, with different levels of detail. States and Regions should use, in collaboration with all the members of the aviation community, this performance management process as the basis to develop national and regional air navigation plans adapted to their specific operational requirements and performance needs. AN-SPA (Air Navigation System Performance Assessment) is an automated tool to guide the user on applying the Six-steps method at a local level (ICAO, 2019).

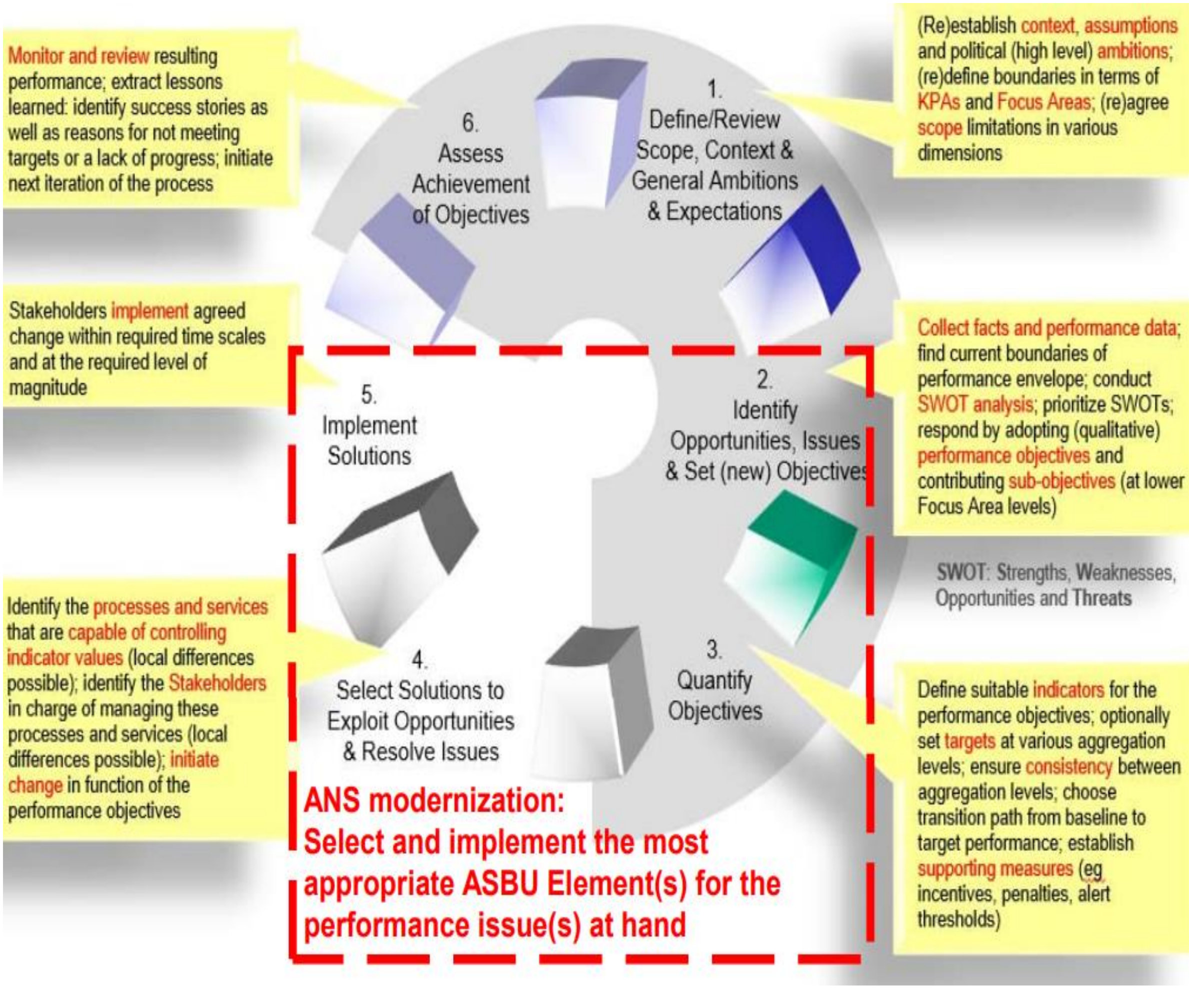


Figure 3.2 - The Six-steps to ANS modernization
Source: Tutorial Six-steps method (ICAO, 2019)

As specified in Figure 3.2, the ICAO Six-steps method for this decision support process works as follows:

a) Steps 1 and 2 are used to get to know our system, its strengths, weaknesses, opportunities and threats, and also how it is running to set goals;
b) The catalogue of performance objectives that is part of the GANP global performance framework facilitates the definition of Goals;
c) Based on these objectives, goals can be defined in steps 3 and 4 as possible solutions identified to achieve the objectives, addressing the weaknesses and threats of the system. After a set of possible solutions has been identified, a cost-benefit analysis, environmental impact assessment, safety assessment and human factor evaluation should be carried out to determine the ideal solution;
d) In the GANP performance structure, a list of KPIs, linked to the relevant objectives in the catalogue of performance objectives, is provided to set goals by quantifying objectives;
e) A list of possible solutions to be considered as part of step 4 is the ASBU structure, with its functional description of the operating system and its associated improvements and performance benefits;
f) Step 5 manages a coordinated implementation of the solution agreed upon by all stakeholders, based on the previous steps; and
g) Finally, step 6 consists of monitoring and reviewing the system's performance after the complete deployment of the system solution.

3.2.4 A-CDM - The IATA Overview

According to IATA (2018), A-CDM is designed to improve airport and network efficiency through improved turn-round processes, harmonising sequencing, surface and departure management.

IATA supports common objectives and performance metrics between all A-CDM stakeholders, based on mutually agreed targets:

a) Airport Operations:

- Increased Departures and Arrivals punctuality and airport slot adherence
- Efficient use of infrastructure, e.g. stands and gates

- Accelerated operational recovery in adverse conditions or other disruptions
- Reduced environmental impact, e.g. emissions and noise

b) Aircraft Operators:

- Daily programs of flight operations and turn-round times on a schedule
- Possible schedule disruptions predicted early, thus managed efficiently
- Preferences and priorities are taken into account
- Reduce taxi fuel burn

c) Ground Handling:

- Enhanced punctuality of operations
- Maintenance of Service Level Agreements
- Optimised resource management

d) Air Traffic Services:

- Flexible pre-departure planning
- Reduced apron and taxiway congestion
- Smooth flow of traffic reducing air traffic controllers' workload

e) Air Traffic Flow Management:

- Increased predictability
- Enhanced Calculated Take-Off Time (CTOT) compliance
- Optimum utilisation of available capacity reducing sector (airspace divisions)
- Improved demand and capacity balancing

3.2.5 A-CDM - The EUROCONTROL/SESAR Overview

Europe's civil air transport industry will face more challenging performance levels when the Single European Sky (SES) II performance scheme, currently set by the European Commission, was introduced in 2013. Notably, the safety, efficiency, and environmental targets apply to operations on the ground and in the air, with airports considered an integral part of the system. Eurocontrol first recognised the importance of airports when it set up its Airports Operations Programme in the early 2000s. It launched several projects, including runway safety, advanced surface movement guidance and control (A-SMGCS), airside capacity enhancement (ACE) and airport collaborative decision making (A-CDM). The A-CDM programme received a boost in October 2010 when Eurocontrol, Airports Council International - European Region (ACI Europe) and the Civil Air Navigation Services Organisation (CANSO) signed an agreement to increase operational efficiencies at European airports (Joppart, 2011).

According to SESAR Joint Undertaking (2015), an airport is considered a CDM Airport when Information Sharing, Milestone Approach, Variable Taxi Time, Pre-departure Sequencing, Adverse Conditions and Collaborative Management of Flight Updates Elements are successfully implemented at the airport. The future European ATM system is based on the full integration of airports placed as nodes in the network. This means enhanced airport operations, which ensures a continuous process through CDM under normal conditions and the development of collaborative recovery procedures under adverse conditions. This feature allows for improved runway throughput, integrated surface management, airport security networks, and full airport management within this context. It also introduces some initial concepts, above, which are basic definitions to guide the implementation of the operational concepts, which are meticulously explained in the 363 pages of the Airport CDM Implementation Manual.

The future European ATM system is based on the full integration of airports as nodes in the network. This implies improved airport operations, ensuring an ongoing process through CDM under normal conditions, and further developing "collaborative recovery" procedures under adverse conditions. In this context, this resource addresses the improvement of runway performance, integrated surface management, airport safety nets, and total airport management. SESAR is developing a series of solutions within the framework of collaborative airport decision making (A-CDM) to improve the sharing of information at airports, thereby improving flight efficiency and predictability. One such answer is the Airport Operations Center (AOC), which brings together key stakeholders from the airport as a platform for communication and stakeholder coordination based on shared knowledge. Instead of potentially different decision-making islands, the AOC provides a coordinated capability, backed by technology and processes, that balances all airport stakeholders' priorities and business strategies. Thus, these Operational Centers are fundamental in the organisation and fluidity of traffic at airports, combining resources and facilities and being the primary support in resolving changes in demand or schedule (SESAR Joint Undertaking, 2015).

The costs and benefits for all partners to implement the CDM Airport have been identified through operational testing at a significant number of European airports. These will encourage other airport administrations to analyse the benefits of CDM and implement it at their airports. Airport CDM requires the structured cooperation of many partners; success will only be achieved if all are aware of what is expected of them and continue to do so even in the light of temporary setbacks.

In short, to initiate an A-CDM project, the following steps must be followed (EUROCONTROL, 2017a):

a) Engage all partners;

b) Defining objectives;

c) Define the organisation;

d) Write the plan; and

e) Start implementing.

Airport CDM represents partners working together and making decisions based on more accurate and higher quality information, where each information has the same meaning for each involved. The desired outcomes are a more efficient use of resources and improved event punctuality and predictability (EUROCONTROL, 2017a).

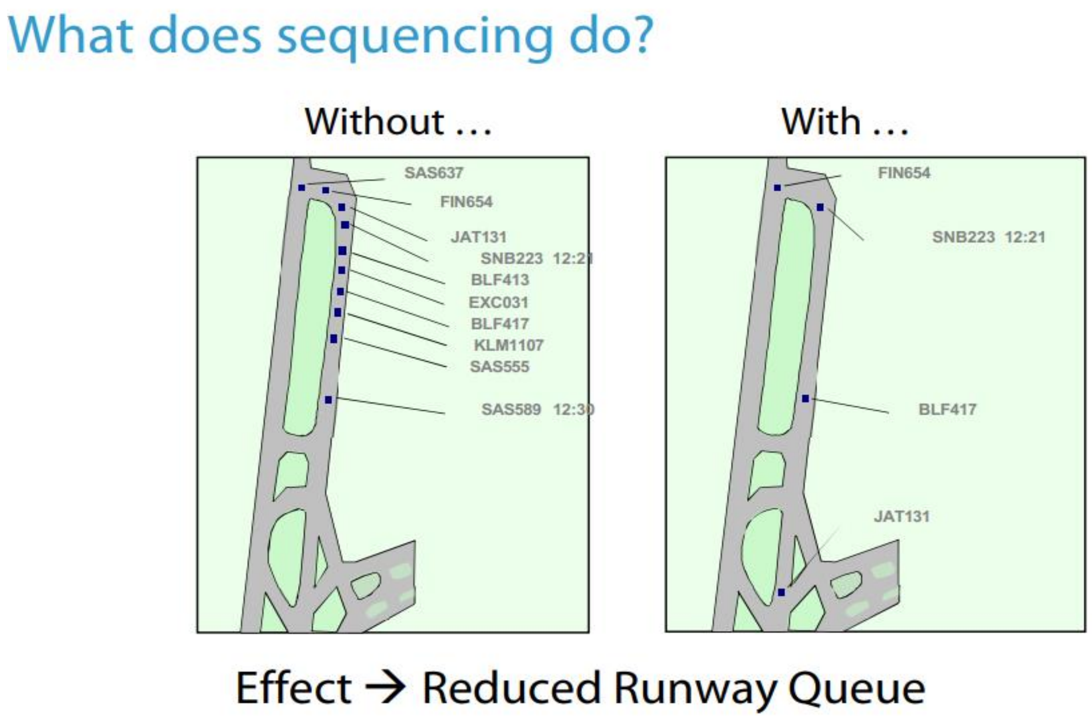


Figure 3.3 - A-CDM effects
Source: EUROCONTROL, 2019b

3.2.6 A-CDM - The FAA/NextGen Overview

FAA and NextGen address A-CDM as a Surface Collaborative Decision Making (S-CDM). A concept that will allow better airports to use and describe the need for time sharing of relevant operational data among surface CDM stakeholders. Improving situational awareness and predictability through a common understanding of the "real" airport demand and anticipated imbalances between demand and available airport capacity. This concept's heart is a set of distinct features and procedures that facilitate the proactive management of surface traffic flows and lane departure queues through continuous airport capacity and demand assessment. The goal is for resources and procedures to improve the efficiency of surface traffic flows at US airports and reduce environmental impacts. The CDM capabilities and related procedures must be transparent, flexible, agile, and equally important. They should be capable of supporting the distinct needs of US airports and the business models of the different Flight Operators. The concept of surface CDM will require the development of new and consistent policies for each of the identified resources and procedures (FAA, 2012).

Some of the greatest efficiencies that can be gained while an aircraft is still on the ground. The FAA commits to implementing near-term surface improvements, sharing more data with stakeholders and completing feasibility assessments of other capabilities of interest. These enhancements aim to measurably increase predictability and provide actionable and measurable surface efficiency improvements. These commitments are a subset of the overall series of programs and activities the FAA plans to improve operations in these domains (FAA, 2016).

FAA Traffic Management CDM has been in use since the mid-1990s. Recent surface traffic management projects have demonstrated that the potential efficiency and environmental benefits can be gained from including other stakeholders in the area, including airports, in the CDM process. As airports have been active in CDM activities, their usefulness and importance in aircraft movement management, gate management, ground service equipment coordination, defrost operations, special events, runway delays and Irregular Operations (IROPS). A-CDM is thought to be a tool that can only be applicable and achievable by major airports; however, smaller airports can also use it. Its perception of the situation helps airports of all sizes (Vail et al., 2015).

Collaborative Decision Making (CDM) in the USA airports is mainly directed to en route benefits. It enables better operational information sharing and collaborative partnerships between the Federal Aviation Administration (FAA) and the aviation industry to enhance the efficient and safe utilisation of the National Airspace System (NAS). CDM seeks to solve the problem of reduced airport arrival capacity mainly in cases that lead to ground delay programme (GDP) or ground holding strategy (GHS). The exchange of updated schedule information between the airlines and the FAA positively impacts ATM decision-making. In contrast to the US paradigm, the airport lies at the core of the European A-CDM system, which focuses on establishing broader and better communication channels first between airport partners and secondly between them and the central flow management unit (CFMU) (Katsaros & Psaraki-Kalouptsidi, 2011).

According to U.S. Airport Surface Collaborative Decision Making (CDM) Concept of Operations (ConOps) in the Near-Term (FAA, 2012):

- The Surface Domain is a Core Element of the NextGen Implementation Plan (NGIP). The Surface Collaborative Decision Making (CDM) concept will enable U.S. airports to optimise available airport capacity. It is thereby increasing traffic management efficiencies across the National Airspace System (NAS).
- The concept describes the need for timely sharing of relevant operational data among Surface CDM Stakeholders to improve situational awareness and predictability through a shared understanding of “real” airport demand and predicted imbalances between the demand and public airport capacity. At the core of this concept is a set of well-defined capabilities and procedures, which facilitate the proactive management of surface traffic flows and runway departure queues via the continuous assessment of airport capacity and demand. The skills and processes are expected to improve the efficiency of surface traffic flow at U.S. airports while reducing environmental impacts. It is understood that Surface CDM capabilities and corresponding procedures must be transparent, flexible, agile, and, equally important, capable of supporting the distinct needs of individual U.S. airports and the unique business models of different Flight Operators.

The concept includes the following capabilities and procedures, which build on one another:

a) Transparent and real-time sharing of current operational information, as well as that planned to improve awareness of the situation among all stakeholders, and thus allow continuous and accurate predictability of the airport demand and capacity;

b) Tactical and strategic management of the airport aircraft traffic flows utilising a departure reservoir management capability to manage departure queues better to avoid excessive taxi-out times and a measurably improvement in departure efficiency;

c) Management of arrival traffic flows to increase total airport throughput with balanced arrival and departure demand;

d) Analysis, measurement and monitoring capabilities that position Stakeholders to better understand operational performance and the impact on the NAS utilising a "scorecard" that provides an objective, transparent measurement of the performance of the local Stakeholders; and

e) Global harmonisation facilitates standardisation across international Airport CDM programs and the U.S. Surface CDM concept.

According to Varcadipane and Carter (2015), the US Surface CDM concept support ICAO ASBU "Block 0" goals and provides several improvements that results in A-CDM effects (Figure 3.3) for the operation such as:

a) Improved predictability for ATC, Traffic Management, Flight and Airport Operators, and the travelling public;

b) Reduced taxi-out times, with associated reductions in fuel consumption, emissions, and noise;

c) Enhanced safety through more orderly surface traffic management and better sector demand prediction;

d) Enhanced air traffic management productivity through improved real-time data exchange and use of electronic flight data in the ATCT;

e) Substitutions will be allowed with the S-CDM;

f) Departure slot will be the property of the airline;

g) Each airline will be allowed to swap flights within their airline; and

h) Departure slots for cancelled flights will be used in substitution or, eventually, made available for others.

3.3 DECEA/EUROCONTROL Cooperation Agreement

In Brazil, the implementation of the A-CDM has already had one of its initial milestones through the agreement signed between DECEA and EUROCONTROL in October 2015. During the international ATC Global 2015 conference in Dubai, cooperation was signed between the two organisations to optimise the exchange of information and operational flight data between South America and Europe, mainly in collaboration to manage air traffic flow (ATFM). The agreement extends cooperation in two main areas: support for capacity management and exchange of operational flight data between the two regions and the A-CDM area (EUROCONTROL, 2017b).

According to DECEA (2017), in Brazil, the first airport to start the implementation of A-CDM was Guarulhos Airport - São Paulo. At the end of 2017, the Airspace Control Department and several national and international airlines and airport service providers signed the Guarulhos A-CDM Operational Cooperation Agreement.

EUROCONTROL's successful practices inspired the implementation of the Brazilian A-CDM process. As of the conclusion of this Agreement, the airlines, GRU Airport and DECEA are committed to implementing collaborative tools to increase efficiency, air capacity and, mainly, to optimise the quality of services provided at Guarulhos Airport.

In addition to DECEA and GRU Airport, several companies that operate at Guarulhos Airport participate in the A-CDM project to reduce delays, provide greater predictability of events that influence flight and optimise resources.

3.4 Operational implementations and characteristics

3.4.1 Framework

The planning and operation of A-CDM should always consider a preliminary assessment of the current operational constraints and which critical milestones of the implementation, and corresponding milestones, should be adjusted to mitigate such restrictions and improve the operating conditions of the airport and air traffic flow.

An airport can be considered as CDM airport when A-CDM Information Sharing (ACIS), the Turn-Round Process (CTRP), and the Variable Taxi Time Calculation (VTTC) concept elements are applied at the airport. CTRP describes the flight progress from the initial planning until take-off by defined ‘milestones’ to monitor significant events closely. Flight Update Messages (FUMs) and Departure Planning Information (DPI) are used to inform all participating CDM partners about the flight’s progress. It is a complex task, given that situational awareness must be established across multiple subsystems of different organisations and operational structures having their causal and intentional domain constraints. ‘Subsystems’ here refer to actors who include the airport operator, airline company, ATC, ground handler, and Central Flow Management Unit (CFMU). Additionally, all terminal and ramp processes have operational interdependencies, e.g. methods can typically not be parallelised, and legal requirements, e.g. one side of the aircraft must be clear of obstructions to ensure firefighting access is always possible (Groppe, Pagliari & Harris, 2010).

3.4.2 Stakeholders recommendations

Corrigan et al. (2014) state some consolidated overview recommendations that were accepted by the stakeholders at the airport in the A-CDM implementation:

a) Appoint a dedicated A-CDM coordinator in all stakeholder organisations (airport, ground handling, airline, ATC, fuel, cleaning, catering etc.) that can attend all project meetings;

b) Each coordinator develops a communication strategy for their respective organisations. Create a project team to develop an overall airport-wide communication strategy;

c) Create a sense of collective leadership across all actors to ensure a win-win attitude for all of them;

d) Clearly define and agree on objectives and key performance indicators at global and individual stakeholder organisations;

e) Prioritise the visit of the operational space of other interested parties on a regular basis. Make this a fundamental tool for ensuring a common operational picture between stakeholders. This kind of action may be developed into a regular programme of cross-training;

f) Develop an agreed strategy for rewarding collaborative behaviour and discouraging non-collaborative practice;

g) Develop a dedicated training programme to deal with the softer issues of communication and collaboration; and

h) Address the question of what communication support and methods are required to support the turn-round process operations.

3.4.3 A-CDM implementation. Partners and data responsibilities

Airport CDM Implementation Manual (EUROCONTROL, 2017a) considers that the partners are the primary sources of data provision to the Airport CDM Platform in A-CDM Operational Implementation. Below is a list of partners and associated data (Fig. 3.4 and 3.5).

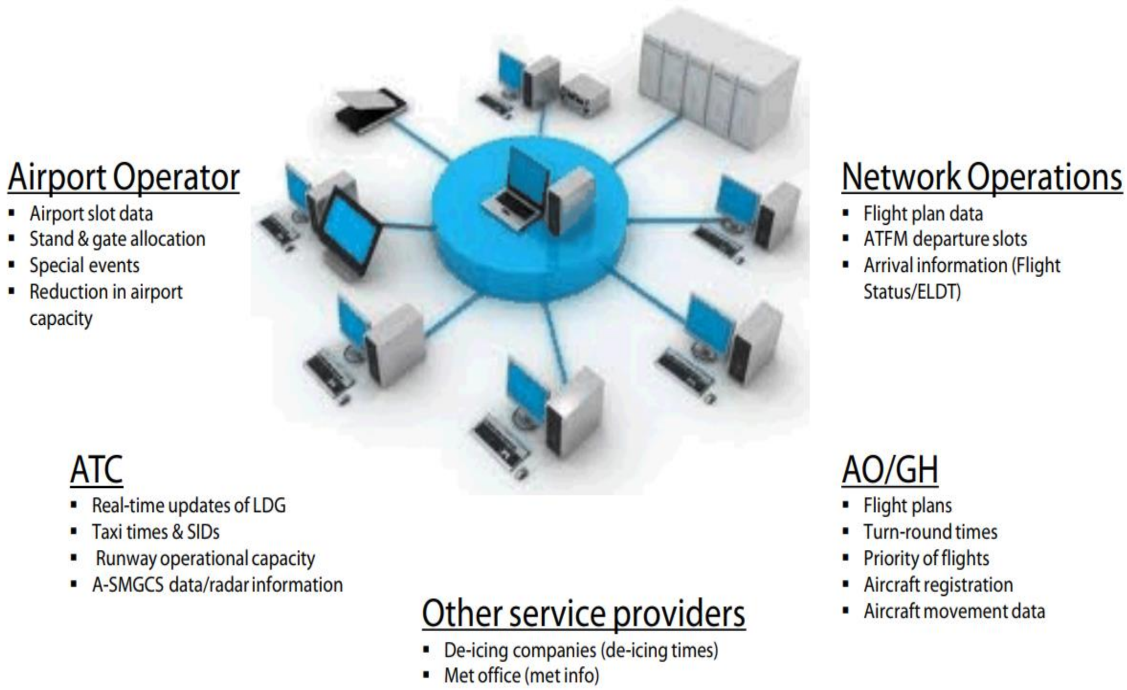


Figure 3.4 - A-CDM single platform
Source: EUROCONTROL, 2019b

a) Aircraft Operator / Ground Handler:

- Aircraft movement data
- Priority of flights
- Changes in turn-round times
- Target Off-block Time (TOBT) updates
- Planning data
- Information concerning de-icing
- Flight plans
- Aircraft type
- Aircraft registration
- Flight type

b) Airport:

- Slot data, including relevant information such as Aerodrome of Destination (ADES), Scheduled Off-block Time (SOBT)

- Stand and gate allocation
- Environmental information
- Special event
- Reduction in airport capacity

c) Network Operations:

- Data from flight plans
- Slot Allocation Message (SAM)
- Slot Revision Method (SRM)
- Flight Update Messager (FUM), containing the Flight Status/Estimating Landing Time (ELDT) including change (CHG) or cancellation (CNL) messages

d) Air Traffic Control:

- Real-time updates for Estimating Landing Time (ELDT); or
- Target Landing Time (TLDT)
- Actual Landing Time (ALDT)
- Runway and taxiway condition
- Taxi times and SID
- Target Startup Approval Time (TSAT)
- Target Take-Off Time (TTOT)
- Runway capacity (Arrival/Departure)
- A-SMGCS data/radar Information

e) Other Service Providers:

- De-icing companies (estimated and actual times related to de-icing)
- MET Office (forecast and practical meteorological information)
- And others (fire, police, customs, fuel etc.)

