

Feasibility study to convert the operational risk management process of reports into Bowtie methodology at euroAtlantic Airways

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Folha em branco

To my beloved family, parents and sister,
for the unconditional love and support
given throughout this entire journey. From
the bottom of my heart, thank you.

Folha em Branco

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Resumo

Ao longo dos anos, a comunidade da aviação tem concentrado os seus esforços em minimizar o risco associado às operações das aeronaves, tais como erro humano ou questões técnicas. Seja com melhorias de segurança, desenvolvimentos tecnológicos ou regulamentações mais rigorosas, esse tem sido sempre o caminho rumo ao futuro. Portanto, os operadores aéreos devem estar cientes de tudo o que envolve as suas operações, principalmente os perigos que podem comprometer os níveis de segurança operacional normais.

Em sequência disto, a euroAtlantic airways sentiu a necessidade de rever o seu processo de Gestão de Riscos de Segurança Operacional de reportes e verificar se ainda se mantinha otimizado ou se poderia ser substituído por outro método disponível no mercado que pudesse melhor servir as necessidades da empresa. Para isso, foi desenvolvido um estudo de viabilidade para converter o processo de gestão de risco operacional de reportes em metodologia *Bowtie*.

Foi realizada pesquisa bibliográfica sobre sistemas de gestão de segurança operacional, identificação de perigos e avaliação de riscos para melhor compreender os processos anteriormente implementados na empresa. Foi construído um diagrama *Bowtie* para analisar eventos de *hard landing*. De seguida, um evento real de *hard landing* reportado no *Integrated Quality and Safety Management System (IQSMS)*, considerado um incidente crucial para a operação da empresa, foi analisado, usando o método atual da euroAtlantic airways (EAA) e a metodologia *Bowtie*.

Os resultados de ambas as análises foram então comparados e revelaram que embora a metodologia *Bowtie* seja um método bem estruturado e reconhecido na indústria, é muito complexo para a realidade da empresa e a sua operação. Concluiu-se que o uso do método atual, com atualizações específicas em termos da base de dados, pode continuar a desempenhar o seu papel.

Numa fase final, foram propostas melhorias ao sistema atualmente estabelecido, incluindo atualizações na base de dados para a categorização do evento, bem como a introdução da metodologia *Bowtie* para análise de eventos críticos como, por exemplo, o *hard landing*.

Palavras-chave

Segurança Operacional, Sistema de gestão de segurança operacional, *euroAtlantic airways*, IQSMS, metodologia *Bowtie*, Avaliação de risco.

Resumo Alargado

Introdução

Este resumo alargado apresenta de forma concisa o enquadramento desta dissertação e os objetivos que se pretendem atingir com a realização da mesma. São também referidos os aspetos mais relevantes do caso de estudo, as principais conclusões retiradas durante o seu desenvolvimento e as perspetivas de trabalhos futuros.

Enquadramento da dissertação

Atualmente, várias entidades reguladoras e autoridades aeronáuticas internacionais, como a *International Civil Aviation Organization* (ICAO) e a *European Aviation Safety Agency* (EASA), reconhecem a importância de os operadores conhecerem os perigos e consequentes riscos associados a todas as suas operações.

Como membro da *International Air Transport Association* (IATA) com certificado *IATA Operational Safety Audit* (IOSA) e operador aeronáutico português obrigado a cumprir as regulamentações EASA, a euroAtlantic airways (EAA) tem de assegurar que controla o máximo de perigos aos quais as suas aeronaves, tripulações e clientes estão sujeitos em todas as suas operações.

Em 2014, a EAA implementou o seu próprio Sistema de Gestão de Segurança Operacional. Desde então que tem focado fortemente os seus esforços em contribuir para o sucesso deste sistema e para que cumpra por completo uma das suas principais funções: gerir da melhor forma os riscos a que a empresa está sujeita a todos os níveis.

Para isso, conta com um software (IQSMS) para reportar eventos que ocorram no universo da companhia, identificar os perigos e avaliar consequentes riscos que daí advenham e prevenir que causem dano à empresa e seus trabalhadores, bem como de acontecerem novamente.

Uma parte importante deste sistema é o processo de avaliação de risco e o método utilizado para efetuar essa avaliação. Atualmente, a euroAtlantic airways conta com um sistema eficiente, mas que carece de alguma automatização em alguns

tópicos. No entanto, os responsáveis pela segurança operacional da empresa acreditam que estas lacunas do atual sistema possam ser, eventualmente, colmatadas por outro método existente no mercado.

Objetivos

O objetivo desta dissertação é estudar a viabilidade de converter o processo atual de gestão de risco operacional de reportes utilizado na euroAtlantic airways, em metodologia *Bowtie*, de modo a melhorar o funcionamento do respetivo Sistema de Gestão de Segurança Operacional da empresa.

Em particular, este trabalho centra-se na apresentação da metodologia *Bowtie* e do método já utilizado pela empresa e na avaliação de um evento crítico para a empresa reportado no IQSMS tendo por base os dois métodos. Com isto pressupõe-se tirar conclusões acerca de ambos e auxiliar os responsáveis pela segurança operacional da empresa a tomar decisões relativamente à questão pertinente de qual dos métodos se adequa melhor às necessidades da empresa.

Caso de estudo

Numa fase inicial, foi necessário desenvolver um estudo sobre a organização interna da empresa de modo a permitir um melhor conhecimento acerca da mesma e dos seus procedimentos, com especial foco no departamento de Segurança Operacional. Para tal, o Manual da Organização e o Manual de Gestão de Segurança Operacional foram utilizados como principais guias na realização do presente estudo.

Para este estudo, foi realizada uma pesquisa bibliográfica sobre sistemas de gestão de segurança operacional, identificação de perigos e avaliação de riscos, incluindo manuais e regulamentos internos da EAA e documentos de autoridades e agências nacionais e internacionais, como EASA, Autoridade Nacional da Aviação Civil (ANAC), ICAO e IATA.

Posteriormente, a recolha de dados foi efetuada principalmente através do IQSMS. Em relação aos métodos de avaliação de risco foi apresentado um evento de *hard landing*, considerado crítico para a empresa, que foi então analisado utilizando ambos os métodos à disposição, ou seja, o *System Related* e a metodologia *Bowtie*.

O evento de *hard landing* reportado no IQSMS foi extrapolado para a versão de teste do software e adaptado por questões de confidencialidade para poder ser escrutinado livremente sem interferir com o normal funcionamento da empresa. Depois de ser aprovado, o referido reporte foi analisado através do método atualmente implementado na empresa - *System Related*, o que permitiu tirar algumas conclusões acerca do mesmo e do seu funcionamento.

Em seguida, foi criado um diagrama *Bowtie* para o já referido evento de *hard landing*, considerando os devidos perigos e seus controlos, bem como as possíveis consequências e respetivas medidas de mitigação. A criação deste modelo contou com a ajuda de profissionais experientes da EAA para, assim, ser mais bem assegurada a fiabilidade e correspondência com a realidade operacional do mesmo.

No seguimento, o evento foi então analisado utilizando a metodologia *Bowtie*, à semelhança do que aconteceu previamente com o *System Related*, permitindo estudar o funcionamento do método e as suas vantagens e desvantagens.

Para finalizar, foram comparados os resultados de ambas as análises e os prós e contras de cada um dos métodos utilizados.

Principais conclusões

O método de avaliação de risco atualmente implementado na empresa é passível de ser melhorado, sendo que este estudo em particular realçou que a metodologia *Bowtie*, apesar de ser um método aceite pela comunidade aeronáutica, é demasiado complexo para ser utilizado como principal ferramenta no IQSMS, tendo em conta a dimensão da EAA.

Relativamente ao *System Related*, concluiu-se que, atualmente, e considerando a dimensão e respetiva operação da EAA, é um método que desempenha eficientemente o seu papel pois revelou-se ser fácil de usar e rápido em termos da obtenção dos resultados pretendidos quando se faz uma avaliação de risco.

No entanto, deverá sofrer algumas atualizações no que diz respeito à base de dados em que se baseia para, assim, acompanhar a evolução da empresa e dos riscos a que a mesma está sujeita.

Acerca da metodologia *Bowtie*, o presente estudo revelou que é uma ferramenta adequada para efetuar a gestão de risco de empresas e operadores aéreos, mas que, contudo, se torna demasiado complexa e difícil de manter atualizada. Seria necessário mais pessoal especializado e tomaria demasiado tempo útil ao departamento de Segurança Operacional implementar por completo uma ferramenta como esta, bem como mantê-la atualizada ao longo do tempo para garantir que continuaria a desempenhar a função para a qual foi adotada.

Perspetivas de investigação

Para melhorar o processo de gestão de risco da empresa, a base de dados do método utilizado para a avaliação de risco deve ser atualizada, para que acompanhe o progresso na operação da EAA.

Relativamente à metodologia *Bowtie*, seria benéfico que fosse utilizada na análise de eventos mais críticos para a empresa, para permitir uma melhor investigação dos reportes associados a esses referidos eventos.

Abstract

Over the years, the aviation community has focused its efforts on minimizing the risk aircraft face, such as human errors or technical issues. Whether with safety improvements, technological developments or stricter regulations, that path has always been the way towards the future. Therefore, airline operators must be aware of everything surrounding its operations, particularly the hazards that may compromise the normal safety levels.

Following this, euroAtlantic airways felt the need to review its reports related to the Safety Risk Management process and to verify if it was still optimized or if it could be replaced by another method available in the market that could better serve the needs of the company. To do so, a feasibility study to convert the operational risk management process of reports into Bowtie methodology was implemented.

It was carried out a bibliographic research on safety management system, hazard identification and risk assessment to better understand the processes previously implemented in the company. A Bowtie diagram for hard landing was created. Then, a real event of a hard landing reported in the company's IQSMS, considered to be a crucial incident for the company's operation, was analysed using EAA's current method and the Bowtie methodology.

The results of both analyses were then compared and revealed that even though the Bowtie methodology is a well-structured and recognized method within the industry, it is too complex for the reality of the company and its operation. It was concluded that the current method used, with specific upgrades in terms of the database, can continue to play its role.

In the end, improvements were proposed to the system currently established, including updates in the database for the event's categorization, as well as the introduction of the Bowtie methodology for analysing critical events like, for example, the hard landing.

Keywords

Safety, Safety Management System (SMS), euroAtlantic airways, IQSMS, Bowtie methodology, Risk assessment.

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Acronyms List

ACMI	Aircraft, Crew, Maintenance and Insurance
AM	Accountable Manager
ANAC	Agência Nacional de Aviação Civil (Brasil)
ANAC	Autoridade Nacional de Aviação Civil (Portugal)
AOC	Air Operator Certificate
ARMS	Aviation Resource Management System
ASQS	Advanced Safety and Quality Solutions
CAA	Civil Aviation Authority
DAF	Administrative and Financial Department
DCM	Compliance Monitoring Department
DCO	Commercial Department
DME	Maintenance and Engineering Department
DOT	Ground Operations Department
DOV	Flight Operations Department
DSP	Dispatch Department
EAA	euroAtlantic airways
EASA	European Aviation Safety Agency
ERC	Event Risk Classification
FAA	Federal Aviation Administration
FAOC	Foreign Air Operator Certificate
FAR	Federal Aviation Regulation
GPIAAF	Gabinete de Prevenção e Investigação de Acidentes com Aeronaves e Acidentes Ferroviários
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IOSA	IATA Operational Safety Audit
IQSMS	Integrated Quality and Safety Management System
SAF	Safety Department
SEC	Security Department
SHELL	Software, Hardware, Environment, Liveware
SIRA	Safety Issue Risk Assessment
SMM	Safety Management Manual
SMS	Safety Management System
SRM	Safety Risk Management
SSP	State Safety Programme
TRN	Crew Training Department
USA	United States of America

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Main concepts

Accident (ICAO, 2013): it is an occurrence associated with the operation of an aircraft, which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which:

- a person is fatally or seriously injured as a result of:
 - Being in the aircraft, or
 - Direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or
 - Direct exposure to jet blast, or
- the aircraft sustains damage or structural failure which:
 - adversely affects the structural strength, performance or flight characteristics of the aircraft, and
 - would normally require major repair or replacement of the affected component, or
- the aircraft is missing or is completely inaccessible.

Bowtie (IP Bank B.V., 2015): it is a risk assessment method that can be used to analyse and communicate how high risk scenarios develop. The essence of the bowtie consists of plausible risk scenarios around a certain hazard, and ways in which the organisation stops those scenarios from happening.

Hazard (ICAO, 2018): it is a condition or an object with the potential to cause or contribute to an aircraft accident or incident.

Incident (ICAO, 2013): it is an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.

Safety (ICAO, 2018): it is the state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level.

Safety Risk Assessment (Skybrary, 2021): it is the second step in the risk management process. Once hazards and their effects have been determined during the first step by

means of hazard identification, an analysis is required to assess the probability of the hazard effects occurring and the severity of these effects on aircraft operation.

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Chapter 1 - Introduction

1.1 Motivation

The aviation industry has learned a lot from its mistakes and has applied that learning over the decades. Accident investigation work has matured, as has the industry's ability to capture data to inform those investigations so that they can produce robust mitigations, which have been applied in better technology, procedures and training.

In some areas of the world, and with some types of aircraft equipment, the world is witnessing a plateau in accident rate improvement (figure 1). It is clear that it has entered an era in which people must look harder for performance improvements, work beyond goals and be sure that what is introduced will improve performance. As a growing industry and increasingly used, the travelling public and costumers in general are counting on continual safety improvement.