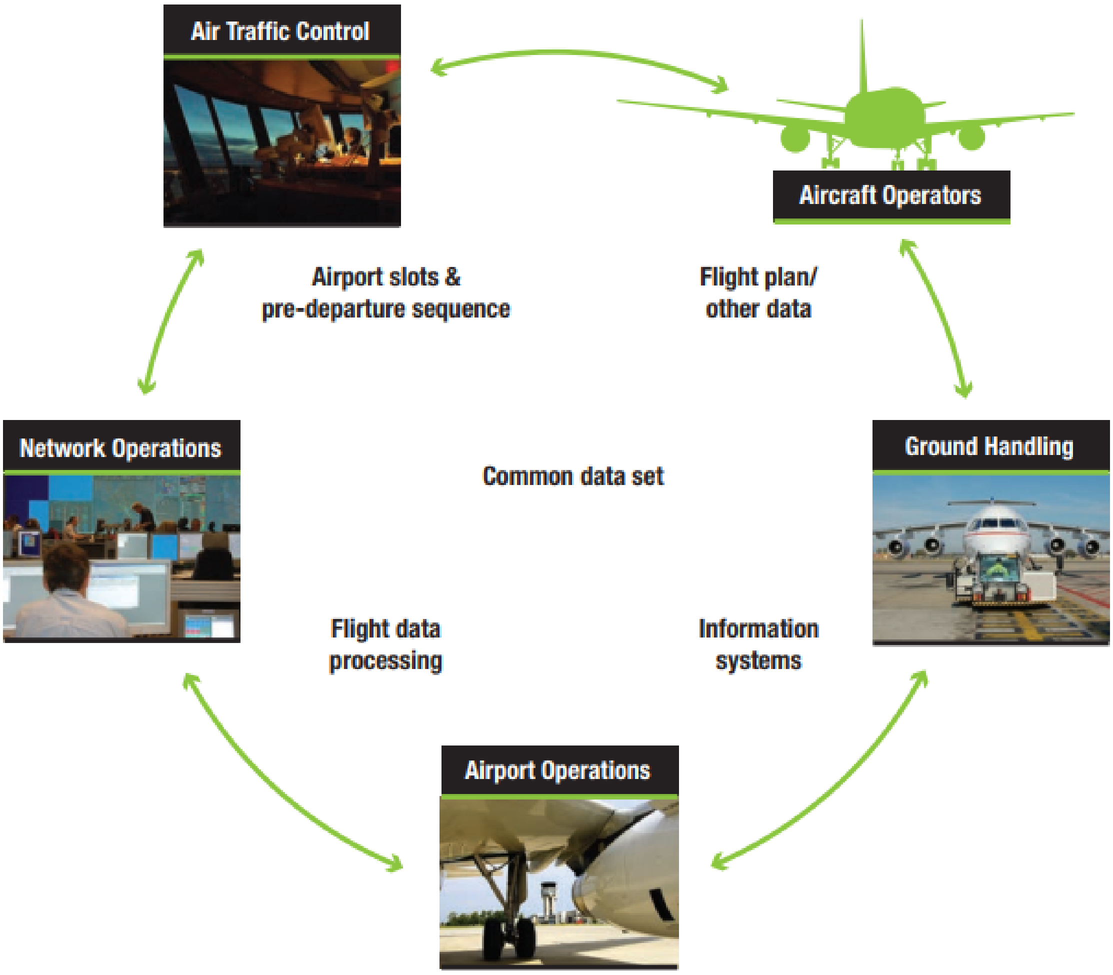


Figure 3.5 - A-CDM operational implementation
Source: EUROCONTROL, 2017a

For a perfect A-CDM implementation, a correct data flow at the right times is indispensable. Thus, especially the update messages exchanged between the ATC, Airport Operations, Aircraft Operations and Groud Handlings must be carefully processed. They are the basis that are more significant for the correct functioning of the process as a whole (Figure 3.5).

3.5 The EUROCONTROL milestone approach concept element

In A-CDM processes, it is common to use the term Milestone, widely used in Project Management. It originates from the stones used to mark the distances at the edge of a road or path. In the cases of A-CDM are used as determinant milestones of each activity (termination of some stage and changes of phase, transition or completion of steps within the process). The Milestone Approach element describes a flight's progress since the initial take-off planning, defining the Milestones that will closely monitor significant events. The aim is to achieve an everyday situational awareness and to predict the forthcoming events for each flight with off-blocks and take-off as the most critical events.

A total of 16 essential Milestones have been defined. The list of Milestones is indicative; more milestones may need to be included to cover extra information updates on critical events, such as de-icing. Local procedures may dictate that some milestones may not be required and are therefore considered as not highly recommended. For each milestone, there are Time References, previously defined or that vary according to each airport, which should be presented and systematically updated to all stakeholders (EUROCONTROL, 2017a). The defined Milestones are presented in Figure 3.6 and Table 3.1 below.

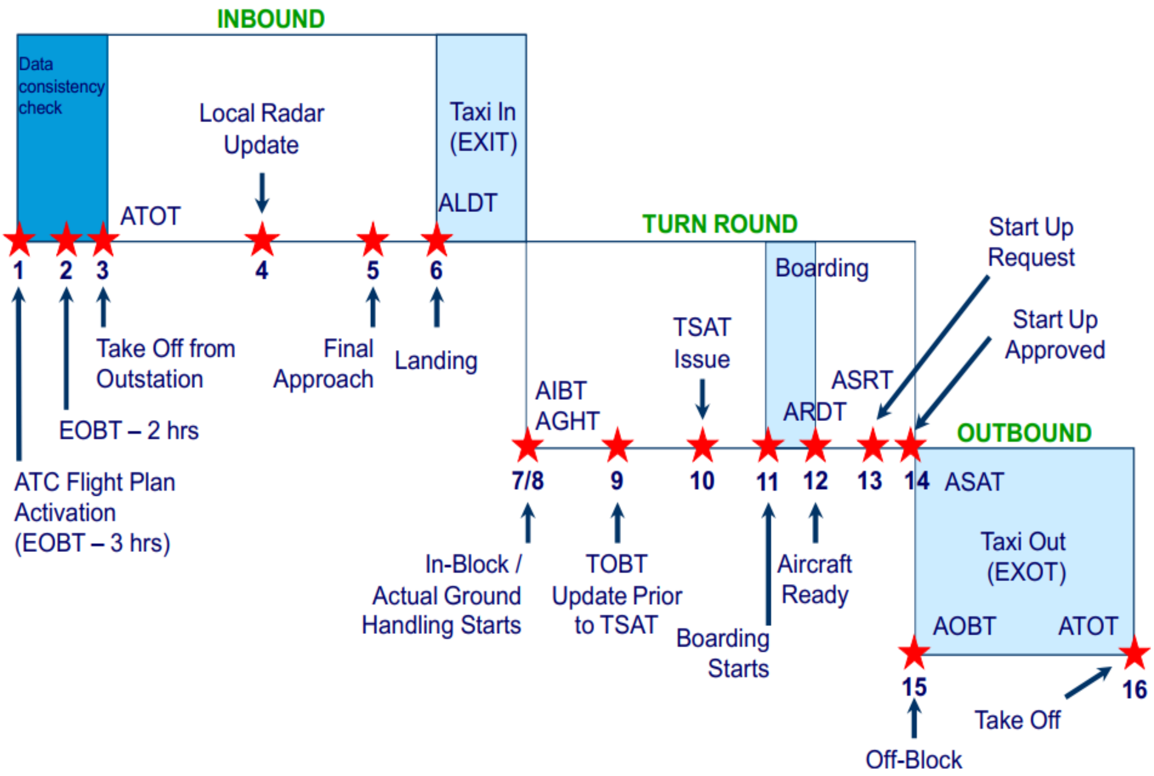


Figure 3.6 - A-CDM Milestones
Source: EUROCONTROL, 2019b

The simplification of the A-CDM is the focus of the vast majority of professionals. Schultz, Olive, Rosenow, Frick, and Alam (2020) present a proposal to implement an A-CDM that they call Lite, supported by ADS-B. With the advantage of being cheap and easy to deploy. With aircraft equipped with ADS-B, the A-CDM lite provides appropriate performance-based airport management in airports equipped with this equipment. The study analyses only the part of the airside trajectory with aircraft movement data sources, which validates part of the concept. Future work should include incorporating flight plan and operational history data accessible through Eurocontrol services for further validation of the concept and to improve the predictive power of the approach.

Table 3.1 - Milestones Descriptions
Source: Own elaboration based on Airport CDM Implementation (EUROCONTROL, 2017a)
*Obs.: Highly Recommended **(HR)** or Mandatory; and Recommended **(R)** or Optional Milestone*

N. º	MILESTONES	DESCRIPTION
1/HR	**ATC Flight Plan activation**	The ICAO flight plan is submitted to the ATC. At this time, the flight is activated on the Airport CDM Platform, and all available information is processed. This usually, occurs 3 hours before the EOBT. However, it may be later. In many cases, a repetitive flight plan (RFPL) is already in the database covering daily or weekly flights.
2/HR	**Estimates Off-Block Time (EOBT): - 2 hs before**	At EOBT -2 hr most flights will be known in the Airport CDM Platform, including if they are regulated or not. If the flight is regulated, a Calculated Take-off Time (CTOT) is issued at EOBT -2h.
3/HR	**Take-off from outstation**	The Actual Take-Off Time (ATOT) from the outstation (Departure Aerodrome - ADEP). The outstation provides ATOT to the Network Operations and Aircraft Operator.
4/HR	**Local radar update**	The flight enters the FIR (Flight Information Region) or the local airspace of the destination airport. This information is usually available from the Area Control Centre (ACC) or Approach Control Unit that is an airport. The radar system can detect a flight based upon the assigned SSR code when the flight crosses a defined FIR/ATC boundary.
5/HR	**Final approach**	The flight enters the Final Approach phase at the destination airport. This information usually is available from ATC. The radar system detects a flight based upon the assigned SSR code and identifies when the flight crosses either a defined range/position or passes/leaves a predetermined level.
6/HR	**Landed**	ALDT – Actual Landing Time. It is the time that an aircraft touches down on a runway. It is provided by ATC system or by ACARS from equipped aircraft.
7/HR	**In-block**	AIBT - Actual In Block Time. It is the time that an aircraft arrives in blocks.
8/R	**Ground handling starts**	Commence of Ground Handling Operations (ACGT). Specific to flights that are the first operation of the day or that have been long term parked. For flights that are on a normal turn-round ACGT is considered to commence at AIBT.
9/R	**Final confirmation of TOBT**	The time at which the Aircraft Operator or Ground Handler provide their most accurate TOBT considering the operational situation. The information is provided *(t) minutes before EOBT. (Where *(t) is a parameter time agreed locally).
10/HR	**Target Start-Up Approval Time issue**	The time ATC issues the Target Start-Up Approval Time. The information is provided (t) minutes before EOBT, where (t) is a parameter agreed locally.
11/R	**Boarding starts**	The gate is open for passengers to physically start boarding (independent of whether boarding takes place via an air-bridge/pier, aircraft steps or coaching to a stand).
12/R	**Aircraft ready**	The time when all doors are closed, boarding bridge removed, push back vehicle connected, ready to taxi immediately upon reception of TWR instructions.
13/R	**Start-Up request**	The time that the startup is requested.
14/R	**Start-Up approved**	This is the time that an aircraft receives its Start-Up approval.
15/HR	**Off-block**	AOBT – Actual Off-block Time. The time the aircraft pushes back/vacates the parking position
16/HR	**Take-off**	ATOT – Actual Take-off Time. This is the time that an aircraft takes off from the runway.

3.6 The FAA operational approach

3.6.1 Implementing CDM at Airports

According to the Guidebook for Advancing Collaborative Decision Making (CDM) at Airports (Vail et al., 2015), to perform A-CDM either as a leader or partner, airports will be required to commit financial and staff resources to the effort. Like more complicated programs and efforts, such as implementing Security Management Systems (SeMS), A-CDM is a change how airports do business and will require staff training to ensure effectiveness. A-CDM is also a process that may require expanded communications and enhanced communications programs. Thus, it is therefore desirable that airports can designate specific staff to lead and track A-CDM activities. During the implementation of A-CDM, it is essential for the airport staff to understand management's goals and objectives and the airport's commitment to A-CDM. In other words, airport staff will need to be trained in A-CDM background and procedures before successfully being deployed. They recommend three necessary steps to start an A-CDM project:

a) Step One - Problem Identification: Implementation of A-CDM begins when an operational problem or issue is identified; A-CDM can also be used to address issues proactively, i.e., before they exist. For example, hazard material (HAZMAT) or security issues are treated much more effectively when a plan exists to address such problems. The airport work unit responsible for implementing A-CDM identifies the subject (s) that could potentially arise and that ACDM could address. This list of topics will help determine which stakeholders need to be included in the ACDM process;

b) Step Two - Developing the A-CDM Approach: Identify which historical and real-time data information should be used to develop and implement the plan; and

c) Step Three - A-CDM Implementation: Execute the project, including identifying each organisation and its responsibilities, existing facilities and identifying data and infrastructure, such as automated decision support and plan execution.

3.6.2 The FAA Milestones

The Improve Individual and Shared Situational Awareness to Manage Departures capability of Surface CDM are not just about access to airport aircraft surface surveillance data. It is also about providing a comprehensive, real-time awareness of surface operations based on the integration of shared airport operations data, along with airspace, flight information, and NAS status data. Furthermore, current tactical information is central to the development of accurate demand and capacity predictions. Accordingly, all Stakeholders will share responsibility and accountability for the timely provision of operational data deemed vital to the successful implementation of Surface CDM. Are recommended that Stakeholders will provide 63 (sixty-three) Data Elements for each flight. In order to group these elements, the ConOps in the Near-Term (FAA, 2012) considers three key milestones to be found in the operation of a Surface CDM (A-CDM) that need to be completed before a flight can depart.

These milestones are:

a) Flight Planning: Relative to the milestone of filing a flight plan, networkwide resource planning enables a Flight Operator to maximise its resources by adapting to changing conditions based on accurate, timely information. For example, Flight Operators may use airport aircraft surface surveillance data, integrated with airspace and National Airspace System (NAS) status data, to detect and understand the nature of any demand/capacity imbalances affecting airport surface traffic.

b) Pushback: Relative to the milestone of pushing back from a gate/parking stand, it is anticipated that the participating Stakeholders will share the following information:

- Scheduled Off-block Time (SOBT)
- Earliest Off-block Time (EOBT)
- Updated flight intent information
- Operating limitations affecting the departure of an aircraft
- Actual Off-block Time (AOBT)
- Access to pushback and other specified event data

c) Taxiing on the Airport Surface: Taxiing to a Holding Area, a gate may be needed for an arrival, making it necessary to push back a departure earlier than otherwise would be required. In such cases, Ramp Control and ATC perform coordination as essential to taxi the aircraft to the designated holding area. Using surface surveillance and flight intent information, Surface CDM monitors current and predicts the capacity of the holding areas. Three notifications are provided to subscribing Stakeholders to improve their situational awareness regarding the designated Airport Movement holding areas.

3.7 Conclusions

As can be seen, A-CDM is a process, not a project, a process that, when implemented, brings excellent operational advantages to air operators, airports and airspace control. And consequently to the final customer, the passenger, who is the biggest beneficiary of the improvements implemented (Figure 3.7). Economic and environmental factors are also huge components favourable to deployment.

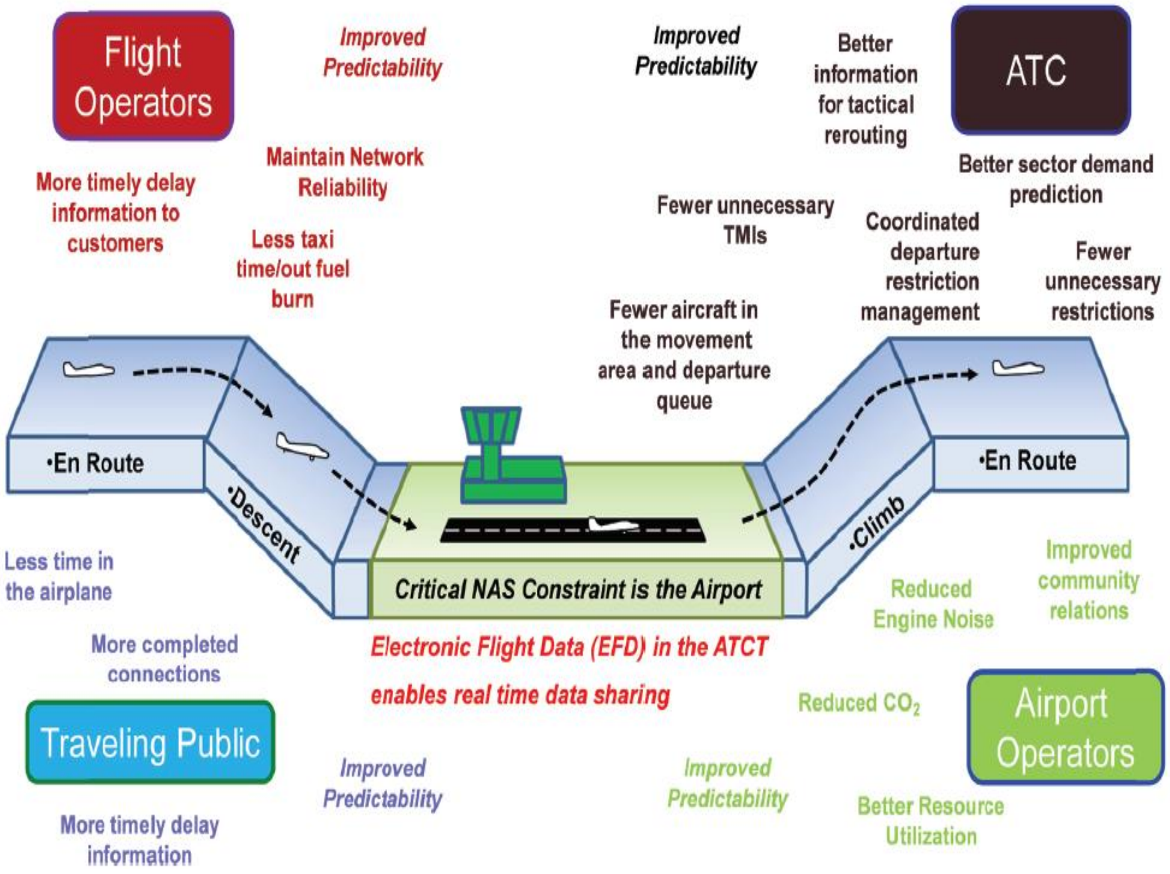


Figure 3.7 - A-CDM efficiency benefits
Source: Vail et al., 2015

The decision-making process in the organisational environment is increasingly the object of studies and growing challenges. Globalization, outsourcing, technological advances, new management models, rising unemployment, and automation have caused significant changes for organisations and work, requiring constant professionals in decision-making processes [1](Arantes, Netto & Silva, 2019).

[1] Author's participation in Sector 2.1: The airport concession in Brazil

Based on the ICAO Global Air Navigation Plan recommendations, the complexity of a CDM deployment at large airports receives several approaches from signatory countries and their ATM Systems. In all of them, especially those of greater importance, we have seen confluent points that should always be part of A-CDM processes regardless of airport size. The process will always involve three significant stakeholders: airport, air traffic control and air carriers, all connected around a regulatory entity and the application of the Operational Concepts (ConOps) they recommend, applicable for each State.

In the implantation, we also see integrating factors, in the implantation in large airports, as:

a) The stakeholders that will be involved;

b) The milestones:

- That EUROCONTROL points out in 16 major brands, of which ten are Highly Recommended;
- Which the FAA points to three broad groups and divides them after, in a systematic way.

The process, now implemented in almost a hundred airports worldwide, will require later interaction with smaller airports. This fact occurs because, among other factors, they are also feeders of the system. For the gears to function correctly, they must also have processes for controlling and transferring information and data to the extensive world air traffic system systematically and comprehensively.

The academic documents based on A-CDM, which exists today, focuses on commenting details of its functioning. Little can be found in terms of comments that will support the question: how can a reduction of costs and implementation time be conducted in A-CDM, which is the question of this Thesis. Documents that most support these claims come from ICAO and EUROCONTROL. Thus, this literature gap must be filled in other ways, such as case studies, interviews and surveys.

Chapter 4. AIRPORTS CASE STUDIES

4.1 Introduction

Following the presentation of the theoretical and operational implementation of the A-CDM, this chapter will present a case study of the application of the process at some of the major European airports. The data presented here were all collected before the 2020 pandemic.

This chapter, intended for a case study, has its main characteristic: it is mainly supported by figures and tables from nonacademic sources, such as publications and websites found on the Internet. This is because this subject, as it is relatively new, there are not enough articles and academic materials, especially regarding the need for conducting Case Studies. Thus, we are showing successful case studies - going deeper into the first two cases, Madrid and Schiphol -presented in the A-CDM Training Course at the EUROCONTROL Institute of Air Navigation Services (IANS), and presented here by permission of that Institute and based in information according to A-CDM Impact Assessment Final Report (EUROCONTROL, 2016).

4.2 Madrid Airport – Barajas

4.2.1 Characteristics and facilities

Figure 4.1 - Adolfo Suarez Madrid Barajas Airport
Source: EUROCONTROL, 2019b

Adolfo Suarez Madrid Barajas Airport, distant 12km from Madrid city centre, there is a total area of 35 km² and has the following essential characteristics (EUROCONTROL, 2019b) according to Figures 4.1 and 4.2.:

a) More than 80 (eighty) Airlines flying to;

b) 211 (two hundred and eleven) destinations;

c) 74 (seventy-four) different countries; and

d) 03 (three) buildings are operating Terminals 1, 2, 3, 4 and 4S.

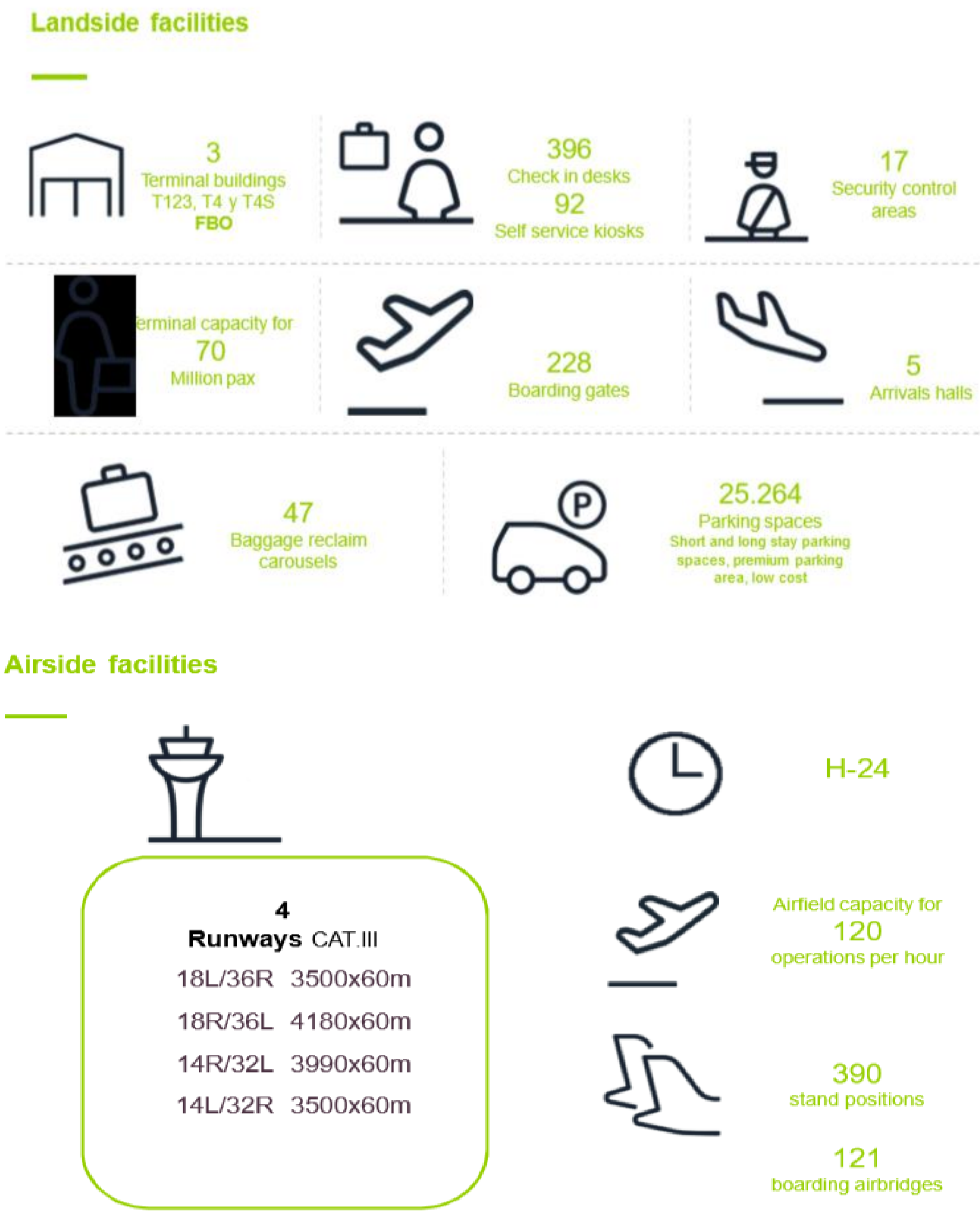


Figure 4.2 - Barajas, Landside and Airside facilities
Source: EUROCONTROL, 2019b

Madrid-Barajas Airport (MAD) is currently Europe' 6th busiest airport with over 40 million passengers annually. AD recorded almost 350,000 movements in 2014, with a daily peak of over 1000 movements. The airport is operated by AENA and is an operational and maintenance hub for Iberia and Air Europa, serving long haul flights across the Atlantic and a busy European schedule. Other dominant carriers include Easyjet, Norwegian and Ryanair (EUROCONTROL, 2016).

4.2.2 Challenges to be faced

There are a lot of challenges to be faced, like two examples in Figure 4.3, that is, problems with queues and disruptions. The implementation of A-CDM at Madrid Airport aimed at improving the following areas:

a) Taxi Times;

b) Improve use of stands/gates;

c) Queues at the holding points (Hub Airport);

d) More fluent traffic flows; and

e) Accurate information during disruptions.

Figure 4.3 - Challenges with queues and disruptions
Source: EUROCONTROL, 2019b

4.2.3 Implementation process

The complete implementation and A-CDM process at Madrid Barajas Airport took place from July 2011 to July 2014 and had the following phases (steps):

a) Organisational Structure definition (Figure 4.4);

b) Definition Process (Figure 4.5);

c) Locally implementation (Figure 4.6); and

d) Full CDM (Figure 4.7).