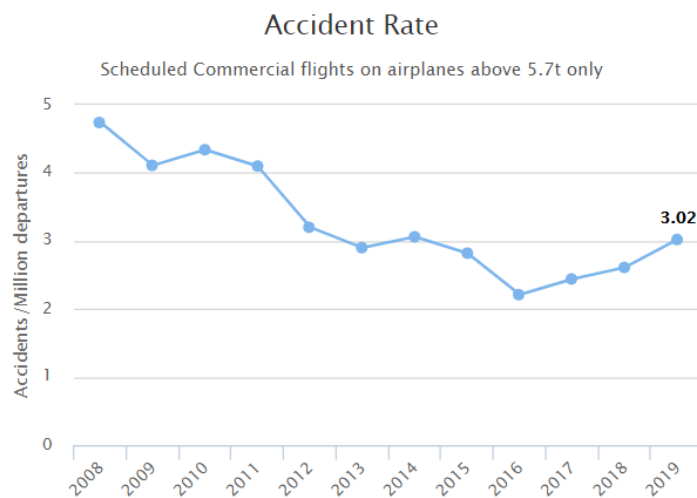


Figure 1 - Accident rate on commercial flights (ICAO, 2020)

One of the most potentially significant and impactful developments that may help to break through the plateau is the introduction of safety management systems (SMS). Using a performance-based approach to improve safety, combined with gathering relevant safety information in a “just culture” environment, has advanced the capability of many organisations around the world.

The complete elimination of risk in aviation operations (for example, bird strikes or power discharges) is an unachievable and impractical goal, because humans do not have the power to control such environmental effects. Risks can be divided into two different kinds: internal (those related to the aircraft, its crew and its operation) that the human can control but never eliminate and external (meteorological factors and nature related events) that were mentioned above.

In other words, it is accepted that there will be some probability - between 10^{-9} and 10^{-7} (FAA, 1994) - of occurring harm to people, property or environment, but this is considered to be acceptable or tolerable by the responsible authority and society. In aviation, no one tries to eliminate the risk, everyone tries to lower the probability of its occurrence to the minimum possible (Čokorilo & Dell'Acqua, 2013).

As a key component of an effective SMS, risk management is a planned and structured process aimed at helping organisations to make the right decision at the right time to identify, classify, quantify the risks and then to manage and control them. As such, risk management becomes an integral part of safety management which intends to identify and manage potential and unforeseen risks, that can compromise the well-being of operators and organisations (Srinivas, 2018).

To maximize the effects of a good risk management process, it is mandatory to have in count that the system being studied is affected by hazards, with an associated risk, produced by an undesirable event. Naturally, those risks lead to consequences for the system and its safety. As the main goal is to reduce those risks to the minimum possible level, reactive mitigation measures are required. The Bowtie methodology encompasses all this in a model very intuitive and user friendly.

Used throughout the planet and transversal to almost every industry and business, the origins of the Bowtie methodology are to be found in a simplified merge of fault and event tree methodologies, but in the 90's the oil and gas industry founded and developed the practical application of the Bowtie methodology as a tool to facilitate a better understanding of how risks were being overseen and managed. The benefits of the methodology have since been recognized in numerous other industries including defence, medical, financial and the aviation industry (CAA, 2020).

The aviation community is mostly familiar with Professor James Reason's model, referred to as "Swiss cheese" and the Bowtie methodology is a barrier-based structure illustrating this approach. This method is also referred to in ICAO's Safety Management Manual

document referencing defensive barriers in accident causation with ICAO Annex 19 referring to understanding and appreciating safety risk controls (CAA, 2020).

As an airline with schedule and non-schedule operation, EAA faces a large scope of hazards. With the operation constantly changing, it must adapt to different realities and different occurrences, always having the safety of its passengers and crew as the major concern. Although EAA already has its own risk assessment method, it could benefit from improving it to a Bowtie methodology, which can be a very interesting tool to improve the safety of everyone within the aircraft environment.

1.2 Objective

The objective of this dissertation is to evaluate the feasibility of converting into Bowtie methodology the Operational Risk Management process of reports used currently at euroAtlantic airways, aimed at improving to a more efficient level vis-à-vis the existent method in the company.

1.3 Methodology

For this study, it is used documental and bibliographic research about safety management system, hazard identification and risk assessment. The sources are all referred to in the references, which includes manual and internal regulations from EAA and documents from national and international authorities and agencies, such as EASA, ANAC, ICAO and IATA.

Afterwards, data collection is mainly made through IQSMS¹ report system as well as different types of risk assessment analysis, to verify and attest the feasibility and viability of each one. Regarding the Bowtie methodology, a case of study is presented in which a diagram is built referring a top event within the company.

The results provided by this study shall be validated by the Safety department, through the Safety Manager and by the Accountable Manager.

1.4 Work limits

The biggest limitation of this work is the lack of literature and scientific knowledge regarding the currently risk assessment method used by EAA. The complexity of the

¹ Integrated Quality Safety Management System. It is presented in a more detailed way in chapter 3.

Bowtie methodology and lack of practical examples of companies that use it in its main form is also a great difficulty.

1.5 Organisation

This dissertation is organised in five chapters as follows:

Chapter 1 presents the motivation, objective, methodology, work limits and the structure of the study.

Chapter 2 has a brief presentation of euroAtlantic Airways in terms of history, operational overview, aircraft fleet and organisation of the company itself, globally and specifically in the Safety Department.

Chapter 3 focuses on the state of art of the topic studied throughout this dissertation, introducing key topics to the work developed such as safety risk management, the evolution of SMS both in EAA and in the aeronautics industry and an exposition of the company's reporting system, more specifically the risk assessment module, which is the main focus of this study.

Chapter 4 represents the procedure followed to achieve the main goal in this thesis: determine if the Bowtie methodology is or is not more viable than the current system used. The case study is presented, in which an event is evaluated using the types of methods available in the company's IQSMS (System Related and Bowtie methodology).

Chapter 5 is the conclusion of the work, the answer to the initial question, the recommendations driven from the results achieved and the indication of future work regarding the subject that can be developed to the best interest of the scientific community and the company itself.

Chapter 2 - euroAtlantic Airways

2.1 History and operational overview

Initially founded as Air Zarco on August 25th, 1993 by Tomaz Metello - chairman and former major shareholder - the company operated as a broker² during its first years of operation until 1997. In that year and with the acquisition of its first aircraft, a Lockheed L-1011 Tristar (Figure 2), Air Zarco started operations with its own AOC³. The company first adopted the trade name Air Madeira until May 17th, 2000, date when the memorandum of association was altered by deed, and the current name of euroAtlantic airways - Transportes Aéreos S.A. was adopted (EAA, 2020d).

euroAtlantic airways was bought by a company called I-Jet Aviation PT-SGPS, Lda., on November 15th, 2019, being now majority owned by the referred group.



Figure 2 - Air Zarco's Lockheed L-1011-385-3 TriStar 500 (Carvalho, 2020)

EAA's home base is in Aeroporto Humberto Delgado and headquarters are in Figo Maduro where all departments of the company are based, such as DME, DCM, DSP, DOT, DOV, SAF, SEC, TRN, DCO and DAF.

² A firm which arranges transactions between a buyer and a seller with the purpose of receiving a commission when it is verified the execution of the deal (Burskirk & Stanton, 1978).

³ An Air Operator Certificate (AOC) is a certificate authorising an operator to carry out specified commercial air transport operations (ICAO, 2010).

EAA is an IATA Member since November 2010 with the call sign of YU, FAA (FAR129⁴), EASA (Air-OPS1⁵) and IOSA⁶ certified since August 2009. It provides charter services⁷, long term dry-lease⁸, ACMI⁹ and Ad-Hoc¹⁰ flights from anywhere to several places in Europe and to the rest of the world (EAA, 2020d).

The company also detains the majority of STP Airways, the national airline of Sao Tome and Principe, performing regular flights to and from that country.

euroAtlantic airways is a schedule and non-schedule Portuguese international airline, operating in the most diverse routes in North Atlantic with air transport license and FAOC¹¹ to operate into the USA and Canada, Caribbean, Central and South Americas, Africa, Middle East, Pacific, Australia and Oceania (EAA, 2020d).

According to the Financial Department of EAA, during 2019, 793.735 passengers were transported between more than 123 airports in a total of 54 ACMI operations, 12 charter operations and 1 regular operation.

As of July 31st, during 2020, 107.266 passengers were transported between more than 70 airports in a total of 19 ACMI operations, 52 charter operations and 1 regular operation.

Regarding the number of employees at the company, as of August 25th, 2020, 331 collaborators were registered, divided into Ground personnel and Air personnel.

⁴ Foreign air carriers or operators who would like to conduct passenger or cargo operations to, from, and transiting the United States, must obtain a permit issued by the Department of Transportation (DOT) (FAA, 2020).

⁵ Commission Regulation (EU) No 965/2012 (the so-called 'Air Ops Regulation') contains provisions for the four types of air operations with airplanes and helicopters, being type 1: commercial air transport (CAT) operations (EASA, 2020a).

⁶ The IATA Operational Safety Audit (IOSA) program is an internationally recognized and accepted evaluation system designed to assess the operational management and control systems of an airline. All IATA members are IOSA registered and must remain registered to maintain IATA membership (IATA, 2020).

⁷ A non-scheduled operation using a contractual arrangement between an air carrier and an entity hiring or leasing its aircraft (ICAO, 2009).

⁸ Lease of an aircraft without any crew, whose operation is carried out under the tenant's AOC (INAC, 2003).

⁹ A wet lease where the lessor provides an Aircraft with Crew, Maintenance and Insurance. The aircraft is operated under the AOC of the lessor (IATA, 2017).

¹⁰ A short term lease for operations requiring specifically the lease of an aircraft for a small number of flights, usually 2-5 operations (EAA, 2020c)

¹¹ Foreign Air Carrier Operations Certificate (Seminar et al., 2014).

2.2 Aircraft fleet

As of this date, euroAtlantic airways' fleet is composed by eight aircraft: one Boeing 737-800NG, six Boeing 767-300ER and one Boeing 777-200ER. The company is planning to receive the first Boeing 787 Dreamliner in Portugal, but due to the Covid-19 pandemic had to postpone this new addition to its fleet.

As EAA is mainly a non-scheduled airline, its aircraft and respective configurations are in constant change to comply with the needs regarding its operations. For example, during last spring the company applied for an approval for converting a Boeing 767-300ER originally prepared to transport passengers into cargo, to fulfil the needs of the company and its clients.

Table 1 listed below has all the aircraft registration information as well as other important facts about each of them.

Table 1 - EAA's aircraft informations (EAA, 2020a)

MODEL	REG	SERIAL N.	YOM	JOIN FLEET	IFE Movies / TV Series / Musics	CONF	
						C	Y
BOEING 737-800NG	CS-TQU	30646	2002	2012	General TV in the Cabin	16	144
BOEING 767-300ER	CS-TKR	30854	2001	2015	Individual in-Seat	16	246
	CS-TKS	30841	2001		Individual in-Seat	16	246
	CS-TKT	30853	2001		-	-	300
	CS-TST	33047	2002	2018	-	-	309
	CS-TSU	33048	2002	2018	WiFi	-	267
	CS-TSV	33049	2003	2018	WiFi	34	199
BOEING 777-200ER	CS-TFM	28513	1998	2009	Individual in-Seat and WiFi	24	302

The following figure 3 shows an exemplar of EAA's Boeing 737-800NG.



Figure 3 - euroAtlantic airways' Boeing 737-800 NG (Verguet, 2020)

Table 2 below presents the specifications of EAA's Boeing 737-800NG.

Table 2 - euroAtlantic airways' Boeing 737-800 NG Specifications (EAA, 2020a)

Current Fleet	1
Wing Span	34,3 m
Length	39,5 m
Tail Height	12,5 m
Three Classes Accommodation	12C - 54W - 96Y
Two Classes Accommodation	12C - 156Y 16C - 144Y
Version Full Economy	186Y
Cruising Speed	823 km/h
Range	3.115 nmi / 5.765 km
Engines	2 turbofans CFM 56-7B27

In figure 4 below, it is presented an exemplar of EAA’s Boeing 767-300ER. In this specific case it is represented the CS-TKR.



Figure 4 - euroAtlantic airways' Boeing 767-300ER (Francisco, 2020)

Table 3 below shows the specifications of EAA’s Boeing 767-300ER.

Table 3 - euroAtlantic airways' Boeing 767-300 ER Specifications (EAA, 2020a)

Current Fleet	6
Wing Span	47,6 m
Length	54,9 m
Tail Height	51,8 m
Cabin Width	4,7 m
Three Classes Accommodation	18C – 32W – 226Y
Two Classes Accommodation	16C – 234Y 12C – 273Y 12C – 262Y 10C – 238Y
Version Full Economy	302Y 300Y 266Y
Cruising Speed	651 851 km/h
Range	11,306 km
Engines	2 turbofans Pratt & Whitney PW4060-3 e/and GE CF6

Figure 5 represents an exemplar of EAA's Boeing 777-200ER.



Figure 5 - euroAtlantic airways' Boeing 777-200ER (Martins, 2020)

The following table 4 presents the specifications of EAA's Boeing 777-200ER.