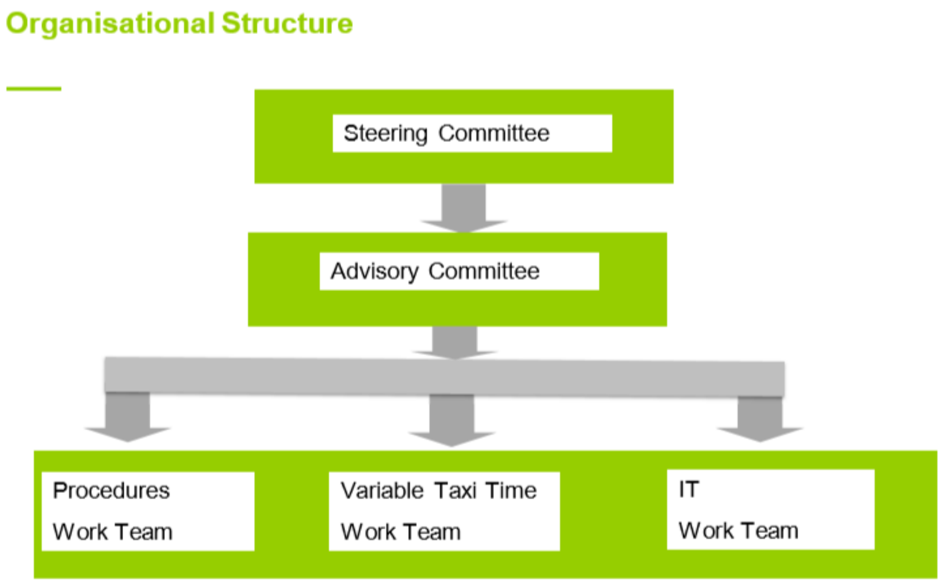


Figure 4.4 - Organisational structure definition
Source: EUROCONTROL, 2019b

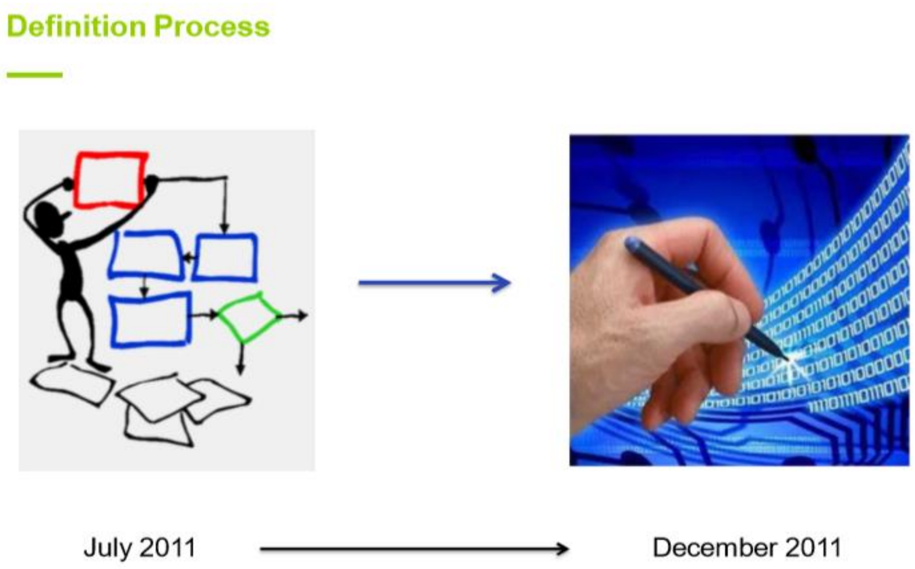


Figure 4.5 - Definition Process
Source: EUROCONTROL, 2019b

Figure 4.6 - Locally implementation
Source: EUROCONTROL, 2019b

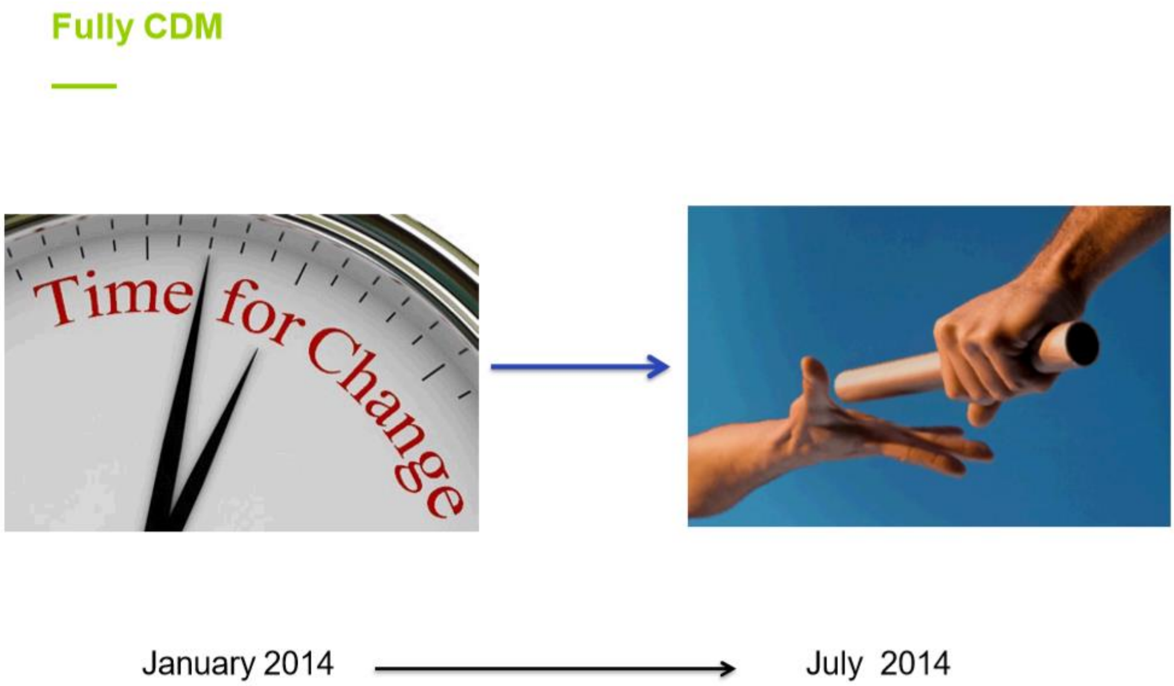


Figure 4.7 - Fully CDM
Source: EUROCONTROL, 2019b

4.2.4 Benefits verified

A study conducted by Madrid Airport from January 2014-May 2019 (Table 4.1) shows several benefits after the A-CDM implementation (EUROCONTROL, 2019b).

Table 4.1 - A-CDM implementation in Madrid – Barajas (January 2014-May 2019)
Source: Own elaboration based on EUROCONTROL (2019b)

BENEFITS AFTER THE ACDM IMPLEMENTATION	
Taxi Time Out Reduction 	• Total operations (Jan2014-May2019): 1.026.832 • Average Taxi Time Reduction: 2.77 minutes • Total Taxi Time saved: 2.844.325 minutes • Total Fuel saved: 69.287.757 litres
Delays Reduction 	• The average Stand waiting time: 1.33 minutes • Total Delay Minutes Saved: 1.478.638 minutes • Indirect Cost Savings: 113.855.132 €
Environmental Benefits 	• CO2 emissions saved: 172.595.802 kg • NOX emissions saved: 256.757 kg • CO emissions saved: 1.232.938 kg • SO2 emissions saved: 42.792 kg
Network Manager Operations Centre (NMOC)  	• More accurate take-off information leads to more efficient use of capacity available. *"Take-off time accuracy has reduced from an average of 9 minutes to 0.5 minutes per flight in 2015."* • Better ATFM slot compliance. *"ATFM slot adherence has maintained a high level of 96% despite increased traffic and regulations."*
Tower 	• Better pre-departure sequence based on updated and accurate information (runway capacity optimisation); • Reduce queues, taxiways and apron congestion; • Traffic controllers work with more fluent and predictable traffic.
Ground Handlers 	• Increased predictability enables better planning; • More efficient use of existing resources (equipment and workforce).
Airlines 	• Improved situational awareness about aircraft status at outstations; • Improved operational efficiency (fleet management) and reduced delay; • Reduced ground movement costs (less fuel burn); • More transparent view of ground handling operations.

More Quantitative Benefits:

Several operational improvements have been realised in Madrid since the implementation of A-CDM in December 2013. Although 100% causality cannot be confirmed, it is thought that A-CDM has contributed to the following performance improvements since January 2014 (EUROCONTROL, 2016):

- Taxi-out time was reduced by an average of 30 seconds to reach 15 minutes per departure in 2015;
- Taxi-in time was decreased by an average of 30 seconds to reach 8 minutes per arrival in 2015;
- The off-block delay was reduced by an average of 9 minutes to 1 minute per flight in 2015;
- ATFM slot adherence has maintained a high level of 96% despite increased traffic;
- Take-off time accuracy was reduced from an average of 9 minutes to 0.5 minutes per flight in 2015;
- Take-off time predictability (standard deviation of take-off accuracy) has reduced from 14.5 minutes to 6.7 minutes and 5.8 minutes per flight; and
- The average ATFM Delay Share Index at MAD decreased from 0.95 to 0.85, resulting in 5,600 less ATFM delay minutes with an estimated tactical delay saving of €0.5 million for aircraft operators in 2015.

4.2.5 Big lessons learnt

According to the presentation made in IANS (EUROCONTROL, 2019b), among a lot of lessons learned, two important points can be highlighted:

a) It is a significant change of culture, so you should have the Top Managers stakeholders on board;

b) It is not just a new system; it is about making collaborative decisions, then you need:

   - Flexible systems and a Communication Plan.

Those responsible for implementing A-CDM in Madrid Barajas focused on lessons learned, mainly because it is a culture change. Thus, there is a need to involve High-Level Managers. For collaborative decision making processes to function correctly, there should be flexible systems and adequate communication plans.

4.3 Amsterdam Airport - Schiphol

4.3.1 Characteristics and facilities

Amsterdam Airport has six runways, and it is possible to perform more than 80 runway configurations. Usually, the average is about 16 runway configuration changes per day (Figure 4.8).

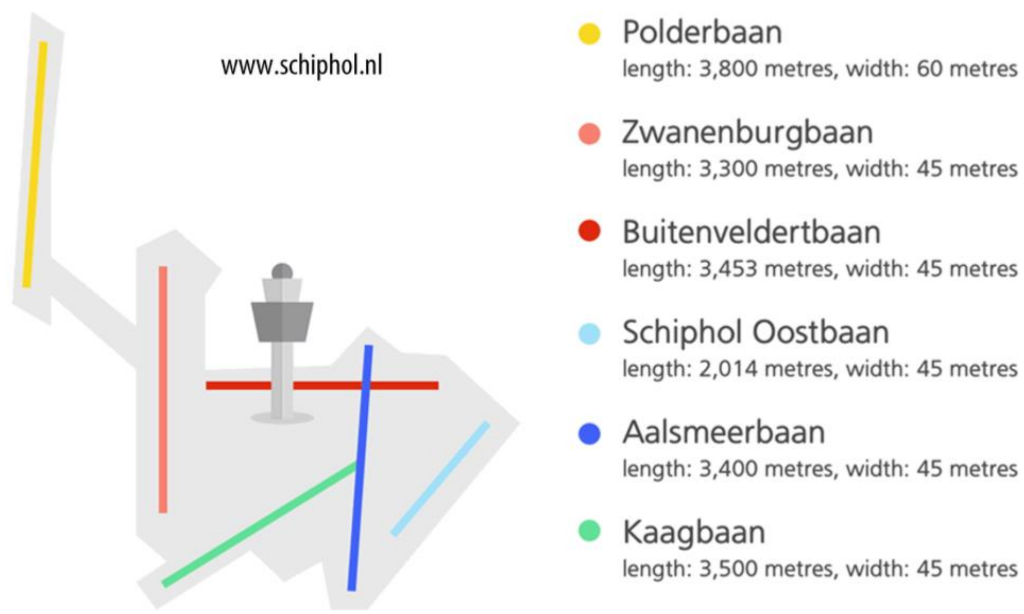


Figure 4.8 - Amsterdam – Schiphol Airport runways (6)
Source: EUROCONTROL, 2019b

4.3.2 Implementing CDM

According to Schiphol (2019), to facilitate the implementation of Airport CDM at Schiphol, a programme has been established which brings together Amsterdam Airport Schiphol, KLM, Air Traffic Control the Netherlands (LVNL), Ground Handlers, and the Schiphol Airline Operators Committee (SAOC). CDM at Schiphol will be implemented in two phases. In the first phase, Schiphol will commence local operations according to the CDM method, basing its operational decisions on shared information concerning the flight and aircraft handling process that it receives from the airport, air traffic control, airlines and ground handling. The second phase entails Schiphol sharing its operational information with EUROCONTROL in real-time. The first phase went into effect on 18 November 2015 and primarily offered benefits in the form of more efficient usage of gates, taxiways and runways at the airport. The second phase, involving the real-time sharing of joint operational information with EUROCONTROL, was implemented on Wednesday, 16 May 2018, to ensure more efficiently scheduled time slots for flights to and from Schiphol, promoting more efficient management of the airspace. During this process, there were 06 (six) important collaborative partners*:*

a) Amsterdam Airport Schiphol: coinitiator of CDM at Schiphol;

b) LVNL: coinitiator of CDM at the Schiphol location;

c) KLM: coinitiator of CDM at the Schiphol location;

d) Royal Netherlands Meteorological Institute - Koninklijk Nederlands Meteorologisch Institut (KNMI): supports the CDM initiative at Schiphol by providing meteorological information and advice;

e) Ground Handlers; and

f) Schiphol Airline Operators Committee: representative of all airlines and ground handlers at Amsterdam Airport Schiphol.

CDM at Schiphol Airport is a joint initiative between the airlines, handlers, LVNL and Amsterdam Airport Schiphol. The key aims are to facilitate the sharing of operational processes and data, so to allow better-informed decisions to be made. The objective of CDM at Schiphol is to optimize the turn-round process to assure the best possible coordination of resources. A-CDM implementation is being done through the introduction of a set of operational processes. The main characteristics of the processes follow the six-steps cycle, as shown in Figure 4.9.

The Schiphol A-CDM process (Schiphol Airports, 2019) focuses on providing stakeholders in the process with accurate and timely information. So those decisions are made to ensure the information and movements of a flight are efficient and that everyone is universally aware of the situation. Partners will also be warned of possible delays and discrepancies by alerts in the system and thus be asked to take corrective measures to ensure the correct flow of data and information. The chosen platform for realizing the Airport CDM system is the existing Airport Central Information System Schiphol (CISS). The Airport CDM system gathers all available flight information during the inbound, turn-round and outbound flight phases. Although all CDM flight information is facilitated in CISS, the data source can be ground handler systems or airline systems.

The Airport CDM system performs the following functions:

a) Collect all relevant data from sector parties;

b) Calculate an estimation of new events, or establish that an event has occurred;

c) Make this new data available to all sector parties, so there is a universal view/situational awareness;

d) Correlate Flight Plan with Flight in Airport Operational Data Base (AODB).

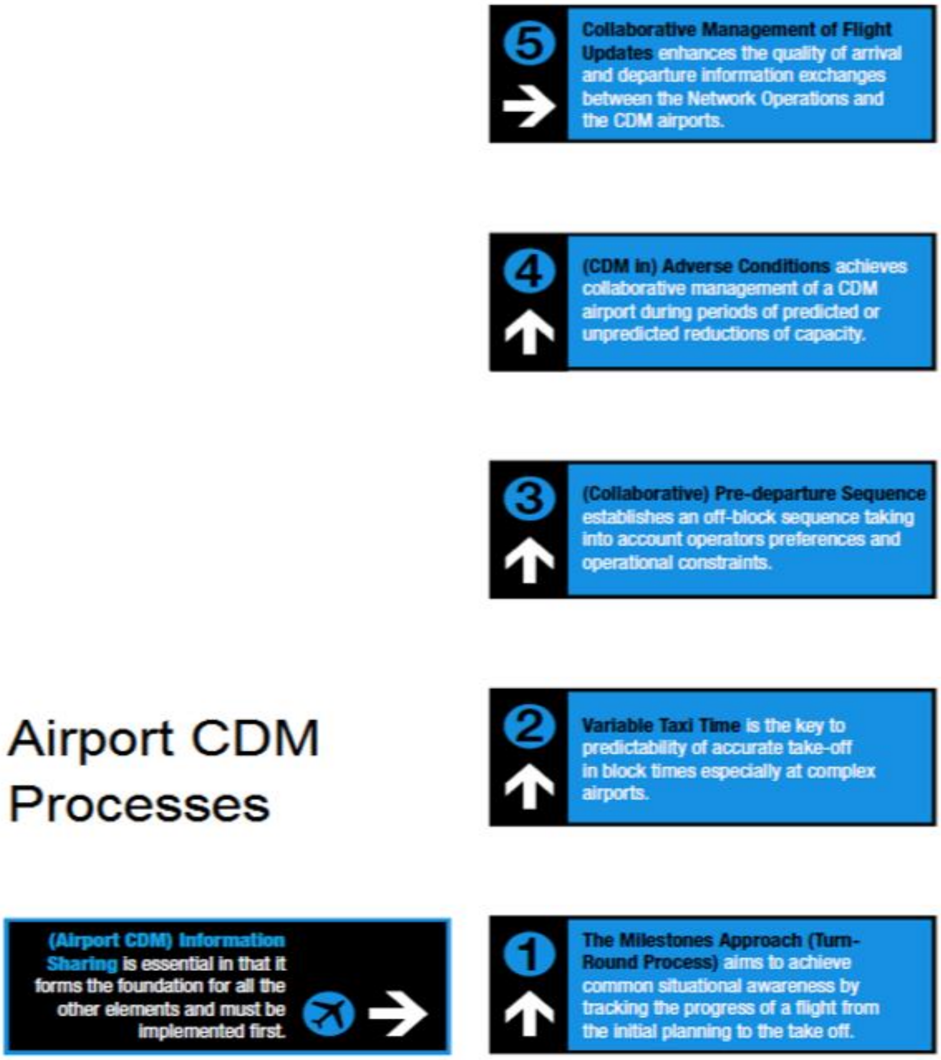


Figure 4.9 - Amsterdam - Schiphol Airport A-CDM Processes
Source: Schiphol Airport, 2019

4.3.3 Monitoring

A lot of monitoring was performed during the process, and the main ones were according to the specified below (EUROCONTROL, 2019b):

a) <u>Performance Monitoring **Steering on Punctuality**?</u>

- Punctuality is a result: Not a steering method!

- Effective Steering on derivatives:
    - Throughput – the number of movements
    - Predictability – the timing of movements

ANSWER: Optimize predictability, and you optimize resource and throughput and hence minimize delays.

b) <u>Performance Monitoring **Who**</u>?

- <u>**Air Traffic Control**</u>
    - Drive the need for Demand and Capacity Balancing (DCB)
    - More demand accuracy means lower buffers and fewer regulations
- <u>**EUROCONTROL Network Manager**</u>
    - Create European Predictability diagrams and lead formatting and KPI's
    - Monthly reporting with special attention to disruptions and recovery
- <u>**Airport Operator**</u>
    - Lead Performance Reporting Committee with main stakeholders
    - Airport change of rules:
        - Service Level Agreements to adhere to Airport regulation on Predictability
        - Airport benefits to adherence and performance

c) <u>Performance Monitoring **How**</u>?

- Monitor accuracy of Stakeholder Target Times inputs
- Manage actively on Adherence of procedures
- Post Operation Analysis: Evaluation of results and feedback
- Automated and commonly agreed data sources
- Transparent reporting

d) Performance Monitoring **Lesson Learned:**

- Set up Cross Stakeholder Performance Committee lead by Airport Operator
- Steer on Predictability Improvement and Punctuality will benefit
- Implement additional "Actual" milestones for validation of Target Times
- EUROCONTROL to report Predictability Performance
- IATA to support new Service Level Agreement (SLA) for ground handlers
- Airport and ATC to drive Performance Monitoring

4.4 Berlin – Shönefeld Airport

According to EUROCONTROL (2016), Berlin-Schönefeld Airport (SXF) was the second busiest German airport with 76,153 movements and 8.5 million passengers processed in 2015, mainly from the low-cost operators of Easyjet and Ryanair. The airport operator is Flughafen Berlin Brandenburg GmbH.

SXF and tower ATC services operational characteristics include:

- SXF is terminal constrained and is adding capacity to manage an increase in demand to 10 million by 2017;
- SXF has 30 (thirty) remote positions, and 3 (three) contact stands on the north apron, 4 (four) remote de-icing areas are located to the east and west of the north apron;
- Stand and apron congestion is beginning to emerge as an operational constraint as traffic demand increases;
- Night curfews for noisy aircraft (up to chapter 3) are in place, but this broadly does not impact the carriers at SXF, which mainly operate low noise category aircraft;
- A significant General Aviation terminal generates about 40-50 movements per day, which includes some test flights;
- Approximately 80% of traffic is from low-cost carriers that fly A319/A320 and B737 aircraft types.

Operational and Quantitative Benefits:

Berlin Schönefeld was the 11th European airport to fully implement the airport's CDM on May 1, 2015. Local procedures were adopted in March of the same year. Although 100% of causality cannot be guaranteed, the A-CDM is believed to have contributed to the following operational benefits:

- Taxi departure times reduced by an average of 45 seconds per flight between 2013 and 2014;
- Adherence to the ATFM slot of 97% and 94% was achieved in 2014 and 2015 -an increase of 7% and 4% on average in 2013-. This occurs despite the greater regulation and traffic demand compared to 2013;
- The accuracy of the take-off time reduced from an average of 11 minutes to 1 minute per flight in 2015;
- Take-off time predictability (standard deviation of take-off accuracy) has been reduced from 14.5 minutes to 4.6 minutes;
- Performance improvements at Berlin Schönefeld have been estimated to generate the following annual savings based on 2014 traffic levels:
    - 360,000 kg of Fuel Burn
    - 1,100 Tonnes of CO_2
    - 300 kg of SO_2
    - 26,300 Minutes of Taxi
    - 2,000 Minutes of Delay
    - 280,000 Euros in Fuel

4.5 Brussels Airport

According to EUROCONTROL (2016), Brussels Airport (BRU) is the 17th busiest airport in Europe, generating more than 225,000 IFR movements annually and serving almost 22 million passengers.

Operational Overview:

- Belgocontrol provides tower and local approach services;
- The airport is an operational hub for Brussels Airlines, Jetairfly, Thomas Cook Belgium and the cargo operations of, amongst others both Singapore, DHL and Saudi Airlines.

Other operational characteristics include:

- 3 (three) runways are most commonly operated in segregated mode. Most typically, runway 25R is used for departures, and both 25L and 25R are for arrivals. All runways are available for night operations;
- IFR traffic consists mainly of narrow-body aircraft. Approximately 10% of IFR movements are twin-aisle aircraft (in passenger configuration);
- Traffic demand is at its highest in September and at its is lowest in January - with about 25% less demand;
- A significant military (logistical) operation is present at BRU, which can comprise a substantial proportion of the traffic mix at certain times;
- BRU provides both on-stand and remote de-icing services, which Aviapartner and Swissport supply;
- 70% of flights are ”de-iced on-stand”. During severe winter operations, this can make it challenging to meet holdover times and the avoidance of subsequent delays;
- Opened in March 2015, the airport boasts a new collector facility that links both departure piers A and B and centralizes the border control to a 25 lane security screening platform.

Operational and Quantitative Benefits:

A-CDM at BRU has evolved with the development of the concept in the early 2000s. The airport has experienced both the benefits and challenges of an A-CDM implementation longer than most. It is thought that A-CDM has contributed to the following performance improvements at Brussels:

- There is no longer a need for departure restrictions at BRU. A-CDM is a permanent solution for eliminating departure regulations through the flexible streaming of aircraft to the threshold;
- Pilots have improved awareness of their expected startup resulting in little or no requirement for further discussion with ATC;
- Turn-round performance is growing, particularly in periods of adverse conditions where limited resources are allocated following the TSAT;
- The accuracy of take-off times within ETFMS has improved by almost 70% during peak times;

- The average reduction in taxi-out time was calculated as 3 minutes per departure;
- The average ATFM Delay Share Index at Brussels is now 0.85, resulting in an estimated 28,500 less ATFM delay minutes with a tactical delay saving of € 2.6 million for aircraft operators in 2015;
- The performance improvements at Brussels have been determined to generate the following annual savings based on 2014 traffic levels:
    - 4,500 Tonnes of Fuel Burn
    - 14,400 Tonnes of CO_2
    - 3,800 kg of SO_2
    - 330,000 Minutes of Taxi
    - 28,500 Minutes of Delay
    - 3,5 Million Euros in Fuel
    - 2,6 Million Euros in Delay

4.6 Frankfurt Airport

According to EUROCONTROL (2016), Frankfurt Airport (FRA) average generated more than 470,000 annual movements and processed 60 million passengers. Frankfurt is Europe's 3rd busiest airport by movements and the most massive cargo operation with over 2 (two) million tonnes of freight handled in 2014.

Operational Overview:

- 4 (four) runways which allow for independent parallel approaches. However, the northern runway (25R/07L) is for arrivals only - and may not be used for A380, MD11 or B747 aircraft types (due to noise reduction);
- Noise abatement procedures force departments from 25C to make a left hand turn to avoid overflying a residential area. This causes a conflict with the go-around track of westerly inbounds (on 25L) and potential overflying of RWY18 - which is used for departments to the south only. This left turn is limiting the operating capacity of the airport for the most frequently adopted runway configuration (used 75% of the time);

- Departures on RWY18 will not take place if tailwinds are more significant than 15 kts. Stand constraints can result in arrival regulations when departure capacity is limited;
- FRA is restricted by a curfew that restricts movements (from the runway) between 11 PM and 5 AM local time;
- De-icing is performed approximately 60% on-stand. FRA has 5 (five) remote de-icing pads;
- 77% of flights are conducted by narrowbody jets;
- Less than 1% of movements are from general or business aviation jets;
- 5 (five) major ground handling companies and a single de-icing contractor currently operate in Frankfurt;
- FRA serves as the main hub for Lufthansa, Condor and Aerologic;
- Fraport AG operates the airport, and DFS provides tower ATC services.