Table 4 - euroAtlantic airways' Boeing 777-200 ER Specifications (EAA, 2020a)

Current Fleet	1
Wing Span	60,9 m
Length	63,7 m
Tail Height	18,5m
Two Classes Accommodation	30C - 293Y
Version Full Economy	360Y
Cruising Speed	892,08 km/h
Range	14 260 km
Engines	Motores Engines 2 turbofans Rolls-Royce Trent 884

2.3 euroAtlantic airways organisation

euroAtlantic airways has a very well-defined structure, so that all departments can work effectively and in constant interaction. EAA's mission in the aircraft leasing business, is to become the first choice for airlines worldwide. Therefore, its continuous and systematic effort is focused on efficiency, safety, security and fulfilling the high levels of quality (EAA, 2019).

euroAtlantic airways' operation is based in six crucial values, that lead the company's path to success and keep all parts together (EAA, 2019):

- **Safety and Security**: all company personnel are responsible for promoting a Safety and Security culture to achieve the highest levels of safe and secure operations;
- **Quality**: because a quality service leads organisations to success;
- **Courage**: it requires strength and determination to embrace changes;
- **Integrity**: all known champions have always been honest and transparent, and true success comes from integrity;
- **People**: maintaining and developing excellence among company's employees as they reflect euroAtlantic airways' reputation and success;
- **Value for Cost**: we shall deliver value for money, and continually review our activities to ensure that we operate in a cost-effective way.

In figure 6 it is represented the General Organisation chart of the company where it is possible to see the different officers and departments.

euroAtlantic airways General Organogram

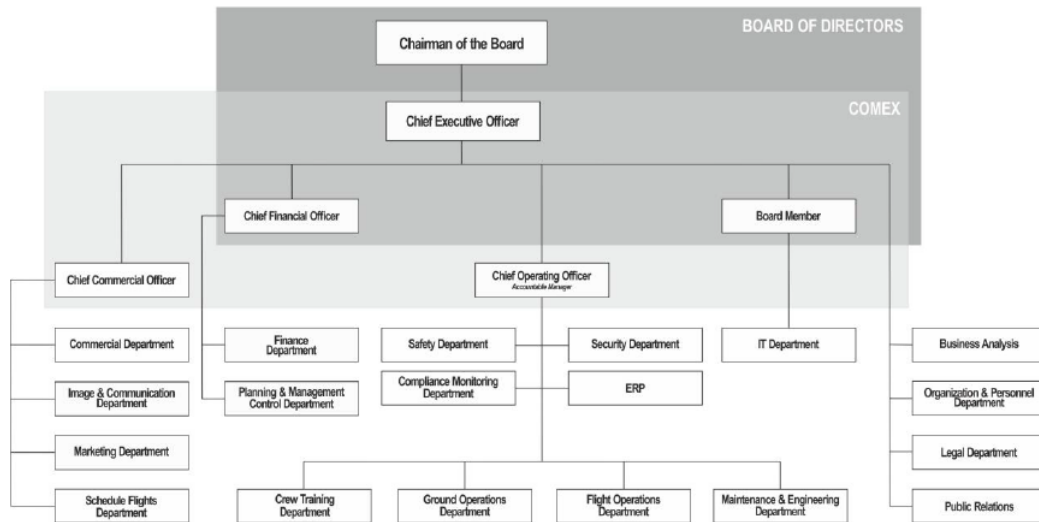


Figure 6 - euroAtlantic airways' General Organisation chart (EAA, 2019)

euroAtlantic airways' management is composed by the Accountable Manager (AM), all Nominated Persons, sector managers, and their deputies and responsables for the remaining areas (EAA, 2019):

- **Accountable Manager:** is appointed by EAA and accepted by ANAC;
- **Nominated Persons:** EAA is responsible for appointing managers, that must be accepted by ANAC, responsible for the management and supervision of the following areas:
 - Flight operations;
 - Crew training;
 - Ground operations;
 - Continuing airworthiness.
- **Sector Managers:** EAA is responsible for appointing managers, that must be accepted by ANAC, responsible for the management and supervision of the following sectors:
 - Compliance monitoring system;
 - Safety system and security system;
 - Dangerous good transportation program;
 - Electronic data management program (EFB).
- **Deputies:** for all mentioned above. Require equally acceptance of ANAC.

2.3.1 Accountable Manager

The Accountable Manager can be described as the single individual who is designated as the person responsible to a regulatory authority (ANAC) in respect of the functions which are subject to regulation and carried out by an aircraft operator. That person is normally expected to be the person who has corporate authority for ensuring that all operations activities can be financed and carried out to the standard required by the regulator authority (ANAC, 2018).

In this particular case, the Accountable Manager (EAA, 2019):

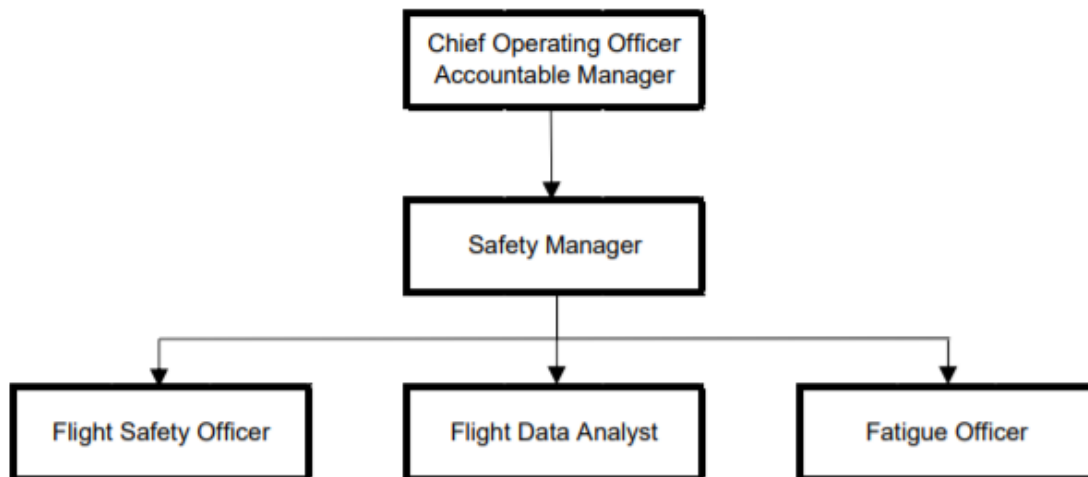
- Has ultimate responsibility and accountability on behalf of EAA for the implementation and maintenance of the safety management system (SMS) throughout the organisation;
- Has the authority to ensure the allocation of resources necessary to manage safety and security risks to aircraft operations, including human resources conditions, financial resources and the existence of the necessary facilities, workspace, equipment and supporting services, as well as work environment;
- Has overall responsibility and is accountable for ensuring operations are conducted in accordance with conditions and restrictions of the AOC, and in compliance with applicable regulations and standards of EAA and applicable regulations such as requirements of ANAC, EASA, and other relevant aviation authorities regarding the company's fleet and operation;

Nominated Persons report directly to the Accountable Manager.

2.3.2 euroAtlantic airways Safety Department

EAA's Safety Department plays the most important role on the safety approach of the company as its main concern is assuring the safety of all company members and respective duties. euroAtlantic airways' safety policy is the means whereby it is established how to maintain and, where practicable, improve safety levels in all its activities and to minimize its contribution to the risk of an aircraft accident as far as is reasonably practicable (EAA, 2020b).

In figure 7 it is represented the Safety Management Organisation chart and its respective chain of command.



Safety has representatives in all other departments of EAA. Their functions are documented in SMM¹².

Figure 7 - euroAtlantic airways' Safety Management Organisation chart (EAA, 2020b)

The AM has corporate authority for ensuring that all operations and maintenance activities can be financed and carried out to the standard required by the Authority, and to any additional requirements defined by euroAtlantic airways. The Accountable Manager chairs the Safety Review Board¹³, endorses the safety objectives and approves the Safety quarterly reports (EAA, 2020b).

The AM has the authority and responsibility for (EAA, 2020b):

- Define and approve the SMS policies and objectives;
- Communicate to the organisation the importance of an SMS;
- Provide the resources (personnel, funding, and support) necessary to fulfil SMS requirements;
- Foster a strong safety culture within the organisation;
- Facilitate implementation of the SMS across the organisation;
- Promote awareness of safety requirements throughout the organisation.

¹² The Safety Management Manual (SMM) is the key instrument for communicating the approach to managing safety within the Company. The SMM documents all aspects of safety management, including the safety policy, procedures and individual safety responsibilities (EAA, 2020b).

¹³ euroAtlantic airways' Safety Review Board is responsible for ensuring that the safety management system processes are established, communicated, implemented, audited, measured and continuously improved for the company and key customers. It is held twice a year (EAA, 2020b).

The Safety Manager, which is the individual responsible for the oversight of euroAtlantic airways' safety performance, is the focal point for the development, implementation and day-to-day administration and maintenance of the SMS on behalf of the Accountable Manager. It reports directly to the Accountable Manager on all safety matters and in this way safety reports and recommendations can be assured of the proper level of study, assessment and implementation. The Safety Manager coordinates SMS functions through the organisation and is responsible for, among others, facilitating the hazard identification, risk analysis and management processes (EAA, 2020b).

So that the company's policy can be well and directly implemented in every single area of EAA, each Department has a Safety Representative (or Representatives) that handle the entire Department Safety programme directly with the Safety Manager. The main tasks of the department safety representatives are (EAA, 2020b):

- When required, support the investigation procedures for all the occurrence reports related to their functional area, providing the safety department with all the necessary elements to the investigation process closure;
- Promote the volunteer safety reporting among their department and team members, raise awareness to the importance of the volunteer safety reporting;
- Cooperate with the Safety Department promotion activities;
- Actively participate in the Safety Review Board and Safety Action Group¹⁴;
- Send the Safety Department all relevant information or recommendations to improve the operational safety;
- Relay urgent and routine safety related information within their department;
- Identify and analyse safety hazards within their department aiming at its elimination or risk mitigation;
- Collect and manage data for safety performance indicators.

¹⁴ A Safety Action Group is established as a standing group to assist and support the Safety Management department. This forum involves all Safety Representatives from all departments and meets at least once every quarter. The Safety Manager chairs the Safety Action Group (EAA, 2020b).

Folha em Branco

Chapter 3 - State of Art

3.1 Safety historical perspective

Aviation safety is a dynamic system that keeps on presenting new challenges, in terms of hazards, risks and its respective mitigation measures. In a perfect scenario, all risks are fully mitigated and the system itself is free from hazards and threats. However, as mentioned before in 1.1, such state is impossible to achieve unless all aircraft stay on ground and the aviation world stops completely which in essence is an absurd condition as that is contrary to the nature of an aircraft, that is, to fly.

Within the aviation community, safety is defined as “the state in which the risks associated with aviation activities related to, or in direct support of, the operation of aircraft, are controlled and reduced to an acceptable level” (ICAO, 2018). The progress in aviation safety has come through four different periods in time (figure 8), which roughly align with eras of activity:

- a) **Technical era** - from the early 1900's until the late 1960's, aviation emerged as a form of mass transportation in which identified safety deficiencies were initially related to technical factors and technological failures. By the 1950's, technological improvements led to a gradual decline in the frequency of accidents, and safety processes were extended to include regulatory compliance and oversight;
- b) **Human factors era** - in the early 1970's, the frequency of aviation accidents was significantly reduced due to major technological advances and enhancements to safety regulations. Aviation became a safer mode of transportation, and the focus of safety endeavours was extended to include human factors issues including the man/machine interface. By the early 1990's it was first acknowledged that individuals operate in a complex environment, which includes multiple factors having the potential to affect their behaviour;
- c) **Organisational era** - from the mid-1990's safety began to be viewed from a systemic perspective, which was to encompass organisational factors in addition to human and technical factors. As a result, the notion of the “organisational accident” was introduced, considering the impact of organisational culture and policies on the effectiveness of safety risk controls. Routine safety data collection and analysis using reactive and proactive methodologies enabled organisations to monitor known safety risks and detect emerging safety issues;

- d) **Total system era** - as of today, many countries and service providers have reached a higher level of maturity with the implementation of their SSP or SMS's. However, SMS's have focused more on their own safety performance and what they have control over rather than consider the wider context of the total aviation system. This has led to growing recognition of the complexity of the aviation system and the different organisations that all play a part in aviation safety.

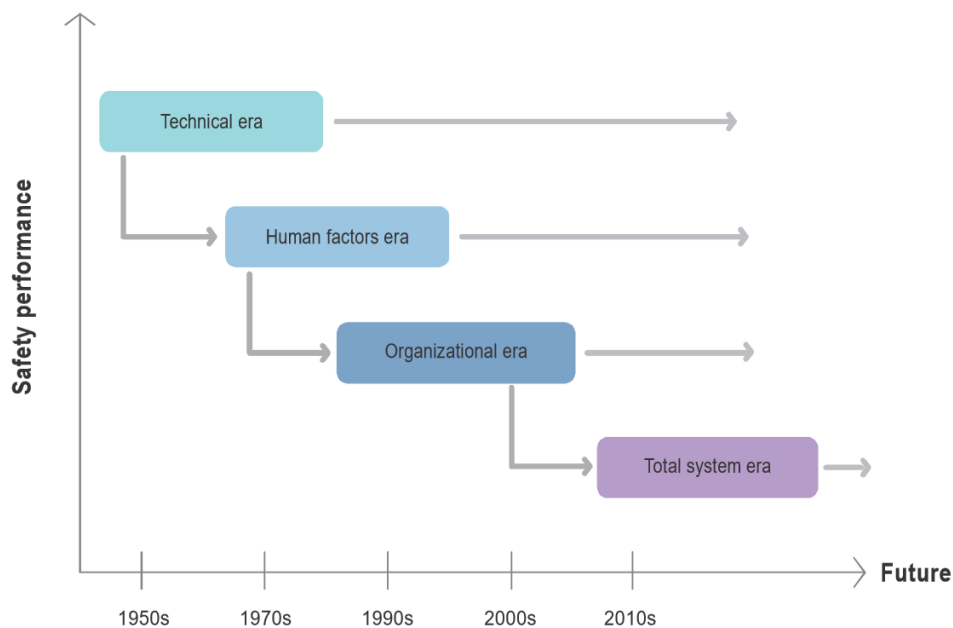


Figure 8 - Safety evolution (ICAO, 2018)

3.2 Human factors in aircraft accidents

It is generally accepted that like most accidents, those in aviation do not happen in an isolated manner. Rather, they are the result of a chain of events often culminating with the unsafe acts of aircrew (Wiegmann et al., 2005).