Operational and Quantitative Benefits:

The implementation of A-CDM occurred during the same year that the new ATC tower and RWY 25R/07L became operational. This invalidated quantitative pre and post-ACDM comparisons of taxi time performance due to the change of standard taxi routings. Although 100% causality cannot be confirmed, other performance gains generated from the Frankfurt A-CDM implementation include:

- ATFM slot adherence has increased to an average of 91% despite both large regulation volumes in the summer of 2014 and 2015 and the complex operational constraints and interdependencies;
- Stand stability (defined by the percentage of flights where the stand did not change after the final approach fix) has continued to improve. Since the refinement of the EXIT tables in early 2015, the stand stability has not dropped below 95%;
- The average ATFM Delay Share Index at Frankfurt is now 0.87. Before integration, this value is typically between 1.05 and 1.1;
- Based on 2015 ATFM regulation volumes, it is estimated that DPI integration has saved approximately 34,800 minutes of ATFM delay, with an estimated tactical delay cost saving of 3.6 Million Euros for aircraft operators.

4.7 Helsinki - Vantaa Airport

According to EUROCONTROL (2016), Helsinki-Vantaa Airport (HEL) is the leading international airport of Finland with some 16 million passengers and 168,000 IFR movements annually. The airport offers a busy European and Scandinavian route schedule, with a significant number of long haul routes to the Far East.

Other operational characteristics of HEL include:

- Both the airport and ATC Tower services are provided by Finavia, the state-owned enterprise that operates 25 (twenty-five) airports within Finland;
- Helsinki is an operational hub for Finnair, Norwegian Air Shuttle and Nordic Regional Airlines;
- Of the 450 (four hundred and fifty) daily movements, 100 (one-hundred) of the AT72 and B717 types. About 35 (thirty-five) are Finnair 30 (thirty) full-body flights and cargo operators (UPS, Turkish Cargo, Airbridge Cargo). The rest are narrowbody aircraft (mainly B737/A320/E190 families);
- 160,000 (one hundred sixty thousand) snow trucks were removed from the airport in 2014. An accumulation of ice in moderately cold weather is a challenging aspect for airside operations;
- HEL now performs 70% of all anti/de-icing activity in 2 (two) Central De-icing facilities (CDF). CDF capacity varies between 20 (twenty) and 40 (forty) aircraft per hour, depending on the severity of conditions;
- Most widebody aircraft are not treated on site. The location of the CDFs restricts the output capacity due to timeout limitations;
- HEL must continue to operate in prolonged periods of snow and ice, mainly supported in the flexibility afforded by 3 (three) runways, large numbers of snow and ice removal vehicles and effective daily planning to coordinate the use of available capacity.

Operational and Quantitative Benefits:

Although 100% causality cannot be confirmed, it is thought that A-CDM has contributed to the following performance improvements at Helsinki Airport:

- Operational resilience has improved owing to the integration of the TOBT into the de-icing process;
- A-CDM has added to the increased use of available de-icing and runway capacity;
- The average time between the off-block event and startup request has reduced notably since 2013;
- Off-block delay has decreased by an average of 1 minute to reach 9 minutes per departure;
- Taxi-out time has been reduced by an average of 0.7 minutes to achieve 8.2 minutes per departure. This is despite an increase in the proportion of flights that are deiced remotely;
- Take-off time accuracy was reduced from an average of 9.8 minutes to 2 minutes per flight in 2015;
- Take-off time predictability (standard deviation of take-off accuracy) was reduced from 14.0 minutes to 3.9 minutes per flight in 2015;
- The average ATFM Delay Share Index at HEL decreased from 1.05 to 0.9, resulting in 8,400 fewer ATFM delay minutes with an estimated tactical delay saving of € 0.9 million for aircraft operators in 2015;
- The performance improvements at Helsinki have been expected to generate the following annual savings based on 2014 traffic levels:
    - 800,000 kg of Fuel Burn
    - 2,600 Tonnes of CO2
    - 700 kg of SO2
    - 60,000 Minutes of Taxi
    - 86,000 Minutes of Delay
    - 650,000 Euros in Fuel
    - 6,9 Million minutes in Delay

4.8 London - Gatwick Airport

In 2015 (EUROCONTROL, 2016), London Gatwick (LGW) generated 267,776 IFR movements and served more than 40.2 million passengers, making it the UK's 2nd and Europe's 10th busiest airport by traffic. In August 2015, LGW handled 934 traffic movements in a single day, a world record for a single-runway airport. LGW is a base for airlines across the three main airline business models to include EasyJet (43%), British Airways (16%) and Norwegian (8%). LGW is operated by Gatwick Airport Limited (GAL), and ATC services are currently provided by NATS Ltd., but will be assumed by Air Navigation Services Ltd on March 1st 2016.

Other operational characteristics of LGW include:

- Gatwick has two runways but operates the northern runway as a contingency only -with no ILS capability-. Almost 70% of departures take-off to the West on runway 26L;
- LGW stand planning is constrained by a requirement to disembark 95% of passengers directly into the terminal;
- Aircraft type mix is 90% narrow body (B737/A319/A320) and 8% wide body (B777/B747/B787/A380);
- SID separation is more of a constraint to runway throughput than wake vortex separation minima;
- LGW is vulnerable to LVP, especially in April/May and September to November;
- Night Jet Movements are subject to restrictions from 23:30 until 06:00 local time;
- Most aircraft de-icing is performed on stands. However, remote de-icing is made available on taxiway Sierra;
- Five ground handling companies operate at LGW. Turn-round performance is one of the key performance areas targeted by GAL in maximising both OTD performance and the utilization of airport capacity.

Operational Benefits:

London Gatwick was the 15th airport to fully implement Airport CDM. The primary motivation for A-CDM at LGW has been to maximize runway throughput and bolster operational resilience during adverse conditions. It is thought that A-CDM has contributed heavily to some of the following operational benefits. However, other improvements might have been provided to these too:

- Take-off time accuracy has reduced from an average of 7 minutes to 1.5 minutes per flight in 2015;

- Take-off time predictability (standard deviation of take-off accuracy) has reduced from 15.9 minutes to 12.9 minutes and 7.4 minutes per flight ;
- The average ATFM Delay Share Index at LGW decreased from 1.05 to 0.95;
- The peak departure rate has increased, which has powered record runway throughput and enabled the more expeditious recovery from periods of reduced capacity. On average, LGW has departed 60 aircraft 20 minutes sooner after periods of reduced departure capacity.

4.9 Paris - Charles De Gaulle Airport

In 2014 (EUROCONTROL, 2016), Paris Charles De Gaulle (CDG) was Europe's second busiest airport, generating 471,000 movements and processing 63.8 million passengers. CDG is Europe’s second-leading cargo operation by tonnage (after Frankfurt) and hosts a hub operation for Federal Express and Air France.

CDG is operated by Aeroports de Paris (ADP), and ATC services are provided by Direction des Services de la Navigation Aérienne (DSNA), the French national ANSP.

Other operational characteristics of CDG include:

- 2 (two) pairs of parallel runways operate independently in an Easterly or Westerly (preferred) configuration depending on the wind direction. 08R/26L and 09L/27R (further from the terminals) are used for arrivals, while 08L/26R and 09R/27L (nearer the terminals) are used for departments;
- 100 km of taxiway connects the 4 (four) runways with the 4 (four) terminals and satellite buildings. CDG has 4 (four) critical taxiway hotspots that connect the north and south runway pairs;
- Deconflicting SID routings from the north and south runway pairs impose departure capacity constraints that depend on the departure mix;
- Arrival flow separation minima can also impose notable capacity constraints during peak times;
- De-icing at CDG is on one of the 22 (twenty-two) remote de-icing pads. FedEx operates 2 (two) of these, and ADP operates the remainder, along with 2 (two) on-stand de-icing units. 6 (six) ground handler companies currently operate at CDG.

Operational and Quantitative Benefits:

After Paris CDG became fully A-CDM implemented, although 100% of causality cannot be assured, it is thought that A-CDM has contributed to the following operational benefits:

- Improved utilization of stands and gates resulting in less stand congestion;
- Ground handlers benefit from improved arrival time accuracy. Handlers match resources to the current demand rather than the scheduled demand;
- The mean take-off accuracy has been enhanced to an average of 2 (two) minutes per departure. The standard deviation of take-off accuracy has improved from 13 (thirteen) to 8 (eight) minutes;
- Departure metering based on the TSAT has resulted in reduced lineup times;
- Taxi times have decreased by an average of 2 minutes since the adoption of the TSAT procedure;
- These improvements translate to the following annual savings for Paris CDG and its CDM partners, based on IFR traffic levels between January 2014 and January 2015:
    - 6,500 Tonnes of Fuel Burn
    - 20,300 Tonnes of CO_2
    - 5,400 kg of SO_2
    - 470,000 Minutes of Taxi
    - 86,000 Minutes of Delay
    - 5,0 Million of Euros in Fuel

4.10 Conclusions

The reduction of taxi time is usually the main reported benefit of A-CDM implementations, frequently being cited as the primary financial incentive for airlines to become engaged in the program.

The research (EUROCONTROL, 2016) has shown a taxi time improvement average in the range of 0.25 to 3 minutes per departure. Airports with less runway constraints, such as Prague, Oslo, Venice, Stuttgart, and Berlin Schönefeld, were still able to generate fuel and emission savings. A more significant benefit is realized for these airports during operational peaks (e.g. 3-5 minute saving per flight). However, an overall average of less than 1 minute per flight is generated when considering the average over the entire day. The emissions and fuel cost savings have been calculated based on the parameters within the EUROCONTROL Standard Input for Cost-Benefit Analysis (EUROCONTROL, 2016). The data presented below summarises the annual consolidated savings generated from 13 of the 17 CDM airports that have demonstrated tangible taxi time performance improvements.

Thus, the total relative savings across the 17 CDM airports in 2015 when compared to pre-A-CDM performance (total saving based on 2,1 million departures):

- 34,200 Tonnes of Fuel Burn
- 102,700 Tonnes of CO2
- 28,700 kg of SO2
- 2.200,000 Minutes of Taxi
- 26,6 Million Euros in Fuel
- 7% relative total savings across 17 CDM airports

According to EUROCONTROL (2016) and also based on information collected at the IANS (EUROCONTROL, 2019b), significant cost savings were verified for airlines operating at a CDM airport, mainly in reductions in taxi departure time and delay in ATFM. Smaller airports with fewer restrictions have also shown considerable savings for airlines far exceeding implementation costs. It was found that most of the benefit falls on airlines. However, the vast majority of costs are borne by the airport and ANSP stakeholders. It was impossible to calculate a cost-benefit for the soil handler, ANSP and airport operator in the studies.

Typically, the main cost-benefit for these stakeholders is in the optimization of resources and better use of assets, resulting in fewer capital expenditures to meet the growing demand:

- For defrosting companies, this may mean that more aircraft can be processed with less defrosting equipment;
- At the airport, it can mean a more efficient service that results in reduced overtime costs;
- For an ANSP, it could mean better compliance with the Calculated Take-off Time and better peak service rates on the runway -which could prevent future investments in more expensive efficiency programs-.

A-CDM is helping the airport maximise infrastructure utilisation, consequently some gains in passengers volume, but to measure this data would require a dedicated set of performance indicators and indicators implemented and monitored over several years as A-CDM partners.

Although the studies carried out, mainly in A-CDM Impact Assessment Final Report (EUROCONTROL, 2016), had direct information about the costs of implementing an A-CDM, it can be verified that it generated reliable cost savings (for airlines) based on historical operating results.

Three levels of implementation were estimated and recurring maintenance costs, a regional cost-benefit. The Cost-Benefit Ratio (CBR) was calculated for all CDM airports based on these three cost scenarios.

The implementation cost scenarios that have been considered include:

a) LOW: Implementation of € 750,000, plus annual costs of € 50,000;

b) MEDIUM: € 2.5 million implementations, plus € 150,000 annual costs;

c) HIGH: Implementation of € 5.0 million, plus annual costs of € 500,000.

Against these implementation costs, the average cost-benefit ratio and the time to return on investment when considering only the airline's CBR is described in Table 4.2 below.

These figures do not include savings due to improvements in airport punctuality or reductions in flight cancellations.

Table 4.2 - Payback and CBR analyses
Source: Own elaboration based on EUROCONTROL (2016)

	LOW	**MEDIUM**	**HIGH**
Payback Period	**< 15 months**	**< 18 months**	**< 24 months**
5 Year CBR	9.37	2.92	1.18
10 Year CBR	21.10	6.57	2.66
15 Year CBR	32.80	10.23	4.24

Assuming a Medium implementation cost scenario, Table 4.2 shows that, on average, A-CDM provides a return on an investment after 18 (eighteen) months and CBR values nearing 7 (seven) over 10 (ten) years.

Smaller airports can generate CBR values nearing 10 (ten) over 5 (five) years. In essence, this is particularly important for those airports with fewer restrictions and less likely to generate real savings with future evasion operating costs.

A-CDM is about much more than generating fuel savings and reducing airline delays. However, the savings made so far more than justify the cost of spending across the European zone where it was implemented.

The advantages are undeniable as can be seen in this case study, but the investments are also high. But is it possible that all European airports are prepared or even ready for significant assets such as those already made in these airports studied? And if not, are there alternative solutions? This question that we are trying to answer in this work and whose answers are being sought.

Chapter 5. INTERVIEWS AND SURVEY

5.1 Introduction

As the base for the studies and following the Chapter focused on the case study of the implementation of the A-CDM process, in more depth at two major European airports, Madrid-Barajas, Amsterdam-Schiphol and, concisely, some results collected at other 6 (six) airports.

This chapter will present interviews and surveys with international experts in airports, air traffic control and related industries from Europe and the Americas.

In the first part of Chapter 5 (in 5.2), structured interviews will be carried out with specialists in the sector. The questions, directed to professionals who have already been involved in some way- with A-CDM, were aimed at getting to know their opinion on the effectiveness of the A-CDM, currently being used by EUROCONTROL and FAA. They were asked if they thought that the processes could still be improved. It also sought to find out if they considered it possible to refine the current process that would allow it to be more economical in its implementation and, in a shorter period. Finally, it aimed to gather their opinions on those who most favoured implementing a collaborative decision process in airports. We also left an opportunity to speak freely about A-CDM.

Subchapter 5.3 contains a survey presented to members of the Air Sector with multiple choice questions for a wider audience, that is, not only for those who know (are involved with) A-CDM. To complement the results of the interviews, as addressed by the interviewees, issues such as flight delays, information sharing and stakeholder adaptability to the A-CDM process or the application of a simple Information Sharing a questionnaire was designed for members or participants of the airline industry. They were not necessarily knowledgeable of the A-CDM. Its aims were to investigate the concerns and discomfort that a passenger faces in all aspects of delay involved in a flight, in this case, especially from an accurate view of those who know the industry. Although the focus of most analyses is always directed towards reducing taxi time, saving fuel and improving airport and ATFM processes, the passenger, as an end customer, also indirectly receives some of these results. This item could be evaluated if most of the delays could be mitigated by a simple implementation of Information Sharing or requiring a full A-CDM. Such results and those collected in the interviews will serve as one of the bases for elaborating the Analysis and Conclusions (Chapter 6) and the referral to the Final Considerations (Chapter 7) of this Thesis.

5.2 Interviews

The structured interviews presented here with international experts in airports, air traffic control and related industries in Europe and the Americas were planned using the criteria of sending these experts a structured questionnaire, sent by email, with questions that directly or indirectly influence the implantation and use of A-CDM processes.

Figure 5.1 and Table 5.1 describe the enterprise headquarters and briefly the profile of interview respondents. Their names for ethical and professional reasons will be preserved.

Experts	Respondent companies' nationalities and headquarters
The interviewees are executives from companies in Europe, South and North America. Specialists, planners and managers in the areas of ATC, Airports, Handling Services, as well as airline and academic associations. Everyone, somehow, involved and knowledgeable about the A-CDM processes.	

Figure 5.1 - Respondent companies' profile and countries
Source: Own elaboration

Table 5.1 - Respondent companies' profile
Source: Own elaboration

INTERVIEWED	EXPERT'S AREA
1	ATC and airport expert, international aviation industry manager
2	ATC expert and manager
3	Airport operational area Director
4	Strategic and operational level airport manager
5	Airport planning and operational strategies expert
6	ATC Specialist, Assistant Director of an airline association
7	Handling operational and manager

Due to his vast international experience, interviewed number 1 deepened the issue, expanding it without escaping the central focus, which greatly enriched the research. For this reason, item 5.2.1 contains some observations made by this interviewee before answering questions that are common to all others.

5.2.1 Answers - Interviewed numbers 1, 2, 3, 4, 5, 6 and 7

Following each question will be presented all answers given by the experts. Some specific names will appear like (...) to preserve the answers identities.

QUESTION/SUBJECT 1
Do you consider that the A-CDM process currently used by EUROCONTROL or FAA's Surface CDM is best suited for use at large and medium-sized airports, or improvements to the process can be implemented in terms of cost reduction and deployment time?

INTERVIEWED 1:

The European A-CDM and the North American S-CDM were developed based on the characteristics and needs of the local airport and aeronautical management. Both can (and should) be customised for deployment in other operating scenarios what is common between the two models. The prerequisite for any Collaborative Decision Making Resource Optimization Initiative is the understanding that the increased global availability of resources comes from LOWER INDIVIDUAL FLEXIBILITY users in resource allocation.

It is the most significant burden of the A-CDM deployment, and without this, there is no BONUS. **Notably, the initial step of the A-CDM (Information Sharing) Operational Model is beneficial in itself for any medium/large airport WITHOUT necessarily imposing the implementation of the A-CDM FULL Model**. It is consolidated in the A-CDM Implementation Manual itself. However, it is UNKNOWN to the vast majority of A-CDM "Experts" in the LA region. In other words**,** **Information Sharing should be implemented BEFORE deciding** whether the full A-CDM implementation makes sense for the airport.

INTERVIEWED 2:

I believe that processes can always be improved. I understand that the main results expected from A-CDM are the reduction of flight delays and the automation of airport resource allocation focusing on the following topics:

a) Speed on landings and take-offs;

b) Security in airport ramp activities;

c) Accuracy in resource utilisation;

d) Detection and prevention of potential problems in airport capacity; and

e) Collaboration in the delivery of airport resources involving all entities.

INTERVIEWED 3:

Before implementing the A-CDM management concept, airports first need to make necessary improvements to their structure. Gaining efficiencies in training their CCO staff will be an achievement to change the culture to prevent the creation of internal barriers. At the beginning here at our airport, we put 100 (one hundred) Control Center employees to Crew Resource Management (CRM) training, emphasising A-CDM. Next, an evaluation of the runway system must be carried out to achieve the maximum performance for that existing structure and propose new work, if any, with the objective of growth. It has been our way.

We have just done a Track System improvement study, aiming at a capacity jump in this variable. In practical terms, our Airport jumped from 47 (forty-seven) movements/hour (2012) to 57 (fifty-seven) movements/hour in 2020 (before the pandemic), without significant work being performed on the Runway System. We closed 2019 as the 4th most punctual airport in our category in the world.

INTERVIEWED 4:

The European and American models have the same goals with slight variations. In the US, the central agency is the FAA, similar to Brazil, while in Europe, EUROCONTROL needs to centralise particularities of each country. Either model will depend specifically on the operating environment of the airport.

Of course, an airport that has deployed automated command and control processes (inside the airport, we have some focused on the monitoring and management of luggage, passengers and aircraft) will have tools that will assist in the implementation of the A-CDM concept, so some timeframes and implementation costs may be reduced, but will always depend on initial analysis.

INTERVIEWED 5:

I think it is necessary to be more pragmatic, notably regarding the complexity of the existing system/requirements. For example, suppose there is no problem with runway capacity. In that case, it seems, there is no need to sequence departure flights through an algorithm but only calculate the earliest departure time based on the most constraining schedule, including arrival time + Minimum Turn-round Time (MTT). This kind of solution is less expansive and associated deployment shorter.

INTERVIEWED 6:

The A-CDM and Surface A-CDM processes are suitable for large airports, as there are some unavoidable stages of the process, such as training and awareness of all those affected by the process, as well as the implementation of Airport CDM Information Sharing Platform (ACISP), the Pre-Departure Sequencer (PDS) and/or Departure Manager (DMAN). In any case, A-CDM does not necessarily need to be implemented at these airports. Some conditions need to be verified to justify implementation, notably if there is a relationship between demand and capacity, in which the operational restrictions to be imposed are necessary.

INTERVIEWED 7:

Generally, I think the A-CDM processes in use today are well suited, even for medium-sized airports. Keep in mind that A-CDM, as we know it today, is the result of constant reevaluations and is reactive, up to a certain measure, to specific local elements (e.g., not all milestones in use).

QUESTION/SUBJECT 2
For airports moving between 5 and 20 million passengers/year, would a refinement of the current process allow a reduction in cost and deployment time? a) *Where could these improvements be made without compromising the system?* b) *Reducing the number of milestones (from 16 recommended by EUROCONTROL to how many, if yes)?* c) *Of hours of training?* d) *From stakeholders?*

INTERVIEWED 1:

I consider it irrelevant/inappropriate to establish a number of operations, number of passengers or other quantities as defining convenience of A-CDM implementation. The convenience of A-CDM deployment compares DEMAND (traffic volume operating at an airport) and CAPACITY (airport resources and airspace availability around the airport). The closer to saturation is using airport infrastructure and adjacent airspace, the more convenient the A-CDM deployment is.

The A-CDM Implementation Manual recommends, as a first step, to perform a gap analysis for the sole purpose of determining this convenience. In general, it can be considered that the main factors of ramp congestion are: long lines for take-off and ATC take-off restrictions, etc.

The more signs of imbalance between DEMAND and CAPACITY that appear, the greater the convenience of implementing the Operational Model A-CDM is. Regarding the implementation complexity, the number of Milestones to be used must be projected in a REASONABLE and GRADUAL way.

The binomial (RELEVANCE/FEASIBILITY) should determine the desirability of adopting each Milestone at each stage of project implementation, which all stakeholders should fully understand.

Finally, the Training and Stakeholder Number should NOT be saved. On the other hand, the higher the emphasis on training and the more comprehensive the implementation of the model, the shorter the transition time to A-CDM operation.

INTERVIEWED 2:

Yes. They should come from an analysis of existing problems following actions such as:

a) Mapping of interactions between entities (Airlines, Regulatory Agencies and Airport Infrastructure Companies, Air Traffic Control, etc.);

b) Definition of communication standards between entities;

c) Identification, investigation and mapping of operational problems among Airlines, Regulatory and Airport Infrastructure Agencies, to seek possible solutions, including preparatory simulations; and

d) Choice of an Automated Tool for future application to identify issues within the airport allocation yard and detect needed real-time resources. It should be noticed here that there is only citation of choice. Depending on the airport complexity, the system may be compromised when applied.

Depending on the operational efficiency achieved, there could, in my view, be improvements in training hours.

I understand that over time, initially, the training problem would take many hours until the concept was as mature as possible. Logically, the efficiency and effectiveness of this training must be monitored using indicators that support decision making on the possibility of some type of cost reduction without prejudice to the A-CDM. Not only in a linear way among the participants but also separately (qualitatively) by each entity involved.

As for stakeholders, I understand that there could be a reduction, but, as described above, for training, it would be necessary to monitor this impact within the concept of collaboration that should exist. I believe that, for this decision making, preferably, the use of requirements specification (monitoring) techniques should be used to map possible operational problems with such decision.

Here, the technique of stakeholder interviewing should be applied to gather important strategic information regarding the relationships between them: airlines, airports, passengers and users (society), operational personnel. It is necessary to verify and certify if, even with the reduction of stakeholders, the objectives of the system and the delivered product remain at the desired level, so that the parameters to guarantee the expected quality are maintained.

INTERVIEWED 3:

I would do the same as in Question 1. Obviously, less complicated airports will have more straightforward and cheaper solutions.

I think that every process should be simple, i.e. the KISS (Keep It Simple, Stupid) principle. Regarding the reduction of training hours and stakeholders, for the authorities Migration, Customs, Sanitary, Agricultural, etc., I would say that the lectures would be enough. For Airlines, Airports, and Air Traffic, the thing is a lot heavier.

INTERVIEWED 4:

a) People management, mainly training;

b) It is the initial concept that should be implemented;

c) It depends on the operating environment in which the airport will be included;

d) It has to be a full mesh project, otherwise deploying at a single airport will not bring any results;

e) Need analysis (one solution for each airport).

INTERVIEWED 5:

a) First of all, I think it's more relevant to talk about the number of movements instead of the passenger. If we want to appreciate the CDM philosophy, it is more a question of infrastructure capacity balancing/airside constraints on an airport. For airports without capacity constraints, CDM process/light solution could be implemented quickly and fast as it **would be based only on Information Sharing** and not only a question of size;

b) Yes, for sure, it is not only a question of the number of milestones but more based on the natural constraints of the airport;

c) It is very important to train people, and what we have done in (....) was crossed training to learn about all stakeholders matters/constraints;

d) It is very important to involve stakeholders at the beginning of the project. Sometimes, in small airports, it could be relevant to imagine cofinancing.

INTERVIEWED 6:

a) At airports of this size, the assessment of the need for A-CDM should be checked more often. In principle, **A-CDM can be limited to sharing information** only;

b) In this case, milestones considered essential in the EUROCONTROL manual should be implemented;

c) Training hours can be significantly reduced if there is only Information Sharing, without the need to establish TOBT, TSAT and the consequent implementation of a DMAN;

d) If only Information Sharing is implemented, it is possible the Ground Handlings can be involved only at a later stage, provided that the airlines can share information with the desired degree of precision.