The human element is the most flexible, adaptable and valuable part of the aeronautical environment, while being the most vulnerable. As most aviation incidents and accidents are the result of failure in the human performance, there is a tendency to attribute the causes of these occurrences to human error. However, the term “human error” does not help in the prevention and investigation of aviation events; although it shows where the

system failed, it does not tell anything about the causes that led to the failure (Dumitru, 2015).

Human Factors have been progressively developed to enhance the safety of complex systems, such as aviation, by promoting the understanding of the predictable human limitations and its applications to properly manage the “human error”. It is only when seeing such an error from a complex system viewpoint that it can identify the causes that lead to it and address those causes (EAA, 2020b).

Particularly useful in this matter has been James Reason (1990) in his “The Contribution of Latent Human Failures to the Breakdown of Complex Systems”, where he presents the description of active and latent failures within the context of his “Swiss cheese” model of human error. In his model, Reason describes four levels of human failure, each one influencing the next.

Reason and other authors describe that organisational influences often lead to instances of unsafe supervision, which in turn lead to preconditions for unsafe acts and ultimately the unsafe acts of operators. It is at this latter level, the unsafe acts of operators, that most accident investigations are focused upon (Wiegmann et al., 2005).

The effectiveness of safety management depends largely on the degree of senior level support and management commitment to create a working environment that optimises human performance and encourages personnel to actively engage in and contribute to the organisation’s safety management processes (ICAO, 2018).

3.2.1 The Swiss cheese model

This model, developed by James Reason and so well known to the aviation industry and commonly used in its investigations, shows that accidents are composed by breaches of multiple layers in the defence system. These same breaches can be triggered by various enabling factors such as equipment failures, operational errors or even human error, which are the most common causes of accidents in the aviation world.

The Swiss cheese model (figure 9) is a heuristic explanatory device for communicating the interactions and chains that occur when a complex well-defended system suffers a catastrophic breakdown. It conveys the fact that no one failure, human or technical, is sufficient to cause an accident.

Rather, it involves the unlikely and often unforeseeable conjunction of several contributing factors arising from different levels of the system. It also indicates what defines an organisational accident, namely the concurrent failure of several defences, facilitated, and in some way prepared, by suboptimal features of the organisation design (Eurocontrol, 2006).

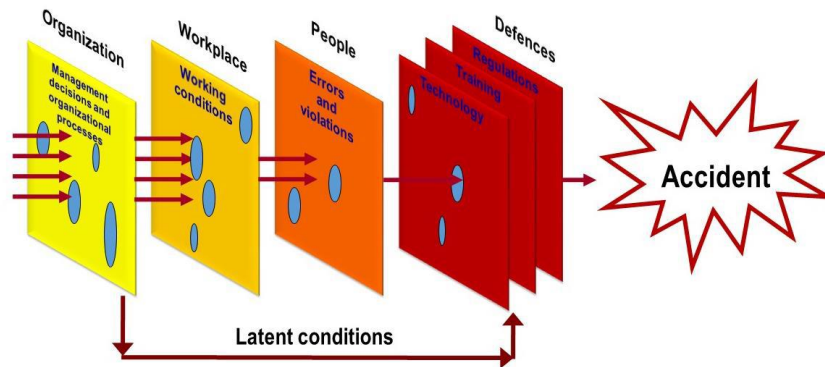


Figure 9 - Swiss cheese model (EAA, 2020a)

Breaches in safety defences can be a delayed consequence of decisions made at the higher level of the organisation, which may remain hidden until their effects are activated by certain specific operating conditions - latent conditions. Under such specific circumstances, human failures - active failures - at the operational level act to breach the final layers of safety defence. The Reason model proposes that for an accident to occur a combination of both active failures and latent conditions may be verified (ICAO, 2018).

Active failures are actions or inactions, including errors and rule breaking, which have an immediate adverse effect. Also viewed as unsafe acts, active failures are generally associated with front-line personnel (pilots, air traffic controllers, aircraft mechanical engineers, etc.) and may result in a harmful outcome (ICAO, 2018).

Latent conditions are those that exist in the aviation system well before a damaging outcome is experienced. Initially, these latent conditions are not perceived as harmful, but will become evident once the system's defences have been breached. Latent conditions in the system may include those created by a lack of safety culture; poor equipment or procedural design; conflicting organisational goals; defective organisational systems or management decisions. People outside the whole system are, most of the times, the ones who create this type of risks (ICAO, 2018).

The Swiss cheese model can also be used as an analysis guide as it helps guide the user to look past the individuals involved in an incident or identified hazard into the organisational circumstances which may have influenced the situation. It can be applied during safety risk management, safety surveillance, internal auditing, management of change and safety investigation.

In each case, the model can be used to consider which of the organisation's defences were effective, which were breached and where additional ones are needed. Once identified, any weaknesses in the defences can be reinforced against accidents and incidents (ICAO, 2018).

3.3.2 The SHELL model

To address the way an organisation influences human performance, it is necessary to exist a senior level support to implement effective safety management. Such approach includes management commitment to create the right working environment, instruct its workers to properly operate the machines and respective software and the right safety culture to address human factors. This will also influence the attitude and behaviour of everyone in the organisation and the way all parts interact between each other (ICAO, 2018).

In order to support the assessment of human factors on safety performance, some models have been created to ease the comprehension of this subject. The SHELL model is well known within the aviation world and very useful to illuminate the influence and interaction that occurs between the different parts of the system and the human itself, focusing also on the interactions of the humans among them.

The SHELL model, as in figure 10, is composed by the human and the workplace components around it (ICAO, 2018):

- a) **Software (S)**: procedures, training, support;
- b) **Hardware (H)**: machinery and equipment;
- c) **Environment (E)**: working environment in which the rest of the system may function;
- d) **Liveware (L)**: other humans in the workplace.



Figure 10 - SHELL model (ICAO, 2018)

In the centre and particularly highlighted is the Liveware, which is the human and the starting point for all the other interactions, as it is the most irregular part of the components mentioned above. The human being is a complex system and is vulnerable to different kinds of effects of external influences and internal, triggered by itself.

Although humans are remarkably adaptable, they are subject to considerable variations in performance. Humans are not standardized to the same degree as hardware, so the edges of this block are not simple and straight. To avoid tensions that may compromise human performance, the effects of irregularities at the interfaces between the various SHELL blocks and the central Liveware block must be understood (ICAO, 2018).