INTERVIEWED 7:

a) Yes, especially if data analysis of A-CDM from airports where the system is well established would show its benefits. In such a case, presenting the project, building workgroups and creating an Information Sharing Platform would reduce deployment time;

b) Some milestones (for example, 8, 11 and 12 - *Chapter 3.5, Table 3.1*) are not in use in some medium-sized A-CDM airports, as they are not deemed absolutely necessary for collecting benefits for ATC and Airport;

c) Increased training hours to guarantee a complete understanding of the system by all partners. Training on Information Sharing, A-CDM milestones, and A-CDM User Interfaces;

d) Nowadays, planning processes and their positive outcome will always depend on the airport capacity to maintain traffic flow, optimally allocate slots and gates and reduce environmental impact. Stakeholders could increase their participation level in A-CDM implementation by jointly considering the benefits for the airport operation and the positive contribution for satisfying passenger experience.

QUESTION/SUBJECT 3
It is clear that in terms of economy, airlines have significant gains in fuel economy. Which other sector(s) do you consider the major financial beneficiary(s) of implementing the A-CDM system?

INTERVIEWED 1:

From a strictly FINANCIAL point of view, airlines, ground handlers and airport operators are the largest beneficiaries, achieving the highest levels of Return of Investment.

INTERVIEWED 2:

In addition to that mentioned in the question (airlines): Airport (COA), passengers and users (society), operational activity - airport in general, air traffic control, environment, handling companies, among others.

INTERVIEWED 3:

The primary beneficiary, besides the Airlines, Airports and Air Traffic, is the PASSENGER. The impact on “OnTime Performance” is vast. Decreases ground and flight hold.

INTERVIEWED 4:

In addition to all the beneficiaries already mentioned: the handling companies.

INTERVIEWED 5:

Air Navigation Service Providers increase the capacity of the airspace and directly the number of incomes. Airports increase their capacity to anticipate delay impact and optimise resources allocations and postpone CAPEX (cash flow related to capital investment expenses, including fixed assets).

INTERVIEWED 6:

Airport, due to the optimisation of resource allocation in the yard and terminals. Airline Company reduced fuel consumption with a reduced taxi-in, taxi-out times, and reduced arrival delays (proper distribution of gates and reduced taxi-in) and departure, if airport and space management aviation avoid unnecessary restrictions to be imposed through the TSAT.

INTERVIEWED 7:

Airport operators such as Ground Handlers can benefit from the better allocation of human resources and equipment in day-to-day operations since there is a much greater flow of information on air traffic, ATC restrictions (CTOT's) and even real-time information Milestone updates.

By playing a crucial role in increasing Network Manager capacity, A-CDM airports will steadily improve the quality of their traffic flow and turn-round process and be able to recover quicker from disruptions or adverse conditions, thus reducing operational costs.

QUESTION/SUBJECT 4
Feel free to make any other observations you think are appropriate.

INTERVIEWED 1:

The summary below offers a new consolidation of concepts:

a) A-CDM Operational Model is a process (not a project);

b) Implementing A-CDM is much more complicated than monitoring KPIs in a collaborative environment;

c) A-CDM is not purchased (not software, not a system, not a service);

d) No A-CDM implementation by individual stakeholder initiative/decision;

e) A-CDM must integrate Airport with ATFM;

f) Airport Operator is A-CDM's natural operating leader;

g) Airlines have the most significant efforts and most considerable benefits of A-CDM;

h) A-CDM implementation follows a logical and gradual sequence;

i) A-CDM operating model can be adapted but not corrupted;

j) A-CDM seeks to optimise turnaround processes based on existing airport infrastructure and airspace capacity.

After answering the structured questions, the interviewed 1 made some interesting supplementary commentaries described below. He takes a more systemic approach to what it means to effectively implement the A-CDM Operational Model or any other similar model (such as the US S-CDM).

- <u>Basic Principle</u>: Any process that seeks to increase the GLOBAL AVAILABILITY of resources shared by multiple actors requires REDUCING the INDIVIDUAL FLEXIBILITY of the actors in blocking these resources. This restriction applies to any environment. In the case of A-CDM, we are talking about airport infrastructure and airspace around the airports involved, which is why A-CDM and ATFM are TWIN integrated processes.

Following on from his commentary, he attached an article on the A-CDM / ATFM processes, which he considers to be twin brothers. He stresses that it does not matter what angle you look at them. You can look down from the perspective of ATFM and see airports as departure sources, which need to ensure that they remain in the available slots in airspace when releasing flights for take-off. *That's what A-CDM is about*. Or, instead, we can choose to take a ground-to-air view from the airport's perspective and view ATFM as the central airspace manager. It should cause minimal disruption to the airport's planned activity, balancing use or the airport's ability to approach and its take-off demand while providing proactive guidance to avoid significant runways and surface congestion at the airport. *That's what ATFM is about*. It concludes that no matter what the approach is, one can only think of air traffic efficiency as an end-to-end process. ATFM and A-CDM need to be seen as fully integrated components of a broader effort. Then, regulatory agencies, air navigation service providers, airport operators, airlines and ground handlers will finally understand that collaboration and information sharing are not specific requirements of A-CDM but somewhat inherent needs of air transport activity itself.

It is a trade-off that Latin American airlines have no idea about, and certainly, when they realise what it means to receive a Target Start-up Approval Time (TSAT) for each flight with a window of (-5/+ 5) minutes of tolerance, they will HATE A-CDM. In Europe and the US, this trade-off is well-known and accepted because infrastructure saturation is more significant than in Latin America. It takes pain to understand and take bitter medicine.

A-CDM (overview): For practical purposes, it is appropriate to split a GRADUAL A-CDM implementation process into three distinct steps which, as reiterated in the EUROCONTROL Handbook, should follow their logical implementation sequence as it is highly recommended to implement the Airport CDM Concept Elements (according to the order in this document):

a) The dramatic increase in Situational Awareness among stakeholders. This process will be ESSENTIAL for Airlines to be able to provide TOBT (Target Off-Block Time) of their flights;

b) TOBT Allocation by Airlines for each flight; and

c) Establishment (by ATC) of Take-off Sequence by allocating TSAT for each flight.

Note: The above sequence supports the principle that the initial A-CDM (Information Sharing) step yields concrete and specific benefits even if a FULL A-CDM implementation with TOBT/TSAT allocation (which is where reduction of individual flexibility for airlines).

The Latin American Challenge: Latin America has an additional challenge to address -in addition to the saturation level of our infrastructure- airport/airspace is not comparable to Europe and the United States.

After his comment, he attached two other articles that focus on the Information Sharing processes and the importance of real understanding of the term "collaborative".

In the first one, on Information Sharing, the question arises: Why is it IMPOSSIBLE to manage SAFELY and EFFICIENTLY the airside in “BLIND MODE”?

And responding, he mentions that: "The best thing in history is to learn from it"! Back in the early 1930s, when the first PSR (Primary Surveillance Radars) was used to provide continuous surveillance of aircraft flying in airspace. When, at that time, an important message was learned: "Accurate knowledge of aircraft positions would allow for a reduction in normal patterns of procedure separation, which in turn promised considerable increases in the efficiency of the airway system." Further, in response to the need to identify Friend or Foe (IFF) aircraft during World War II, Secondary Surveillance Radar (SSR) was created as a means of providing positive aircraft identification. And to this day, technically enhanced versions of PSR and SSR are widely used to enable Air Traffic Controllers to SAFE and EFFICIENT airspace management. Air traffic controllers are needed to reduce the separation between aircraft and make maximum use of airspace to safely and efficiently accommodate an increasing number of aircraft. Under such a challenge, nothing could be as useful as viewing the aircraft in real-time, thus ensuring maximum awareness of the situation at all times. And it leaves the question open: “Why would it be any different with the airside of an airport?” It is not!

In the same way that air traffic controllers depend on full awareness of the situation, to manage air space safely and efficiently, several stakeholders with the task of managing the airside collaboratively, depending on the ideal level of awareness of the situation, to make the best-coordinated use of the various resources available on the airside gates, trucks, cars, tugs, buses, equipment, etc. Let's take a look at the famous A-CDM mode of operation and its TOBT assignment. Would it be fair to challenge airlines (and ground handlers) to dramatically improve the accuracy of their estimates (TOBT), with the airside still managed in “blind mode”? And leave a question that has the answer embedded: How can we expect airlines and ground operators to improve their forecasting capabilities without providing them with the ability to, at the very least, view aircraft and vehicles, in the same way that air traffic controllers do on ATC facilities?

In the second article he attached in the interview, he comments on the A-CDM process and the connection with the word “COLLABORATIVE”, which should trigger a message to alert airport stakeholders (concessionaires, airlines, navigation service providers) aerial, soil handlers) that the spirit of positive collaboration is a non-negotiable value for those considering implementing the CDM operational model at an airport.

He concludes his speech by emphasising that many things must be customised to create viable models for Latin America and that sometimes people leave reality, going far beyond understanding what is being done in Europe and the USA without starting to walk into the specificities of our region, where some ESSENTIAL differences require a different view. For example:

- The level of stakeholder situational awareness at LA`s airports is deficient. For this reason, I consider it to be essential to separate Information Sharing (ACISP + Surface Surveillance) from other A-CDM Concept Elements. In this way, you can promote a drastic increase in the level of situational awareness (which produces its benefits). In a second step, you can define whether or not to implement TOBT / TSAT, which will affect the flexibility level of airlines;
- The absence of surface surveillance is an absolutely critical barrier to efforts toward A-CDM. I do not believe in any CDM initiative that does not involve implementing a surface surveillance network.

ADDITIONAL NOTE:

Respondent number 1, before answering the questionnaire, and afterwards made precious comments for the survey, which we will transcribe below.

He began by stating that implementing the A-CDM Operational Model (which is much more complicated than a "collaborative acting culture") is strictly associated with hugely congested operating environments. Where airlines are challenged to accept a drastic reduction in operating flexibility, to achieve greater GLOBAL resource availability (airport and airspace), it might not be justifiable for most airports in Latin America (LA), yet. He stressed that it is incorrect to associate the implementation of the A-CDM Operational Model with significant financial investments.

He reiterates that the objective complexity associated with the deployment of the A-CDM, which imposes a reasonable implementation time, is CULTURAL since the model is based on a DRAMATIC CHANGE in the behaviour and actions of the main stakeholders (mainly airlines and operators in the ground). This fact is aggravated by the typical misunderstanding about this requirement by the stakeholders in the LA region. They have decided to implement the A-CDM operating model without really understanding what it is, what it implies, and what scenario is justified to implement it. Obviously, the European Model can (and should) be customised and adapted to the reality of each country, WITHOUT RUNNING. However, in its essence, which requires a reasonable time of conception, implementation and continuous optimisation. It is not a PROJECT! It is a new Airport operation PROCESS that should be introduced.

INTERVIEWED 2:

The A-CDM concept proposes effective data sharing among actors involved in airport activity and air traffic flow management. It enables greater predictability of events, optimisation of operating resources, better structuring of ramp areas for aircraft movement, reduction of CO_2 emissions and aircraft noise, among other benefits. Thus, the Collaborative Airport Decision Making Process is the primary tool used today to search for integrated and intelligent solutions for the rationalisation of aircraft movement at airports.

Any A-CDM effort will inevitably involve data sharing. If appropriate data is shared in a way that allows direct access to places of interest, performance is undoubtedly improved. Besides, A-CDM data sharing will provide insightful post-operational analysis and recording of typical and unusual operational trends, allowing for better planning and, therefore, better operational predictability.

INTERVIEWED 3:

European airports, such as ours in (...) with 43 million passengers/year, operating with 42 different airlines, A-CDM is essential to gain efficiency in operation.

INTERVIEWED 4:

He made no further comments.

INTERVIEWED 5:

He made no further comments.

INTERVIEWED 6:

The great challenge of implementing A-CDM is that it is a cultural change at the airport, with reduced operational flexibility for airlines and the need for training and behavioural change for many people. Due to this aspect, it is challenging to facilitate the implementation time frame, considering that the necessary tools (ACISP and PDS) can be acquired on the market and customised for a specific operating environment. Another critical challenge is the establishment of the essential requirements for such customisation, which requires the participation of all previously trained stakeholders.

INTERVIEWED 7:

He made no further comments.

5.3 Survey

This survey which represents half of the present Chapter 5 (Interviews and Survey) was elaborated, among others needs, for clarification, in some features supported by the responses collected in the interviews, which are in the first part of this chapter. Thus a questionnaire will serve as the basis for the Analyses and Conclusions (Chapter 6) and Final Considerations (Chapter 7).

The questionnaire was sent directly to 154 (one hundred and fifty-four) professionals from different areas related to the airline sector. Straight to two Internet discussion groups (email). Such groups had, on average, a total of 70 (seventy) members. It is not possible to specify the number of people in the groups who received the emails. As there are groups with many participants, they are not very accurate, and not everyone regularly opens their emails. We received 39 (thirty-nine) responses from those sent directly, and from those groups, we received 16 (sixteen) responses. The introductory and presentation part of the questionnaire is contained in the text below. Additionally, for each specific type of respondent group, a detailed initial message was added to the email:

- **RESEARCH ABOUT A-CDM**

This research is carried out within the scope of the University of Beira Interior (UBI), Covilhã - Portugal, Department of Aerospace Sciences, PhD course in Aeronautical Engineering, and with the support of the Transportation Research Center (NIT) of this University.

The purpose is to collect data that can support research that is being developed on Airport Collaborative Decision Making (A-CDM). It bears in mind that the implementation of any aviation process aims typically at improving safety, efficiency and economy.

The data collected here will be treated confidentially without mentioning the names of the respondents.

After processing the data, we can analyse facts that allow us to evaluate some details pertinent to each phase of a flight from preboarding, boarding and development of the same, all are aiming to examine the importance of applying A-CDM within a cost-benefit analysis.

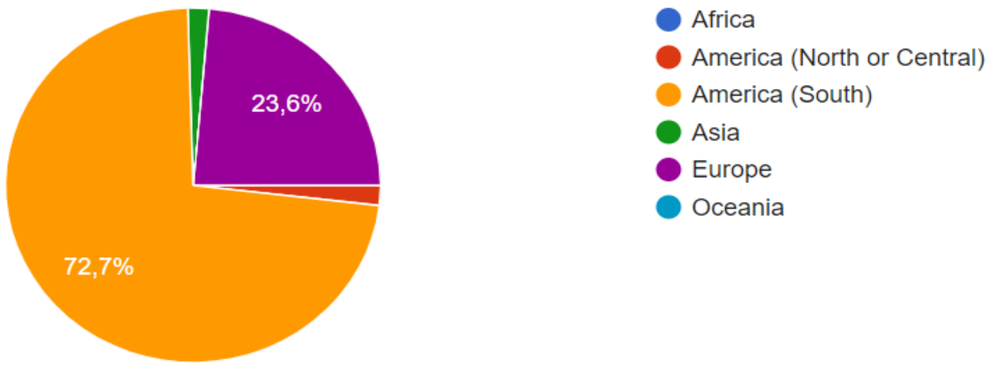
5.3.1 Answers

5.3.1.1 First part - Initial information about respondents

The first part of the survey contains the summary data on respondents, seeking to identify the percentage profile, asking where they live, what area of expertise each has in the airline industry, how long they have been working in aviation and what knowledge they have about A-CDM.

QUESTION 1: What is your continent of residence?

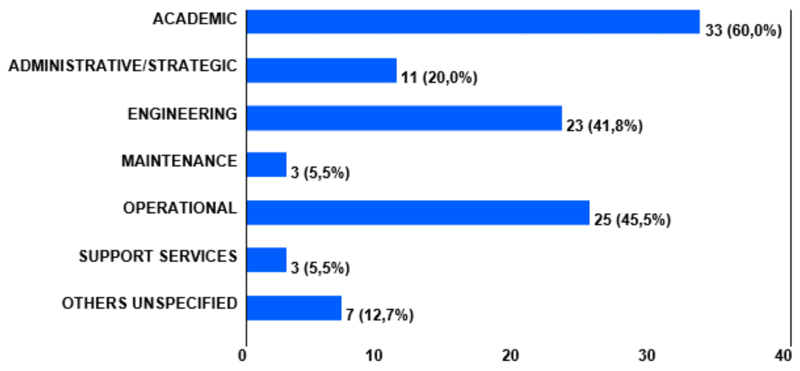
55 replies



Graphic 5.1 - Answers on Question 1 (Initial information), as specified in 5.3

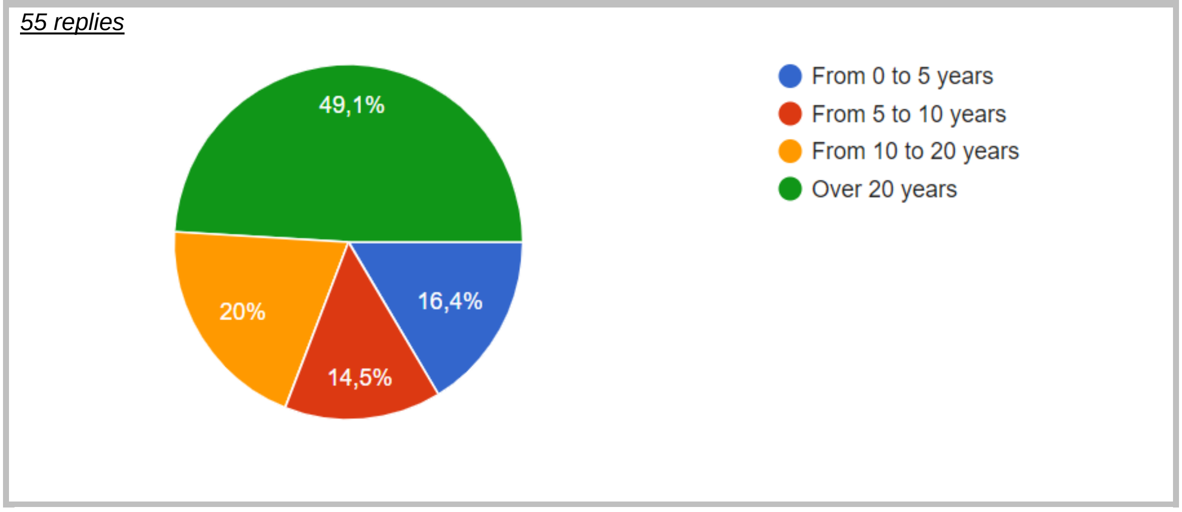
QUESTION 2: What is your area of expertise in the Aviation Sector *(respondents could choose more than one of the alternatives)*?

55 replies



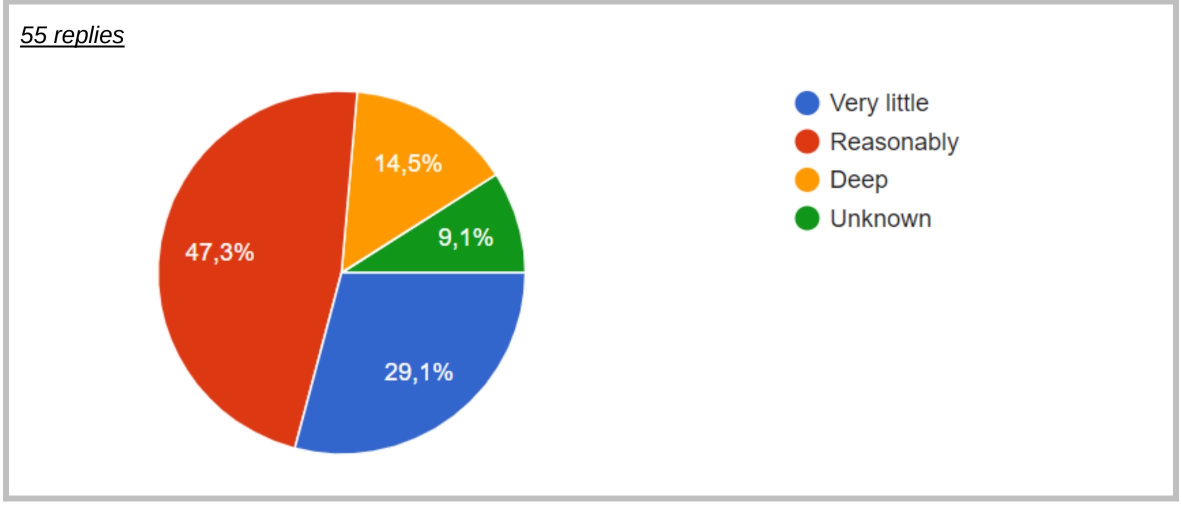
Graphic 5.2 - Answers on Question 2 (Initial information), as specified in 5.3

QUESTION 3: How long have you been participating professionally in the aeronautical environment?



Graphic 5.3 - Answers on Question 3 (Initial information), as specified in 5.3

QUESTION 4: As for the A-CDM process, what about you know?



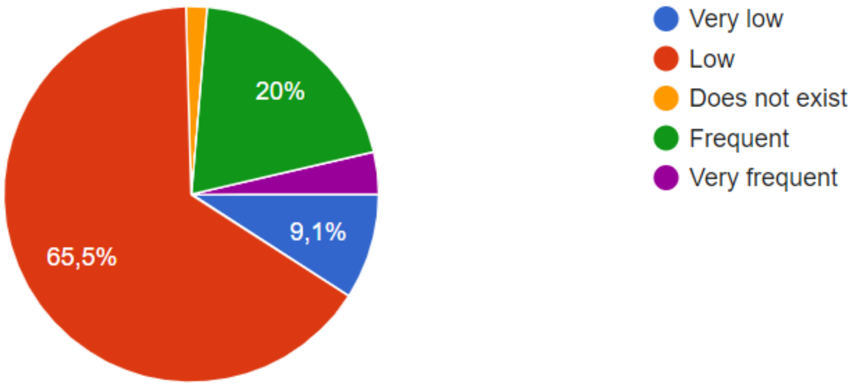
Graphic 5.4 - Answers on Question 4 (Initial information), as specified in 5.3

5.3.1.2 Second part - Delayable procedures

The second part of the questionnaire seeks to explore the experience as an active member of the respondents' airline industry and an eventual passenger, asking them to select the probabilities of delay in the described procedures.

QUESTION 1: Airline check-in procedure:

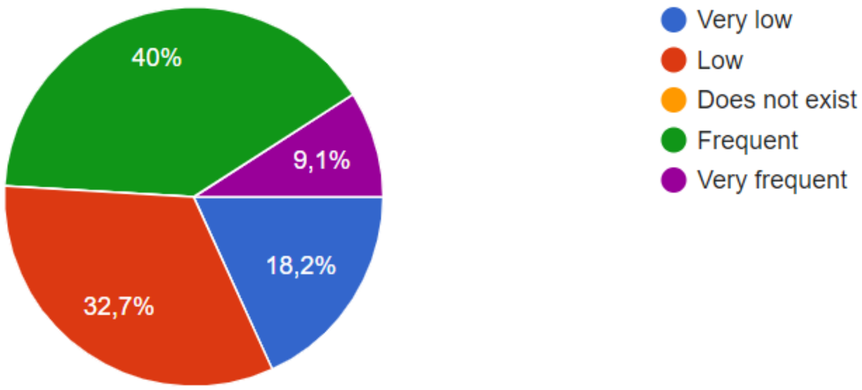
55 replies



Graphic 5.5 - Answers on Question 1 (Delayable procedures), as specified in 5.3

QUESTION 2: Security inspections procedures (X-ray, hand luggage, etc.):

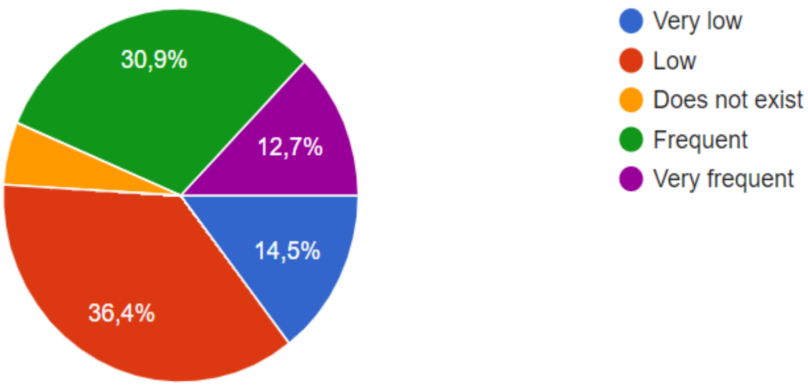
(55 replies)



Graphic 5.6 - Answers on Question 2 (Delayable procedures), as specified in 5.3

QUESTION 3: Passport verification before departure (only applicable for international flights):

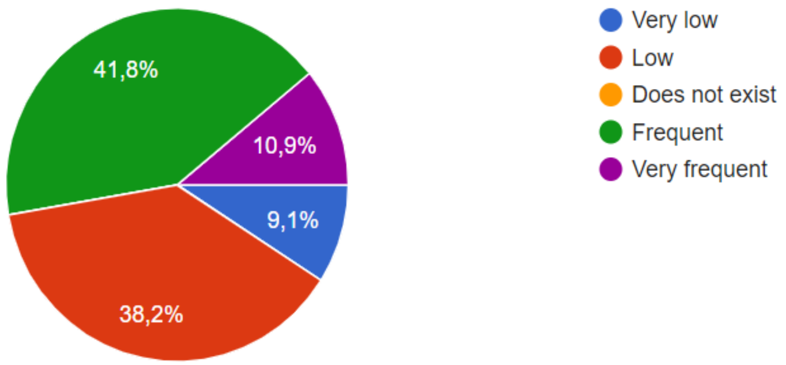
(55 replies)



Graphic 5.7 - Answers on Question 3 (Delayable procedures), as specified in 5.3

QUESTION 4: Waiting in the departure lounge during the turn-round period (disembarking passengers and luggage, cleaning and refuelling of the aircraft, boarding of catering, crew and new passengers until the door closes):

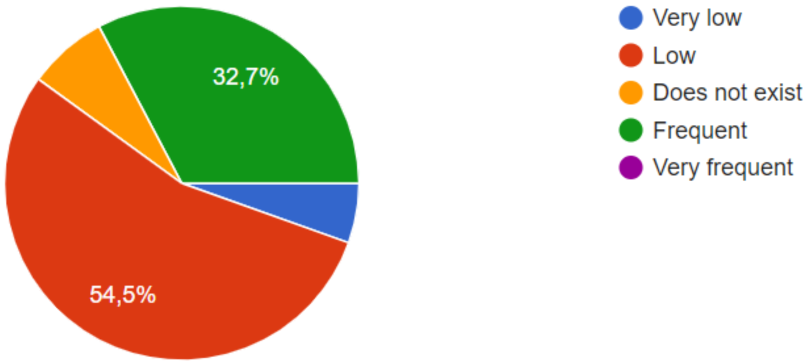
(55 replies)



Graphic 5.8 - Answers on Question 4 (Delayable procedures), as specified in 5.3

QUESTION 5: Delay of airline employees in checking boarding passes, identification documents, and boarding all passengers in the departure lounge for the flight:

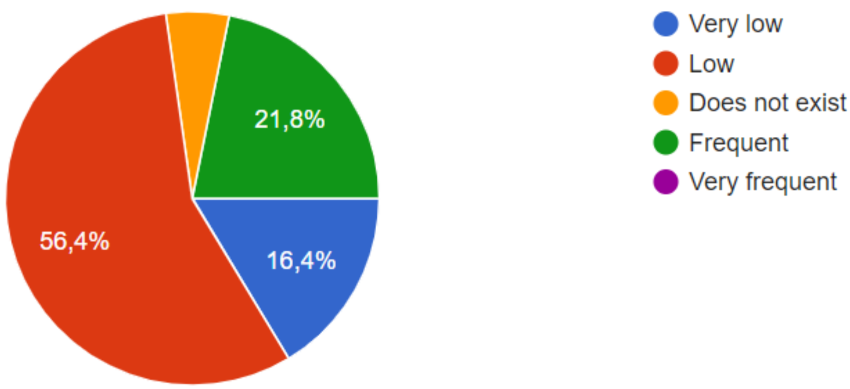
(55 replies)



Graphic 5.9 - Answers on Question 4 (Delayable procedures), as specified in 5.3

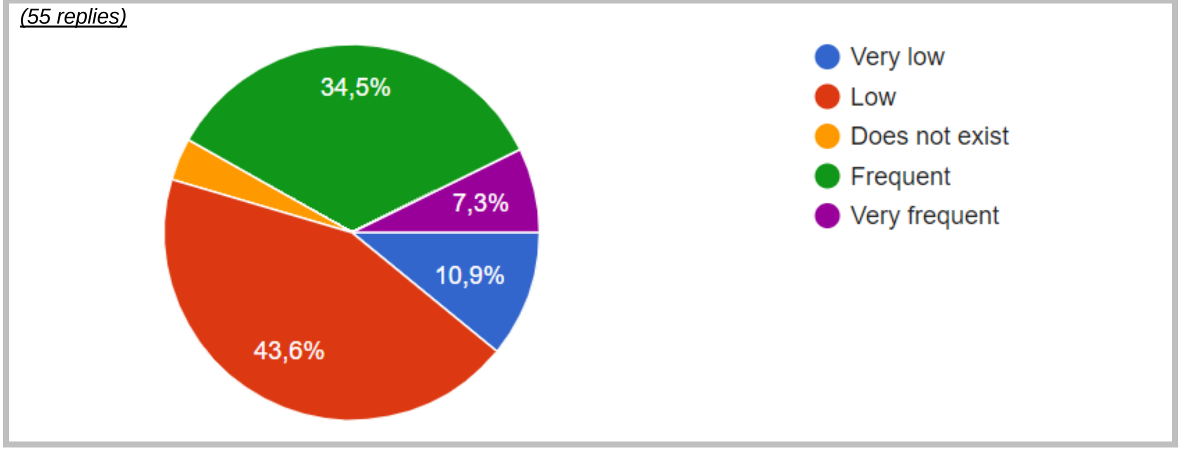
QUESTION 6: You are staying on the ground, inside the aircraft, due to waiting for connecting flights:

(55 replies)



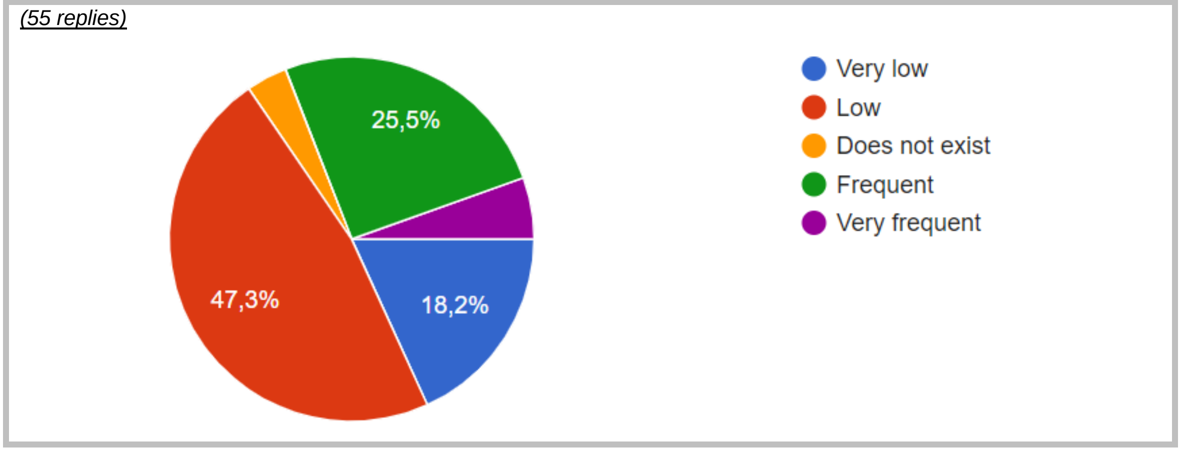
Graphic 5.10 - Answers on Question 6 (Delayable procedures), as specified in 5.3

QUESTION 7: Stay inside the aircraft after boarding awaiting air traffic authorization:



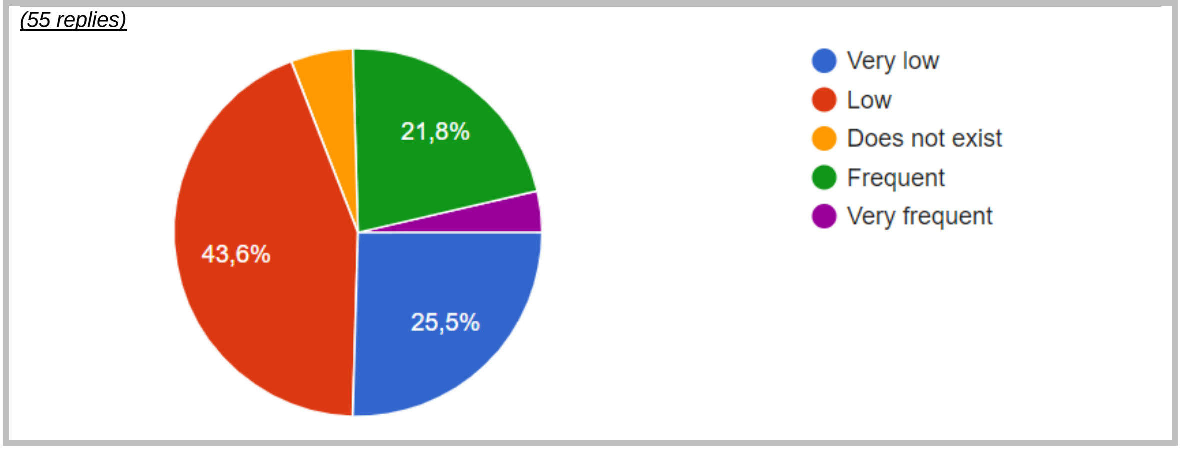
Graphic 5.11 - Answers on Question 7 (Delayable procedures), as specified in 5.3

QUESTION 8: Delay during the taxi procedure until the moment of take-off:



Graphic 5.12 - Answers on Question 8 (Delayable procedures), as specified in 5.3

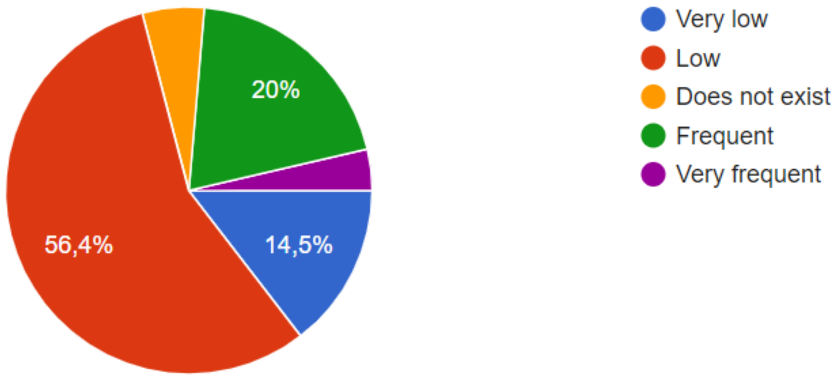
QUESTION 9: In-flight delays were forcing the flight to perform holding procedures due to aircraft problems:



Graphic 5.13 - Answers on Question 9 (Delayable procedures), as specified in 5.3

QUESTION 10: After landing, delay during the taxi procedure:

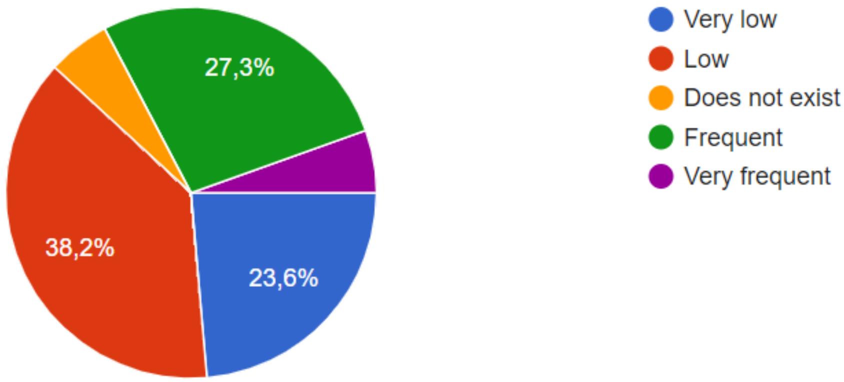
(55 replies)



Graphic 5.14 - Answers on Question 10 (Delayable procedures), as specified in 5.3

QUESTION 11: After aircraft parking, delay in opening the door and disembarking:

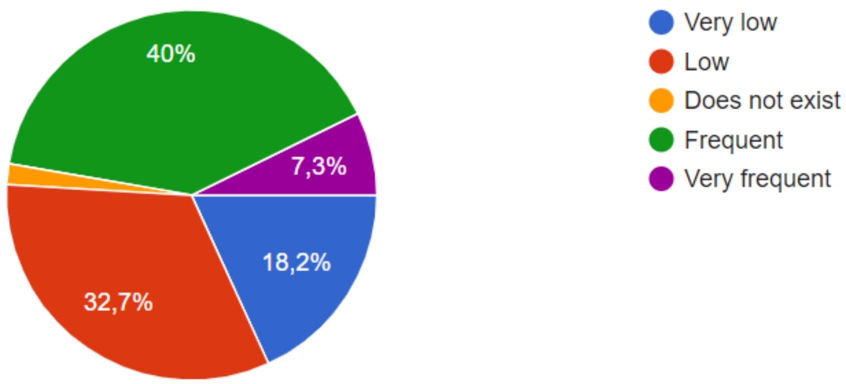
(55 replies)



Graphic 5.15 - Answers on Question 11 (Delayable procedures), as specified in 5.3

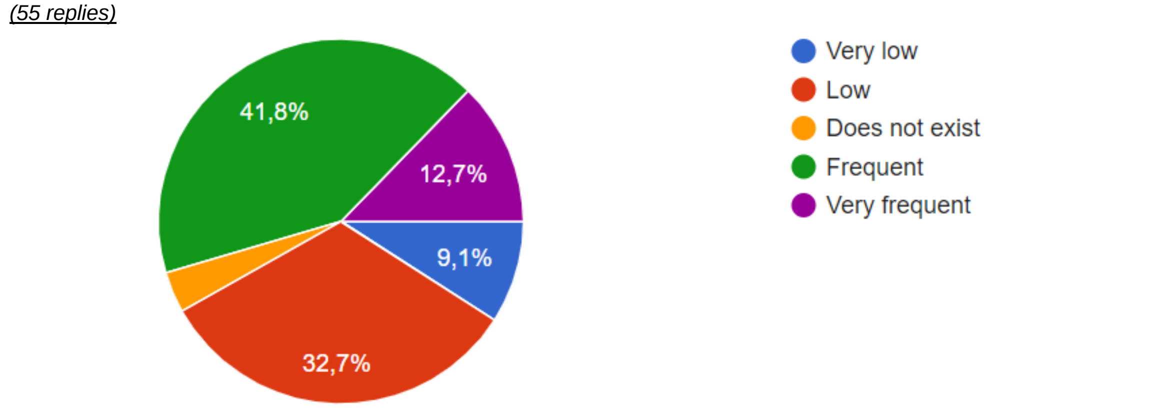
QUESTION 12: After disembarking, delay until reaching the exit door to the airport lounge due to passport inspection procedures (only applicable for international flights):

(55 replies)



Graphic 5.16 - Answers on Question 12 (Delayable procedures), as specified in 5.3

QUESTION 13: After disembarking, delay until reaching the exit door to the airport lounge due to baggage claim:



Graphic 5.17 - Answers on Question 13 (Delayable procedures), as specified in 5.3

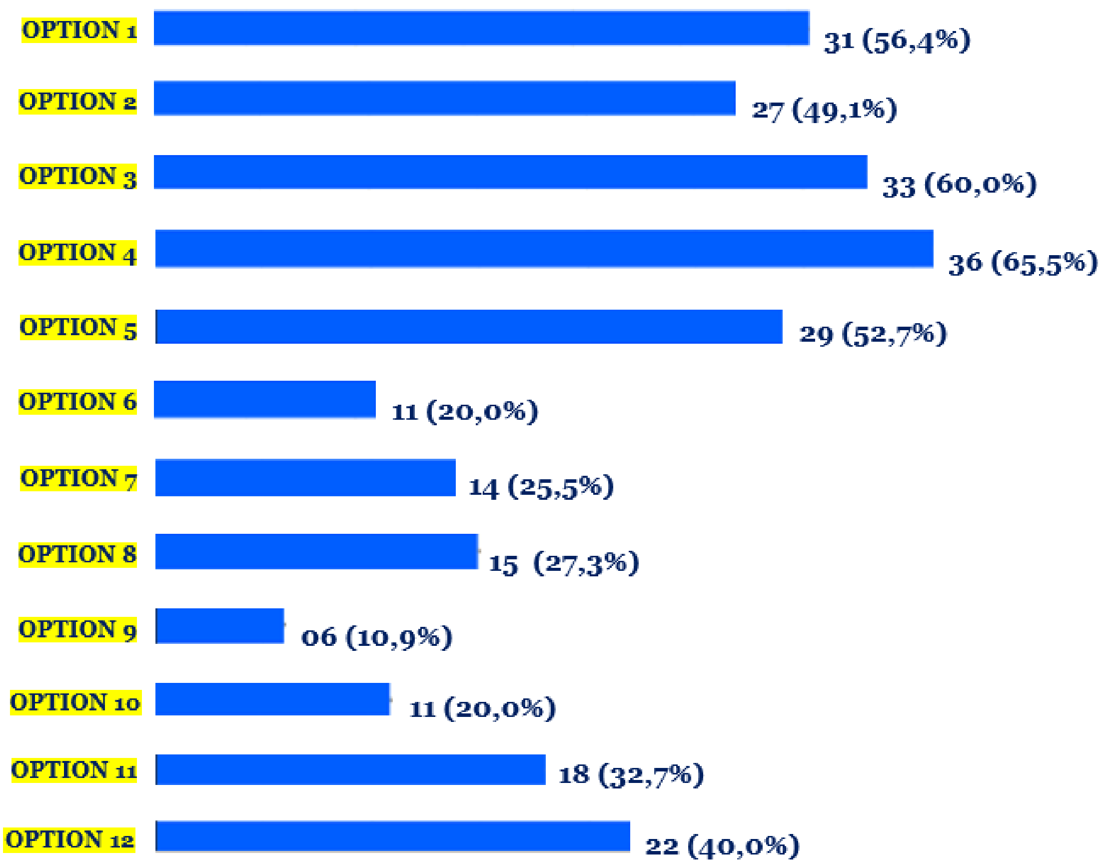
5.3.1.3 Third part – Sharing information

The third, and last part of the questionnaire, seeks to explore sharing information. The first question is asking the respondents, as an aeronautical manager, to act better in a coordinated way at an airport, which of these stages (milestones) of a flight, would they like to be informed of their forecast and have a regular update?

Although all are of significant importance, they are oriented to choose five options to better carry out the evaluation.

Table 5.2 - Questions about SHARING INFORMATION
Source: Own elaboration based on the research as explained in 5.3.1.3

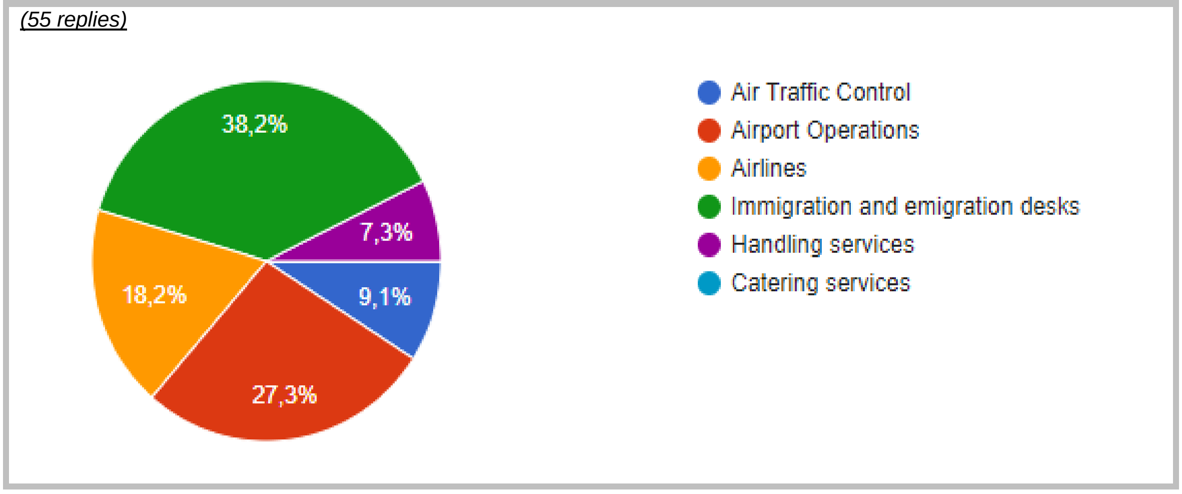
OPTIONS	TYPE OF INFORMATION SHARED	Respondents	
		N.º	Percentage
OPTION 1	Early-Departure Planning Information Message (previously message about Flight Plan)	31	56,4%
OPTION 2	Estimated take-off time from the departure airport	27	49,1%
OPTION 3	Actual take-off time from the departure airport	33	60,0%
OPTION 4	Estimated landing time at the arrival airport	36	65,5%
OPTION 5	Actual landing time at the arrival airport	29	52,7%
OPTION 6	Estimated taxi-in time (between landing and in-block)	11	20,0%
OPTION 7	Estimated in-block time (when aircraft will be in-blocks)	14	25,5%
OPTION 8	Estimated turn-round time (the time between "in" and “off-blocks”)	15	27,3%
OPTION 9	Estimated off-block time	06	10,9%
OPTION 10	Actual off-block time (aircraft start movement associated with departure)	11	20,0%
OPTION 11	Estimated take-off time	18	32,7%
OPTION 12	Actual take-off time	22	40,0%



Graphic 5.18 - First Question answers (sharing information), as specified in 5.3.1.3

The second question in the first step highlights that "to discipline airport operations, it is necessary to share information and work in a coordinated manner with established time parameters", and the question was asked based on this statement.

SECOND QUESTION (sharing information): Which of these stakeholders do you think would have the most difficulty adapting to the set standards (choose only one)?



Graphic 5.19 - Second Question answers (sharing information), as specified in 5.3.1.3

5.4 Conclusions

In the first part of the survey, the interviews were conducted for 60 (sixty days), from the first week of December 2019 until the last week of February 2020. The questionnaire had its answers collected during thirty days, between February and March 2020. Even before the beginning of the restrictions imposed by the pandemic.

We gave all respondents the option to respond personally (via Skype or Zoom), an interview that we would transcribe and send to their address, or through written responses. All of them chose to respond in writing, claiming, for the most part, that they considered that the level of quality and quantity of information would be better.

As explained in the Introduction, regarding the structure of the Thesis, more precisely on the chapters that contributed to the analyses and conclusions (DEEPENING INTO A-CDM, AIRPORT CASE STUDIES and INTERVIEWS AND SURVEY), the Interviews and Survey represent, in terms of quantity of information, 1/3 (one third) of the contribution. If we analyse it coldly, in terms of percentage, it contributes 33.33% of the total. Thus, the questionnaire represents around 16.66% of the contribution to the whole. For sure, the representativeness of each of these chapters, when performing analyses, weighed differently.

The questionnaire, as already explained briefly in 5.3, was sent directly, via email, to 154 (one hundred and fifty-four) professionals from different areas of the Air Sector, such as Airport Operators and Managers, Air Traffic Controllers, Academics related to aviation activities, aeronautical engineers among others.

Indirectly, (collective) emails were sent to two Internet discussion groups. Such groups had, on average, a total of 70 (seventy) members. In terms of vested interests, one of the discussion groups, approximately 50% of this sample, was composed exclusively of specialists in air traffic control and the other by a great diversity of members of the air sector, as mentioned in the previous paragraph. It is not possible to specify the number of people in the groups that received such messages because they have fluctuations in the number of participants (bearing in mind that not everyone opens their emails regularly).

Of the 154 (one hundred and fifty-four) questionnaires sent directly to the answers emails, we received 39 (thirty-nine) responses, and those sent to the two discussion groups that 70 (seventy) members integrated, we received 16 (sixteen) responses.

From the messages sent directly to the respondents, the rate of return was 25.32%, and the rate of responses in the groups was 22,86%.

For a more precise analysis of the return rate, it is more appropriate to use only the data of the values collected when the questionnaires are sent directly to the respondents, considering that we cannot accurately specify the number of members of the Internet discussion groups. Thus, if we think the 39 (thirty-nine) responses received from the 154 (one hundred and fifty-four) questionnaires directly sent, we will have a 25.32% return rate. This can be considered a reasonable number since, for Marconi and Lakatos (2005), questionnaires sent to the interviewees reach an average 25% return.

The specific results (ANALYSIS AND CONCLUSIONS) collected from the interviews and questionnaires will be analysed in the next chapter (in 6.4).

Chapter 6. ANALYSIS AND CONCLUSIONS

6.1 Introduction

In this chapter, conclusive analyses will be carried out on the content of the Thesis, according to the established sequence, maintaining the strategy analysis based on the Second Pillar of the Thesis (SUPPORT): Documental Support, Practical Support (Case Studies) and Stakeholders Support (Interviews and Questionnaires).

When analysing the interviews, questionnaires, and case studies, we cannot deviate from the two theories that guide an airport system, the Systems Theory and the Complexity Theory. The Airport System is constantly interacting and mainly suffering environmental influences, tending to become disorganised. Thus, we consider, and all analyse the assumption that: the entire process, which needs to be implemented, must always take into account the existence of this constant interaction and be a support, so that the tendency to disorganisation is always, and constantly, nullified by processes that aim systematise operations and contribute to the organisation and maintenance of safety.

We have been able to verify, in previous chapters, that the complexity of a CDM implantation in large airports received several approaches from the signatory countries and their ATM systems, all supported by the ICAO GANPS. In all of them, we can see confluence points that should always be part of the A-CDM processes regardless of the airport's size. However, we would like to reaffirm that the process will always involve three significant stakeholders: **airport, air traffic control** and **aerial carriers**. Always connected around a regulatory entity and based on the application of the recommended Operational Concepts (ConOps), applicable to each State.

One of the significant challenges now is continuing this implementation (present in more than a hundred large airports globally) in smaller airports and with low investment capacity. In a systematic and integrated way, these airports, feeders of the system to the extensive world air traffic system, must also have processes of control and transfer of information and data.

It is a matter of discussion that the following steps to be taken in the global A-CDM processes, in addition to targeting other busy and uncoordinated airports, will also focus on airports with fewer aircraft and passenger capacity in countries with fewer aircraft capacity investments. It is a challenge for current and future researchers, as this complex process can be simplified to be applied on a smaller scale. They may be looking for ways to reduce the number of stakeholders and compress the now recommended milestones without losing the safety and efficiency of the process.

6.2 Regulamentar analysis

In addition to addressing the CDM, the ICAO legislation in a very comprehensive way for its use in airspace coordination also provides specific recommendations for service in airports.

In Chapter 3, of this Thesis, we could well observe it distinguishes the two recommendations presented in its legislation wherein the ASBU Blocks it discriminated:

- A first phase, called BLOCK 0, when it is emphasised the correct and coordinated sharing of information; and
- In BLOCK 1, of a subsequent application, already stressed , the so-called Airport Operations Optimized Through Total Management of the A-CDM airport. Which then addresses the planning and management of airport operations, allowing their full integration with the ATM, using performance targets compatible with those of the surrounding airspace. Such evolution then implies the implementation of a collaborative airport, with the application of operations planning and, when necessary, an Airport Operations Centre (APOC). These APOCs would be implemented in complex airports, and their sophistication would depend on the complexity of the operations and their effects on the network.

The positioning of the FAA and EUROCONTROL begins by valuing the CDM process and, as seen in Chapter 3, establish systematic criteria and methods for implementing an A-CDM at its most advanced level. This criteria is highly complex and will require a reasonable implementation time, usually more than two years, and consistent financial investments. These implementation times and the financial cost, which were estimated, are due to some generic analyses, as the estimates were by Eurocontrol presented in Chapter 4 (Case Studies). But without any exact proof of documentation as they are not made available by airports that have already had the experience -or are in the process of being implemented-. Even when questioned, their managers avoid talking about numbers. The associations of companies and professionals in the Air Sector, like IATA and CANSO, in their publications about A-CDM, are educational when explaining the process and positively value its importance in saving resources and time.

There are not many academic articles on this subject. However, all existing ones only analyse the A-CDM positively and as an improvement factor within the Sector. No article or publication was found citing operational deficiencies that could occur due to the implementation of A-CDM in Airports.

6.3 Cases studies

As we have already mentioned, this subject, being relatively new and often dealt with in a reserved manner by airport managers, is very limited in application documentation and costs. We can only find it in a EUROCONTROL document and through, as already reported, the course performed at IANS. In Chapter 4, we show 8 (eight) successful case studies. In two of these airports, Madrid - Barajas and Amsterdam, we went a little deeper. About the others, the data was presented compactly, privileging the operational and financial advantages: Berlin, Brussels, Frankfurt, Helsinki, London (Gatwick) and Paris (Charles De Gaulle).

In addition to the excellent fuel economy observed in all airports where the implantation was carried out, according to data from EUROCONTROL (2016) represented in the 17 (seventeen) airports where the A-CDM was implanted, based in 2,1 million departures, an annual saving of approximately € 26 million in fuel. Also, there are considerable gains in time reduction in the taxi (2,200.00 minutes), reduction of workload for controllers, airport operators, handling companies, and for the crew itself, in addition to the significant decrease in the emission of toxic gases by burning fuel (102,700 tonnes of $CO2$ and 28,700 kg of $SO2$).

The enormous advantages resulting from applying the A-CDM are undeniable; it was also not possible to establish an average implementation time. There are many determining variables, from the number of people involved in the project to the disbursement capacity of airports concerning the project. We verify informally and without supporting documents periods that vary from 2 (two) to 4 (four) years so that the implementation can be considered complete.

As explained in 4.3, implementation costs also have an extensive variation from Low to High Cost, with a variety of € 750 thousand to up to € 5 million. It was also seen in the cost-benefit analysis carried out in Chapter 4 (4.10) and, substantiated by Table 4.2, that Assuming a Medium implementation cost scenario, on average, A-CDM provides a return on an investment after 18 (eighteen) months and a CBR of 7 (seven) over 10 (ten) years.

Although all the positive results were obtained, it can be verified that the most significant financial benefit goes to the airlines. The gains from airports are minimal compared to airlines. They are restricted to greater service efficiency and reduced time spent on the ground, increasing air movement. This fact does not motivate airport operators to invest much. There is a need for time to train all stakeholders, and the cost scares all managers challenged with this implementation. Therefore, one more reason to look for more economical and low-cost ways of implementation.

6.4 Interviews and survey

6.4.1 Interviews

The interviews presented in Chapter 5, were applied to international experts in airports, air traffic control and related industries in Europe and the Americas, all knowledgeable or involved with A-CDM processes. It was carried out by sending these professionals a structured questionnaire with questions that could be answered directly. Such respondents could use the questionnaire as a guide to discuss the points mentioned.

From what can be observed, most of the interviewees, all with experience of implantation or of effective participation in A-CDM deployments, corroborate what was verified in the case studies carried out in Chapter 4. That is, the greatest beneficiaries of the process are airlines. However, there are also significant gains for all stakeholders involved, especially for airport operators and streamlining air traffic flows (ATFM). Others involved, such as handling companies and public inspection agencies, may have greater predictability of workloads. Consequently, and also have economic gains in the correct use of equipment and personnel.

The most significant aspect taken from these interviews is precisely the focus of our research: the analysis of the possibility of using a more compact A-CDM with less investment and less time for implementation.

From the interviewees' responses, we can see that some of them -3 (three) among the 7 (seven) respondents- considered the possibility of reducing a certain number of milestones as valid. They also accept the fact of reducing parts of the training programs with interested parties.

And most of all, they point out that the most important thing for any airport, regardless of the implementation of the A-CDM FULL MODEL, is implementing what ICAO recommends as the first step, that is, the implementation of INFORMATION SHARING. This process must always be performed before the start of the A-CDM implantation. This basic procedure is already sufficient for the proper functioning of many airports where the great movements of air traffic are not yet verified. Such positions are corroborated in documentation from ICAO (2018) and EUROCONTROL (2017a), which always emphasise the need and importance of a fair Information Sharing process before starting A-CDM implementation.

6.4.2 Survey

As specified in Chapter 5, the survey was answered by 55 (fifty-five) of the respondents. It was divided into three parts:

Survey – First Part

- **PROFILE OF INTERVIEWS**

Most of the respondents are Academics involved in research related to the Air Sector and professionals from the Operational and Airport Engineering areas.

- More than 49% had more than 20 (twenty) years of professional experience in the Sector and 20% between 10 (ten) and 20 (twenty) years of experience.

- **SUBJECT KNOWLEDGE**

As for the knowledge of the A-CDM processes, more than 47% knew reasonably, 29.1% reasonably, 14.5% deeply, and 9.1% were unaware of the process.

Thus, it was found that more than 90% of the members of the Air Sector surveyed either heard about or had some knowledge of the process.

These numbers are essential for an implementation analysis of the necessary Information-sharing processes. The results showed that this part of the target audience surveyed already knows, at least, what it is about or has a basic knowledge.

- **Only 9.1% were completely unaware of the A-CDM processes.**

Survey – Second Part

After analysing the profile and level of knowledge of the members, the second part (the more robust body of the questionnaire) aims to investigate the concerns and discomforts that a passenger faces in all aspects of delay involved in a flight, especially from a more accurate view of those who know the sector.

Although the passenger, who is the customer directly involved, and who presently suffers the consequences of delays or process improvement, the analysis that we carry out is practically a new fact within all studies done on A-CDM processes. The focus is always on reducing taxi times, saving fuel and improving airport and ATFM processes. The passenger also indirectly receives some of these benefits.

Thus, with the questions recalled below, as presented in Chapter 5, we can verify in Table 6.1, in descending order, which are the most significant delay factors reported by the respondents:

Table 6.1 - Delay kinds and percentages
Source: Own elaborations based on Chapter 5 - 5.3.1.2

Nº	KINDS OF DELAY	PERCENTAGE
1	Airline check-in procedure	**65,5 %**
2	You are staying on the ground, inside the aircraft, due to waiting for connecting flights	**56,4 %**
3	After landing, delay during the taxi procedure	**56,4 %**
4	Delay of airline employees in checking boarding passes, identification documents, and boarding all passengers in the departure lounge for the flight	**54,5 %**
5	Delay during the taxi procedure until the moment of take-off	**47, 3 %**
6	Stay inside the aircraft after boarding awaiting air traffic authorisation	**43, 6 %**
7	In-flight delays were forcing the flight to perform holding procedures due to aircraft problems	**43, 6 %**
8	Waiting in the departure lounge during the turn-round period (disembarking passengers and luggage, cleaning and refuelling of the aircraft, boarding of catering, crew and new passengers until the door closes)	**41,8 %**
9	After disembarking, delay until reaching the exit door to the airport lounge due to baggage claim	**41,8 %**
10	After disembarking, delay until reaching the exit door to the airport lounge due to passport inspection procedures (only applicable for international flights)	**40,0 %**
11	Security inspections procedures (X-ray, hand luggage, etc.)	**40,0 %**
12	After aircraft parking, delay in opening the door and disembarking	**38,2 %**
13	Passport verification before departure (only applicable for international flights)	**36,4 %**

As shown in Table 6.1, 13 (thirteen) questions were asked; the answer that generated a more expressive percentage of delays (number 1) demonstrates a problem inherent to the service at the airport counter. It is directly linked to the number of check-in counters assigned by airlines and the speed of service. In addition, answer number 4, with a high percentage of signalling by respondents, concerns the agility of airline operators in verifying boarding passes, identification documents and boarding of all passengers in the departure lounge for the flight. These two procedures mentioned by passengers, as factors of discontent and delay in boarding, are not immediately resolved with the simple implementation of Information Sharing, unless there is awareness and training of stakeholders-, which is usually an integral part of a Full A-CDM. Likewise, items 9, 10, 11, 12 and 13, although they have the lowest rates of complaints from respondents.

Items 2 and 3, both reported by 56.4% of respondents and questions 5, 6, 7 and 8 (with common complaints between 41% and 47% of respondents) can be largely mitigated by applying the A-CDM or even with the application of information sharing only. These are problems directly related to the operation and can be resolved with information sharing and good coordination between the ATC and the AOCs sectors.

Thus, 6 (six) of the items confirmed by respondents, such as delays and dissatisfaction factors at the time of a flight, can be quickly resolved or reduced by implementing Information Sharing or A-CDM. And 7 (seven) of them depend on streamlining the processes of members of airlines, airport operators and government agencies, requiring prior work before implementing a simple Information Sharing, or implementing a Full A-CDM, guided by awareness and training of all stakeholders involved.

Survey – Third Part

The third, and last part of the questionnaire, seeks to explore sharing information.

The first question asks respondents, as an aeronautical manager, how to better act in a coordinated way at an airport. Which of these stages (milestones) of a flight would they like to be informed of their forecast and have a regular update? Although all are important, they are oriented to choose five to carry out the evaluation in a better way.

Then, the last question, still on Information Sharing, emphasizes that "Sharing information and working in a coordinated manner with established time parameters, it is necessary to discipline airport operations". The question was asked based on this statement. It aims to identify within the airport environment, which stakeholder is considered more challenging to adapt to changes in standards; consequently, there will be higher resistance to sharing information.

- **INFORMATION SHARING - MILESTONES**

In the responses on Information Sharing, the respondents, positioned as aeronautical managers, placed the following order of reactions when they answered the question:

- *To better act in a coordinated way at an airport, which of these stages (milestones) of a flight would they like to be informed of their forecast and have a regular update?*

The answers below are in descending order and show the number of respondents and the percentage that each reached. Each one chooses five of the options.

1. Estimated landing time at the arrival airport - **36 (65,5%);**
2. Actual take-off time from the departure airport - **33 (60,0%);**
3. EarlyDeparture Planning Information Message (previously message about Flight Plan) - **31 (56,4%);**
4. Actual landing time at the arrival airport - **29 (52,7%);**
5. Estimated take-off time from the departure airport - **27 (49,1%);**
6. Actual take-off time - **22 (40,0%);**
7. Estimated take-off time - **18 (32,7%);**
8. Estimated turnround time (the time between "in" and off-blocks) - **15 (27,3%);**
9. Estimated inblock time (when an aircraft will be in-blocks) - **14 (25,5%);**
10. Actual off-block time (aircraft start movement associated with departure) - **11 (20,0%);**
11. Estimated taxi-in time (between landing and in-block) - **11 (20,0%);**
12. Estimated off-block time - **06 (10,9%).**

Coincidentally, the first 7 (seven) items in the sequence, those with the highest percentage of choice, are all related to information that the ATC facilities have and can update systematically.

This finding contributes to the implementation analysis of the simple Information Sharing instead of a FULL A-CDM, as this information is usually held by ATC agencies. It will be enough to implement a process of setting standards for this information to arrive regularly to Stakeholders, regardless of whether an A-CDM process is installed or not.

Items 8, 9, 10 and 11 will depend on the coordination between airlines, handling companies, airport operations and ATC facilities. The procedures mentioned in these items may still have Information Sharing, requiring centralisation and coordination of an Airport Operations Center.

Even without the implementation of an A-CDM. These 4 (four) processes are more accurate at a fully coordinated airport (A-CDM). However, they can be perfectly controlled by an APOC with adequate training.

- **INFORMATION SHARING - STAKEHOLDERS**

This question focused on how to identify within the airport environment, which stakeholder is considered more difficult to changes in standards, the question was:

- *Which of these stakeholders do you think would have the most difficulty adapting to the set standards? Check only one.*

The answers below are in descending order and show the percentage that each reached:

1. Immigration and emigration desk – **38,2 %;**
2. Airport Operations – **27,3 %;**
3. Airlines – **18,2 %;**
4. Air Traffic Control – **9,1 %;**
5. Handling services – **7,3 %.**

This question was elaborated thinking about identifying among the most critical contributing stakeholders for implementing Information Sharing, which could be more reactive to establishing new standards.

Based on the percentage analysed, respondents consider immigration and emigration bodies the most challenging stakeholders to adapt to changes, and secondly, airport operators.

Air Traffic Control services were cited in only 9.1% of the answers. This information is positive if we think that the ATC facilities, as seen in the previous item in the survey, are primarily responsible for sharing information.

This finding is another contributing point for using simple Information Sharing as an earlier process or even replacing the complexity of a FULL A-CDM.

6.5 SWOT analyses

The analysis using the SWOT matrix was carried out based on legislation, case study and interviews.

The result mainly confirms the testimonies of some interviewees who suggest the implementation of Information Sharing as an economic measure to be applied in airports with low investment power or even at the beginning of the entire process at any airport until it is necessary to implement a Full A-CDM.

As can be seen, the strengths and opportunities arising from the implementation of information sharing are far superior to the threats and weaknesses that may occur. Among others, the low investments in technology and training and the low implementation time, appropriate for airports with a low disbursement capacity.

These stand out as positive factors and the possibility of a significant increase in the number of airports to be involved.

The most significant negative factor that can be considered would be a greater possibility of delays due to not having such a high precision of interaction between stakeholders. However, the positive factors, strengths and opportunities are far superior.

Table 6.2 – SWOT analysis focused on the use of a reduced A-CDM (Sharing Information)
Source: Own elaborations based on Chapters 3, 4 and 5

	POSITIVES	**NEGATIVES OR POTENTIALLY NEGATIVES**
	STRENGTHS	**WEAKNESSES**
INTERNALS	• Less investment in technology • Lower investment in training • Ease of deployment • Less reaction to changes by stakeholders • Shorter implementation time	• Less amount of disseminated information • Less accuracy of information • Less stakeholder involvement • Less training time
	OPPORTUNITIES	**THREATS**
EXTERNALS	• Possibility of increasing the number of airports involved given the low cost • The significant participation of ATCs in the process • Airport ready to undergo System Performance Assessment (SPA), using the ICAO Six-steps method.	• Greater possibility of delays • Loss of credibility by users due to delays

6.6 Conclusions

When developing the work, we always try to be focused on the Thesis question:

- *As for the A-CDM process currently in operation in several airports around the world: It is possible to run this process in airports with low investment capacity, implementing an A-CDM with substantial reductions in financial cost, implementation time, maintaining high levels of efficiency operational, safety and meeting International Civil Aviation Organization (ICAO) guidelines?*

Thus, having this question as a basic assumption, they have been answered through specific objectives, according to the theses sequence presented, which, when analysing this work, brought us the following conclusions:

a) The GANP's recommendations (also in terms of A-CDM) are not mandatory; they are only recommendations. The GANP is a Global Plan, but implementing the improvements described in that plan depend on identifying local or regional needs adding to operational analysis, safety analysis and a business case that justifies its implementation. Notably, in A-CDM subject, ICAO legislation recommends that countries should have sufficient structure to allow their organisations to fulfil the first stage of the A-CDM implementation, set out in BLOCK 0, that is, the use of Information Sharing as the first step in process coordination of an airport;

b) EUROCONTROL's documentation considers very clearly, as the first and essential step in the A-CDM process, the Information Sharing's implementation;

c) FAA's Surface CDM highlights as first and vital steps the CDM's implantation, very well supported by robust information sharing software with stakeholders;

d) The case studies showed that the A-CDM's implementation brings excellent economic and organisational returns. In the financial aspect, especially for airlines, which benefited greatly in the process. There is a need for significant financial investment and time, especially on the part of airport operators. Due to the type of return, they can also occur at smaller airports. However, for those with low investment capacity, more simplified and low-cost processes should be analysed;

e) In the interviews, carried out with professionals from different countries -involved and with excellent knowledge of A-CDM- there was much praise and recognition of the enormous advantages of the process. However, the most valuable return of these interviews was to verify that:

- The milestones' reduction in the process' operation will not bring substantial differences in cost or time of implementation;
- It is not convenient to reduce training, especially concerning ATC personnel and airport operators;
- The correct use of Information Sharing, which is one of the ICAO's basic premises for starting an A-CDM process, can be used at airports that do not yet have an air traffic load and passengers who need to coordinate it (A-CDM), as well as at airports with low investment capacity. Considering that its basic premise is information sharing and coordination between ATC and AOC, a subprocess that does not require significant investment for its execution;
- The great value of simply implementing Information Sharing to make an airport "coordinated" was evident in the opinion given in the interview with two of the world's greatest experts on A-CDM implementation.

f) In the survey conducted with 55 (fiftyfive) members of the Air Sector (also from several countries), it was found that:

- Most passenger delay complaints will not entirely be resolved by implementing only Information Sharing, it requires a Full A-CDM;
- The most critical items that must integrate the simple Information Sharing process are dependent on ATC operations and their coordination. Regardless of whether the airport is coordinated (A-CDM) or not;
- Stakeholders considered it more challenging to integrate change processes are part of the block of public bodies -for immigration and emigration-, and the members of ATC facilities are considered adaptable to changes. Therefore positively evaluated for the need to collaborate in the process of sharing information.

Thus, in response to the Thesis question regarding the feasibility of implementing A-CDM at airports with low investment capacity, with substantial reductions in financial cost and implementation time, maintaining operational efficiency levels and meeting the Organization's guidelines of International Civil Aviation (ICAO), we reached the conclusions described below.

At first glance, the system currently used in large airports where A-CDM FULL is already implemented does not seem to be feasible to have its form reduced to the point of allowing significant savings in resources, as we initially thought with reductions in milestones, for example. Firstly, we arrived at this finding with the information obtained in the A-CDM Course classes that we had at IANS (EUROCONTROL). There was a deep understading in the importance of each of the milestones that are part of the processes implemented today in Europe. There, it was possible to see that for correct coordination between the stakeholders, the process that exists today for high-traffic airports, in principle, should not be reduced. This finding was reinforced after the responses of the 7 (seven) respondents. Even the three who agree to reduce the milestones place some restrictions on it, either in quantity or how it can be done. This subject can be a challenge to delve into in a new academic study on A-CDM.

However, as the focus of this thesis is to respond to the procedure that can be adopted at airports with low disbursement capacity, enabling them to have a good system, the adoption of Information Sharing is a highly recommended process. This fact was highlighted by the opinions of the interviewees and by the milestones considered most important by those surveyed in the survey. These are very operational milestones that can be part of Information Sharing. And this process, much more uncomplicated, puts the airport ready to move towards the second and more complex phase, which is the implementation of a FULL A-CDM if this becomes imperative.

This initial and straightforward conceptual element is the first step. It creates a fundamental basis for implementing a coordinated airport (A-CDM) that ICAO recommends to the signatory countries in BLOCK 0. It is more than feasible for Information Sharing to serve most airports with low investment capacity, especially those belonging to developing countries.

No matter how small, every airport has an APOC, which, although small, can be equipped with software that allows a fair sharing of information. A basic coordination process can be established by the local airport authority with ATC facilities and airport stakeholders. It is not an A-CDM FULL process with all its nuances, but it will meet most local needs and integration with other airports and ATC facilities.

This process, which is already applied in many airports that intend to implement A-CDM, could be called **Airport Information Sharing and Coordination (A-ISC),** an initial process, a fundamental base and precursor of A-CDM.

As explained in Chapter 3, in 3.3.1, the sixth edition of the GANP (ICAO, 2019) includes in its Technical Chapter a new process recommended by the Organisation, the so-called System Performance Assessment (SPA). Through the so-called Six-steps method, this tool makes it possible to assess the best time to implement operational improvements for any modules that integrate the ASBU. This process can be applied in airports where the Sharing Information process is already in operation, aiming cost-effectively to analyse A-CDM implantation.

In 5.2.2, when answering question number 2, interviewee 3, regarding the A-CDM, arguing that the whole project should be simple, quotes the KISS (Keep It Simple, Stupid) concept very properly. This should be the central aspect of the construction of an airport project, because of how complex an airport maybe, operational projects must focus on overcoming the complexities to be as agile and economical as possible.

According to Giezen (2012), in an article called “Keeping it simple? A case study into the advantages and disadvantages of reducing complexity in megaproject planning”, “Simple Stupid”, or the KISS principle is an expression commonly adopted in project management. It is a design pattern that aims to keep the techniques used, originally in aerospace engineering, as uncomplicated as possible (simple) and as easy to understand and repair (stupid). Thus, maintaining simplicity is approached more formally as reducing complexity. The significant reason for doing this is with the reduction of complexity comes a reduction of uncertainty since complexity is often defined concerning fate. Reducing complexity means that there are fewer unknowns and fewer variables to predict, and therefore project planning will undoubtedly become more manageable.

Thus, we conclude that the most economical and time-efficient path for implementing a coordinated airport can be considered even simple, concerning a complex A-CDM process. It is an Airport Information Sharing and Coordination's process, well adjusted and coordinated through an APOC. The evolution to the full A-CDM, when the movement of passengers and air traffic starts to demand, should be evaluated using the Six-steps method already explained. These linked actions can allow countries and airports with low investment capacity to comply with ICAO recommendations and maintain operational efficiency and safety levels.

Chapter 7. FINAL CONSIDERATIONS

7.1 Introduction

7.1.1 Lines of action

Since the first Chapter of this Thesis, we have tried to follow lines of action according to the following determining factors:

a) Comply with the commitments shown in the Work Plan presented at the time of the PhD Enrollment. This Plan established that the research subject should be focused on "The air navigation systems of the future and the respective global interactions";

b) Align the Thesis, remembering that aviation needs to support its operation of two complex support infrastructure systems, which are:

- Airports and Air Traffic Services.

c) Maintain the level of the Thesis according to the modernity of the chosen theme, which correlates with considered to be the most advanced today in the aviation support sector. More specifically, with the Global Air Navigation Plan of the International Civil Aviation Organisation, as well as its developments in the systems currently implemented and being implemented by the signatory countries; and

d) Develop research that is up to an Engineering Course, particularly of the high quality of the works presented in the Aerospace Sciences Courses of the Faculty of Engineering of the Universidade da Beira Interior (UBI).

To meet the above requirements, we were also in agreement with the document already mentioned in Chapter 1: "The structure of an Engineering article" presented at the XXII Brazilian Congress of Engineering Education (Pinheiro & Koury, 1994). An interesting quote is made about the work produced by the engineers, which does not need to go down to the level of calculations and details regarding the production work, which qualified technicians can carry out. They argue that the Engineer produces projects and reports, which need to be understood by stakeholders. Therefore, it is vitally important that the engineering student learns from the beginning to be clear and didactic in presenting projects and writing an engineering report. Thus, insofar as one can establish a connection between the academy and the professional environment.

Besides, our professional experience in the airline industry brought a dichotomous feeling: Positively due to the significant experience in the airline industry, with ATC/ATM and a national airport network management, which has already explained. On the other hand, with the concern of being a neophyte in the academic environment and that this lack of experience, and consequent knowledge of the environment, would not be a contributing factor to low-quality research.

7.1.2 Running the Thesis

We know that the civil aviation sector comprises of personnel from different training and performance areas in the market, and there is little known about this subject in academia. Thus, the thesis also sought to be didactic while increasingly providing information and being organized in this sense. However, without compromising (or replacing) the principal designation of a scientific document of this nature, presenting a solution to a question (or questions), which respond to a need to fill an area of knowledge through scientifically proven solutions/methods. It provides a foundation of technical background information, targeting both: those starting to work in the aviation industry (including those who want to get involved with A-CDM), as well as academics who are not yet familiar with the airline industry.

In development, a topdown approach was sought. Based on the knowledge of the ICAO, and its documents of regulation and organisation, as well as of other international and regional institutions, regulators and associations of the Air Sector. Then, down to the specific ICAO document that addresses the issue to be the focus on The Global Air Navigation Plan. And inside it, then diving into the Aviation Block Systems (ASBU), their respective BLOCKS, and Modules. In a very in-depth way, we approached one of these Modules, which deals with A-CDM. Subsequently, the Case Studies, interviews and research, embodied the Analyses and Conclusions made in Chapter 6.

As for the questionnaire, we were very surprised by the lack of support in terms of responses to the survey, according to the percentage already exposed in 5.3. In the questionnaire presented, the dosage applied to a lot of questions allowing a maximum of 10 minutes to be completed. This was done because we remember that when we lived the role of a manager in a busy and stressful corporate environment (airports), we were bothered to receive surveys (which we always answered) with questions that consumed 30 (thirty) minutes to an hour. For executives in high-performance sectors, this research size is an invitation to the people who do not answer such questions. Thus, we elaborated on direct items, aiming for the minimum consumption of time. Even so, we had a much lower rate of return than we expected.

7.1.3 Conclusive evidence

The conclusion presented, contradicted our initial line of thought: to reduce the number of milestones to simplify the process. Such thinking aligned the development of reasoning until half of the research.

Participation in the A-CDM course at the EUROCONTROL Institute of Air Navigation Services (IANS) in Luxembourg and the A-CDM International Seminar held in Brazil (Guarulhos Airport) began to change the direction of research, which it was looking for, a process, which was not very simple, to try to change the existing process. In other words, looking for a way to reduce the number of milestones in the current process.

A new approach was then envisioned, especially in those moments of the enormous contribution to research -but when we have no scientific evidence- just informal conversations with industry experts. Most airport managers complained about the high investments and long implementation time, where the system had already been implemented. They also complained that, although the high assets were the responsibility of the airports, even despite the organisational improvements obtained, the primary financial beneficiaries were the airlines. Those who have yet to implement the process say that they do not have the capital available for such a complex implementation. They argue that only large airports with a high disbursement capacity can make this kind of commitment.

Then, based on our Documental Support, Practical Support (Case Studies) and Stakeholders Support (Interviews and Questionnaires), in conclusion, presented in Chapter 6, SIMPLICITY was chosen as the final result of our study.

Thus, we have arrived at a conclusion that Information Sharing, procedures recommended in the ICAO documentation and already adopted in preimplantation A-CDM in coordinated airports, as the most suitable for use in airports that do not have resources for this purpose and which are currently undergoing analysis to implement the A-CDM. Besides, there is a recommendation to use a new ICAO methodology called the Six-steps Method, which is part of the System Performance Assessment (SPA) from the last Global Air Navigation Plan.

Such a technique allows a cost-benefit analysis aiming at the most appropriate moment for A-CDM implantation.

7.1.4 A suggested plan for new research

Many developments within theme A-CDM can be sought:

a) Stressing the search for finding a more economical method to implant A-CDM (full) in large airports (a technique that we could not envision in this research). An in depth analysis of Blocks 2 and 3 (Annexe 1); and

b) List one or two airports and using the Six-steps Method (AN-SPA tool) to assess the right moment from the passage of Information Sharing to an A-CDM (full). The researcher gets the collaboration, the administrative, financial and operational areas of the surveyed airports (Annexe 2).

7.2 New scenarios for aviation

The year 2020 will be marked, indefinitely, as a major turning point for various activities in all world countries.

The pandemic that has plagued everyone, from East to West, has also brought untold damage to the Air Sector that will take many years to recover. Airlines have ceased to exist, and others have undergone significant processes to reduce equipment and personnel. Airports and several concessionary companies; handling and catering companies; general and cargo aviation; training aviation; and many other support services, such as transporting passengers on land connections to airport environments, all suffered high losses.

Thus, projects like A-CDM discussed here will have their priorities relegated to a second or third plan. Many others, already running, may even be discontinued. Airports, as well as other members of the sector, will also take a few years to overcome financial losses and recover. The density of movement in the Air Sector is also unlikely to be the same for an extended period.

As a contributing factor in encouraging the implementation of A-CDM or Information Sharing at airports, it can be claimed by regulatory bodies that such processes are facilitators or contributors to health. Coordinating activities, increasing punctuality, and reducing delays allow passengers to be less confined in waiting rooms or waiting inside aircraft, which will be significant factors in pandemic and post-pandemic times. It was worthwhile to give satisfactory answers to the health control agencies, tranquillity, and consequent incentives to travellers.

Experts have exhaustively addressed that people will be more restricted to their regional and local environments in the Air Sector. Due to financial recovery needs, companies in the most productive sectors will drastically reduce the number of trips for their executives. Thus prioritizing the forms of interpersonal communication and corporate meetings, which was used and developed a lot during the pandemic crisis: virtual meetings at a distance. Tourism is also expected to be substantially reduced. Road and short-term tourism should be prioritised. So people will probably prefer domestic trips more.

In terms of the Air Sector, the only highly privileged segment during the pandemic was air cargo. Internet purchases were prefered because of the need for people to stay at home during these times. The tendency is for this type of convenience to be incorporated into families, and the Sector will continue to have a great return. Such a trend will allow the growth of regional aviation combined with cargo hold as a vector of penetration in cities further away from large centres.

The members of the Air Sector must be prepared for the significant challenges that lie ahead. Professionals who combine CREATIVITY and EFFICIENCY will always continuously search for the best COST-BENEFIT relationship, without ever neglecting SAFETY, BASIC ASSUMPTION OF AVIATION, will always be positively differentiated among their peers in this Sector which is also highly differentiated.

The importance of the Academy associated with the corporate world, more than ever, should be highlighted at this time. The study of alternative solutions and continued research, strategically focused on the current moment, are contributions that Companies must now focus on and encourage as one of the great solutions for the new times ahead.

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Annexe 1. ASBU Blocks 2 and 3

- According to ASBU elements, showed by ICAO in the GANP site (ICAO, 2019).

ICAO GANP PORTAL

ASBU ELEMENTS

ACDM-B2/1

☑ Functional Description | O Enablers | O Deployment Applicability | O Performance Impact Assessment

ACDM

ACDM-B2/1	Total Airport Management (TAM)	Operational
Main Purpose	Total Airport Management (TAM) is an approach that takes a holistic view of airport performance management, integrating all stakeholders including the ATM network, local ATM, passenger terminal operations, service providers, passenger and baggage management and ground transportation. All stakeholders are integrated into a coherent planning and collaborative decision-making process using shared information and capabilities.	
New Capabilities	TAM is an enhancement of the APOC with integration of the landside management aspects to support further improvement of the efficiency of the overall airport operation including passenger management. This will be achieved using the shared information and capabilities of the AOP, APOC and landside management thereby ensuring a coherent overall airport performance monitoring, decision making and steering process, addressing all phases of operations (strategic planning, through operation to post operations). All essential airport processes from passenger check-in to aircraft turn-round work collaboratively with the common goal of ensuring that each departure meets its agreed 4D-trajectory. The airport is considered as one node of the overall air transport network. In order to ensure an overall Quality of Service (QoS) of an airport to the customers and to the air transport network, the integrated APOC concentrates on the initial strategic and pre-tactical planning phases using the most accurate information available, followed by the monitoring (and when required, reactive planning) of the tactical working process.	
Description	TAM will bring stakeholders together as physical entity (team) enabling them to better communicate and coordinate, to develop and dynamically maintain joint plans which are executed in their respective areas of responsibility at an airport. Its main information source will be the Airport Operations Plan with the level of predictability allowed by TBO as well as Landside Management including Passenger management, which integrates information from the appropriate process monitors, collating it into consistent, timely and reliable knowledge for the airport's various operational units, in particular the APOC. TAM will be equipped with a real-time monitoring system, a decision support system and will apply a set of collaborative procedures that build upon the capabilities of the APOC. This will ensure that the management of landside and airside airport processes will be fully integrated including passenger management.	
Maturity Level	Validation	
Human Factor Considerations	1. Does it imply a change in task by a user or affected others? Yes 2. Does it imply processing of new information by the user? Yes 3. Does it imply the use of new equipment? Yes 4. Does it imply a change to levels of automation? Yes	

PLANNING LAYERS

Pre-tactical | Tactical-Pre ops | Tactical-During ops

OPERATIONS

Taxi-out | Departure | Arrival | Taxi-in | Turn-around

DEPENDENCIES AND RELATIONS

Type of Dependencies	ASBU Element
Relation-operational need	SWIM-B2/1 - Information service provision
Relation-operational need	SWIM-B2/2 - Information service consumption
Relation-operational need	SWIM-B2/3 - SWIM registry
Relation-information benefit	FICE-B2/2 - Filing Service
Relation-information benefit	FICE-B2/4 - Flight Data Request Service
Relation-information need	AMET-B2/1 - Meteorological observations information
Relation-information need	AMET-B2/2 - Meteorological forecast and warning information
Relation-information benefit	FICE-B2/5 - Notification Service

ASBU ELEMENTS

ACDM-B3/1

☑ Functional Description | O Enablers | O Deployment Applicability | O Performance Impact Assessment

ACDM

ACDM-B3/1	Full integration of ACDM and TAM in TBO	Operational

Main Purpose	To use the integration of ACDM in the overall synchronization of the ATM network, to contribute to end-to-end stable, consistent and robust trajectory-based operations providing the adequate level of performance.
New Capabilities	ACDM is fully synchronized with TBO.
Description	All stakeholders are fully connected. All tactical decisions are fully synchronized and operations are fully trajectory-based. Aerodrome operations are considering the en-route to en-route view with the turnaround process, agree on, and subsequently manage the flights on the surface, to deliver expected surface event times with known impacts to the ATM system, and to ensure that the agreed trajectory is consistent with the Airport Operations Plan. ACDM is contributing to the network based, efficiently-converging coordination process as a subcomponent of the overall ATM network synchronization process.
Maturity Level	Concept
Human Factor Considerations	1. Does it imply a change in task by a user or affected others? Yes 2. Does it imply processing of new information by the user? Yes 3. Does it imply the use of new equipment? Yes 4. Does it imply a change to levels of automation? Yes

PLANNING LAYERS

Pre-tactical | Tactical-Pre ops | Tactical-During ops

OPERATIONS

Taxi-out | Departure | Arrival | Taxi-in | Turn-around

DEPENDENCIES AND RELATIONS

Type of Dependencies	ASBU Element
Evolution	-
Relation-operational need	SWIM-B2/1 - Information service provision
Relation-operational need	SWIM-B2/2 - Information service consumption
Relation-operational need	SWIM-B2/3 - SWIM registry
Relation-information need	DAIM-B2/5 - NOTAM replacement
Relation-information need	AMET-B2/1 - Meteorological observations information
Relation-information need	AMET-B2/2 - Meteorological forecast and warning information
Relation-information benefit	FICE-B2/2 - Filing Service
Relation-information benefit	FICE-B2/4 - Flight Data Request Service
Relation-information benefit	FICE-B2/5 - Notification Service

Annexe 2. Six-steps Tutorial

- According to AN-SPA, showed by ICAO in the GANP site (ICAO, 2019).


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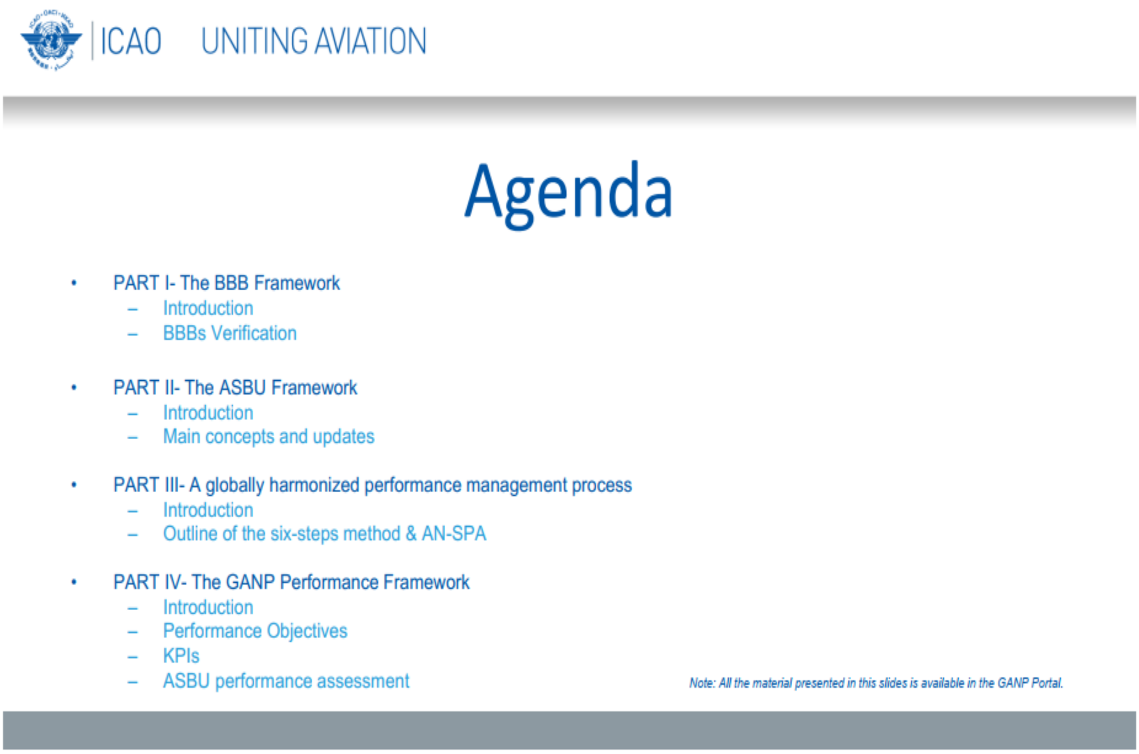
THE GLOBAL TECHNICAL LEVEL OF THE GANP


ICAO UNITING AVIATION
Agenda
• PART I- The BBB Framework
– Introduction
– BBBs Verification
• PART II- The ASBU Framework
– Introduction
– Main concepts and updates
• PART III- A globally harmonized performance management process
– Introduction
– Outline of the six-steps method & AN-SPA
• PART IV- The GANP Performance Framework
– Introduction
– Performance Objectives
– KPIs
– ASBU performance assessment
Note: All the material presented in this slides is available in the GANP Portal.

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PART I – THE BBB FRAMEWORK

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Introduction

The Basic Building Block (BBB) framework outlines the foundation of any robust air navigation system. It is nothing new but the identification of the essential services to be provided for international civil aviation in accordance with ICAO Standards. These essential services are defined in the areas of aerodromes, air traffic management, search and rescue, meteorology and information management. In addition to essential services, the BBB framework identifies the end users of these services as well as the assets (communications, navigation, and surveillance (CNS) infrastructure) that are necessary to provide them.

The BBB is considered an independent framework and not a block of the ASBU framework as they represent a baseline rather than an evolutionary step. This baseline is defined by essential services recognized by ICAO Member States as necessary for international civil aviation to develop in a safe and orderly manner. Once these basic services are provided, they constitute the baseline for any operational improvement.

The BBB framework will be updated every two years taking into account amendments to ICAO provisions. Although an initial draft of the BBB framework is presented online in the GANP Portal (https://www4.icao.int/ganpportal/BBB), the BBBs will be included in a web-based application in a format similar to the ASBU framework.

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BBB Verification

In 2014, the ICAO Council approved a new template for the Regional Air Navigation Plans (ANPs) to better align global and regional planning. This template consists of three volumes. Volumes I and II list the regional facilities as well as the general and specific regional service requirements, required for international civil aviation operations in accordance with regional air navigation agreements, in the areas of aerodrome operations, communications, navigation and surveillance, air traffic management, meteorology, search and rescue and aeronautical information management.

To set a baseline for the system envisioned in the GANP and to ensure a robust foundation for the global air navigation system, an effective process should be established to verify, pursuant to Article 37 of the Chicago Convention, that the essential air navigation services identified in the BBB framework are provided. It is important to highlight that this process should focus on verifying the implementation of the essential air navigation services outlined in the BBB framework as the capability of the States to oversight these services is covered by the ICAO USOAP. To avoid duplications and to align global and regional planning, the process for verifying the implementation of these essential services should be embedded within the methodology for the identification of deficiencies against the regional air navigation plans. If these essential services are not being delivered, ICAO, upon request of a State, provides the necessary technical assistance to address the needs as identified within the process.

To ensure the provision of seamless air navigation services based on the deployment of interoperable systems and harmonized procedures, States need to leverage the implementation of the BBBs through their national air navigation plans as a strategic part of their national aviation planning framework. This will also pave the way for the future implementation of air navigation improvements to increase the quality of the services and meet the performance expectations of the aviation community

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PART II – THE ASBU FRAMEWORK

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Introduction

The Sixth edition of the GANP has a multilayer structure which comprises two global levels- global and technical- as well as a regional and national ones.

The Global Strategic Level is a document, written in executive language, which provides strategic directions for decision-makers, through a vision, performance ambitions and conceptual roadmap, to evolve the global air navigation system.

The ASBU framework is part of Global Technical Level of the GANP.

Based on the evolutionary steps described in the conceptual roadmap available in the GANP Document, different concept of operations have been described for the different areas of the air navigation system- ASBU threads- within six-year timeframes- ASBU Block-, starting with Block 0 in 2013. These concepts of operations have then been translated into specific operational improvements- ASBU elements. In order to ensure full realization of benefits from the deployment of the operational improvements, the different components- ASBU enablers- necessary for their implementation, have been identified. These components include technology, training and regulatory provisions as well as the stakeholder responsible of their implementation.

In the following slides you will find the conceptual clarifications and major updates regarding the ASBU framework.

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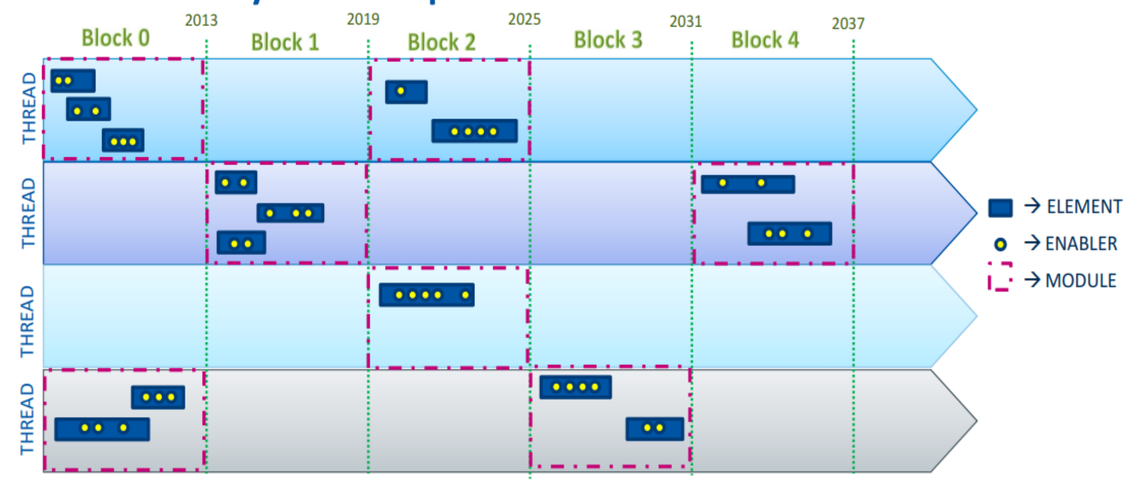
ASBU key concepts



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ASBU Element

- The main concept of the updated ASBU framework.
- The ASBU elements were defined in previous versions of the GANP in an inconsistent manner. With the digitalization of the framework, they have become the core concept and they have been defined in a harmonized manner.
- An ASBU element is a specific change in operations designed to improve the performance of the air navigation system under specified operational conditions.

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ASBU Thread

- Another key concept in the updated framework.
- The ASBU threads already existed in previous versions of the GANP and they were key feature areas of the air navigation system where improvements are needed in order to achieve the vision outlined in the Global ATM Operational Concept.
- The ASBU threads are been categorized in 3 groups:
  - Operational threads: ACDM, APTA, NOPS…
  - Information threads: SWIM, AMET, DAIM, FICE,…
  - Technology threads: COMS, COMI, NAVS, ASUR (previous roadmaps)

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ASBU Thread (cont)

- This updated version of the GANP presents the following major changes regarding the threads:
  - The CCO and the CDO threads have been merged into the APTA thread, which has expanded its scope to cover terminal and approach operations.
  - Some elements in the OPFL thread have been moved to FRTO, so FRTO will from now on cover horizontal and vertical en-route flight efficiency. However, in order to respect stability, elements in Block 0 and one element in Block 1 have been left in OPFL.
  - The RPAS thread is TBD, however, the lower airspace operations improvements have been reflected as elements in other threads.

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ASBU Thread (cont)

- (Continuation):
  - Higher airspace operations improvements have also been reflected as elements in other threads.
  - There is a new thread for global tracking: GADS.
  - The roadmaps have become technology threads in order to show the dependencies on them of the other ASBU elements.
  - The TBO thread has been updated based on the TBO concept and as an integrating concept, its elements are the elements from the operational threads. The communication elements in the previous versions of the TBO thread are now in the COMS (communication services) thread.

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ASBU Enabler

- Another key concept in the updated framework.
- The ASBU enablers are a new concept in the updated ASBU framework.
- They are the components (standards, procedures, training, technology, etc) required to implement an element.
- Their goal is to identify the stakeholders involved in the implementation of an ASBU element as well as all the necessary requirements, in order to ensure an effective implementation. Some of the enablers can be elements in other threads, for instance: avionics or ground systems in the technology threads.

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ASBU Block

- Another key concept in the updated framework.
- The ASBU blocks already existed in previous versions of the GANP and they introduced the “time” dimension to the framework.
- An ASBU Block is the end date of a six years timeframe that defines a deadline for an element to be available for implementation. This implies, that the element and all the enablers associated to it, need to be available for implementation by the ASBU block year.
- ASBU Blocks years: 2013, 2019, 2025, 2031….

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ASBU Module

- The last key concept in the updated framework.
- The ASBU modules already existed in previous versions of the GANP and they are the crossing point between the threads and the blocks. Therefore, an ASBU module is the group of elements from a thread that, according to the enablers' roadmap, will be available for implementation within the defined deadline established by the ASBU Block.
- As such, if in the digital ASBU framework we select in the filter one ASBU thread and one Block, we will obtain the elements that constitute the module.

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By clicking in the following image you can assess your understanding of the digital ASBU framework:

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PART III – A GLOBALLY HARMONIZED PERFORMANCE MANAGEMENT PROCESS

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Introduction

Given the fact that the GANP is about opportunities, the appropriate way to utilize the GANP is to apply a performance-based approach. A performance-based approach is results-oriented, helping decision makers set priorities and determine appropriate trade-offs that support optimum resource allocation while maintaining an acceptable level of safety performance and promoting transparency and accountability among stakeholders.

Although there are several ways to apply a performance-based approach, ICAO advocates for a globally harmonized performance management process based on six well-defined steps.

The goal of this cyclic six-steps method is to identify optimum solutions based on operational requirements and performance needs so that the expectations of the aviation community can be met by enhancing the performance of the air navigation system and optimizing allocation and use of the available resources.

This process can be applied at global, regional and local levels, with different level of detail. At a global level, the performance ambitions and a conceptual roadmap resulted from the application of this approach. States and Regions should use, in collaboration with all the members of the aviation community, this performance management process as the basis to develop national and regional air navigation plans adapted to their specific operational requirements and performance needs.

AN-SPA (Air Navigation System Performance Assessment), is an automated tool to guide the user on the application of the six-steps method at a local level.

In the following slides you will be able to find an outlined of these six-steps method.

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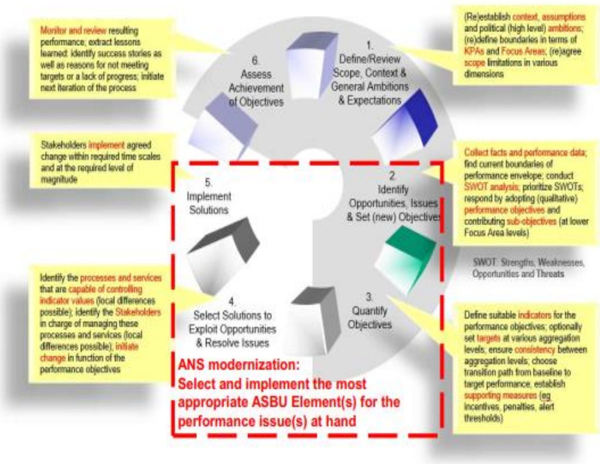
The ICAO six-steps method



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The ICAO six-steps method

- Steps 1 and 2 serve to know your system, its strengths, weakness, opportunities and threats as well as how it is performing in order to set objectives.
    - The catalogue of performance objectives that is part of the GANP global performance framework facilitates the definition of objectives .
- Based on these objectives, targets can be set in step 3 and in step 4 potential solutions identified to achieve the targets by addressing the weakness and threats of the system. Once a set of potential solutions have been identified, a cost-benefits analysis, environmental impact assessment, safety assessment and human factor assessment should be performed to identify the optimum solution.
    - In the GANP performance framework, a list of KPIs, linked to the relevant objectives in the performance objectives catalogue, is provided to set targets though the quantification of objectives.
    - A list of potential solutions to be consider as part of step 4 is the ASBU framework with its functional description of the operational improvements and their associated performance benefits
- Step 5 manages a coordinated deployment of the agreed solution by all stakeholders based on the previous steps. Finally, step 6 consists of monitoring and reviewing the performance of the system after the full deployment of the solution.

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PART IV – THE GANP PERFORMANCE FRAMEWORK

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Introduction

The performance ambitions, at a global level, will be met by pursuing more specific performance objectives.

At a regional level, Volume III of the regional Air Navigation Plans provides regional performance objectives according to specific regional requirements. These objectives are "SMART" — (specific, measurable, achievable, relevant and timely), and although expressed in qualitative terms they may include a desired or required trend for a performance indicator while not yet expressing the performance objective in numeric terms (this is done as part of a performance target setting). The regional performance objectives assist the aviation community in identifying relevant and timely enhancements (operational improvements) to a given region's air navigation system. And at a national level, States can set performance targets for their different operational environments using the list of KPIs, taking into account regional performance requirements.

The GANP performance framework is part of the global technical level of the GANP. Its goal is to allow harmonization of air navigation performance measures at a Regional and national levels. This will allow benchmarking, sharing of lessons learnt regarding the benefits achieved from the implementation of operational improvements within different operating environments, as well as Regions and States to set common performance objectives and comparable targets.

The performance framework consists of a catalogue of performance objectives, defined in the same 11 key performance areas as the ambitions, and an associated list of key performance indicators (KPIs).

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Catalogue of performance objectives

- New in the digital ASBU framework!
- The performance objectives are qualitative but focused statements of desired improvements from today's performance.
- The catalogue of performance objectives was developed to fulfil the gap between the KPAs list and the list of potential KPIs, already available in previous editions of the GANP.
- They served for Regions and States to set common performance objectives and for air navigation implementation planning designers to know, in a qualitative manner, the performance benefits expected from the implementation of the different operational improvements outlined in the ASBU framework, under specific operational conditions.

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List of Key Performance Indicators (KPIs)

- Already available in previous editions of the GANP.
- The KPIs are quantitative means of measuring current/past performance, expected future performance as well as actual progress in achieving performance objectives.
- Three new KPIs have been added to the list of 16 KPIs.
- The list of KPIs will assist States in setting performance targets.

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ASBU Performance assessment

- In the previous editions of the ASBU framework, the performance assessment was only done qualitatively, at a key performance area level (capacity, efficiency, predictability...) and by module.
- In the digital edition of the ASBU framework, the performance assessment is done with more detail:
  - At a level of performance objective within each KPA
  - Qualitatively, however, the performance objectives are linked to key performance indicators (in order to facilitate the implementation of a quantitative approach)
  - By element, operational improvement by operational improvement.

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