The SHELL Model is useful in visualizing the following interfaces between the various components of the aviation system (ICAO, 2018):

- a) **Liveware-Hardware**: The L-H interface refers to the relationship between the human and the physical attributes of equipment, machinery and facilities and how logical and intuitive these are to operate;
- b) **Liveware-Software**: The L-S interface is the relationship between the human and the supporting systems found in the workplace and how easy and accurate they are to follow and understand;

- c) **Liveware-Liveware**: The L-L interface is the relationship and interaction between people in general in their work environment, how they work with each other and how they overcome their possible differences to achieve a higher purpose;
- d) **Liveware-Environment**: The L-E interface is the relationship between the human and the environment that surrounds it. As mentioned before, it includes both internal and external factors that have the power to influence it.

The study of models like the SHELL help to achieve a systematic and more realistic understanding of why humans make errors, and how can these errors lead to occurrences and possible catastrophes.

3.4 The Safety Management System at EAA

As the world today lives in a “total system” era in terms of safety, it has become mandatory to analyse the factors that lead to occurrences and consequent possible accidents, in order to improve the understanding about such events. To do so, an operator must establish, implement and maintain an organised management system introducing the requirements to comply with organisational standards.

The aim of a well-implemented SMS is to provide a systematic approach to manage safety, to continuously improve safety performance by identifying hazards and threats, collecting and analysing data and continuously assessing safety risks. It allows operators to effectively manage their activities, safety performance and resources (both human and technical), whilst increasing the understanding of their contribution to aviation safety (ICAO, 2018).

The 4 components presented below are the pillars of a common safety management system (FAA, 2017):

1. **Safety Policy**: establishes senior management's commitment to continually improve safety. Defines methods, processes, and organisational structure needed to meet safety goals. Shall be distributed to everyone within the company's environment;
2. **Safety Risk Management**: determines the need for, and adequacy of, new or revised risk controls based on the assessment of acceptable risk. It can be divided in 3 key topics: hazard identification, risk assessment and risk mitigation;

3. **Safety Assurance**: evaluates the continued effectiveness of implemented risk control strategies. Supports the identification of new hazards and monitoring of already existent ones;
4. **Safety Promotion**: includes training, communication and other actions to create a positive safety culture within all levels of the workforce.

It is not in vain these are called “pillars”. It is greatly important that all areas work in constant interaction and that everyone around the company work within these standards, because everyone plays a key role in the whole system success.

In terms of safety vision, EAA establishes several objectives based upon national and international authorities’ recommendations, which are annually reviewed by the highest management personnel (EAA, 2020b):

- a) To efficiently implement a Safety Management System;
- b) To identify and mitigate hazardous conditions;
- c) To perform hazard and risk analysis for relevant proposed new equipment acquisitions, facilities, operations and procedures;
- d) To provide relevant SMS education to all and training to the appropriate personnel;
- e) To improve the effectiveness of the SMS through a yearly review of all aspects of the SMS.

According to ANAC, euroAtlantic has its own SMS implemented since 25th October, 2014 (ANAC, 2015). EAA’s SMS is an organised, proactive and integrated approach to manage safety, including the necessary organisational structures, accountabilities, policies and procedures. Size of the company and nature and complexity of its operation shall also be considered, as well as the hazards and associated risks inherent to those operations.

EAA’s SMS is designed and implemented to (EAA, 2020b):

- a) Identify safety hazards in operations;
- b) Ensure remedial action is implemented to control safety risks;
- c) Provide for on-going monitoring and assessment of safety performance;
- d) Make continual improvement to the level of safety in operations.

3.4.1 Safety Policy

EAA’s safety policy is a document endorsed by the Accountable Manager and distributed throughout all, in which several commitments from the company are stated to improve,

when practicable, the safety standards in all its activities. Ensures that objectives and good practices are established to reduce or mitigate, at the maximum level, all the risks that EAA is exposed to.

The Safety Policy includes commitment (EAA, 2020b):

- a) To improve towards the highest safety levels;
- b) To comply with all applicable legislation, meet all applicable requirements and consider best methods available;
- c) To provide appropriate resources;
- d) To enforce safety as a primary responsibility of all managers;
- e) Not to blame someone for reporting something which would not have been otherwise detected in an environment of a “Just Culture”.

Following this concept of “Just Culture”, arises a wider one that plays a vital role in the whole management system and that shall be spread across all.

3.4.1.1 Safety culture

A safety culture is the natural consequence of having humans in the aviation system. Safety culture has been commonly described as “how people behave in relation to safety and risk when no one is watching” (ICAO, 2018), which demonstrates how safety is perceived, valued and prioritized by managers and employees in an organisation.

It is to the best interest of everyone that EAA’s top management is able to institute a positive safety culture in the entire organisation so that the personnel involved in all activities is aware of the impact this concept has in the well-functioning of the company. It is also crucial to spread the idea that safety is a duty of everyone and that all together success is much more easily achieved.

To encourage this safety culture, all staff must be deeply connected to their responsibilities and self-impact in this issue, by achieving these following cultures that all linked together reach a higher level of safety (EAA, 2020b):

1. **Informed culture**: personnel are provided with the necessary knowledge, skills and job experience to work safely. They are also encouraged to identify threats to their safety and to seek the changes necessary to overcome them;
2. **Learning culture**: learning is viewed in the company as a lifetime process. People are encouraged to develop and apply their own skills and knowledge to enhance

organisational safety. Staff is updated on safety issues and the reports processed are used so that everyone can learn from it;

3. **Reporting culture**: all employees are encouraged to freely share critical safety information without the threat of punitive action. Personnel can and may report hazards or safety concerns as they become aware of them, without fear of sanction;
4. **Flexible culture**: EAA and its workers are capable of adapting effectively to changes and to learn how to work with them;
5. **Just culture**: even if a non-punitive philosophy is fundamental for a good reporting culture, all EAA employees must know the difference between acceptable and unacceptable behaviour. An illegal act, gross negligence or deliberate or wilful disregard of regulations or procedures will not be tolerated in this organisation. The just culture recognizes that, in certain circumstances, there may be a need for punitive action.

3.4.2 Safety Risk Management

Safety risk management (SRM) is the second pillar of the SMS and the central theme of this dissertation. It starts with identifying hazards affecting aviation safety and then assessing the risks associated with the hazards in terms of severity and likelihood. Once the level of risk is identified, appropriate mitigation measures must be implemented to reduce the level of risk to an acceptable level, which should then be monitored to ensure that they have the desired effect.

It is important to apply a common standard and method for risk assessment and control throughout the organisation, to homogenize the path everyone takes to conduct this kind of processes. With proper training and communication, this will lead the organisation to a more systematic process of risk assessment and consequently more effective mitigation, as it can be seen in figure 11 (CAA, 2010).

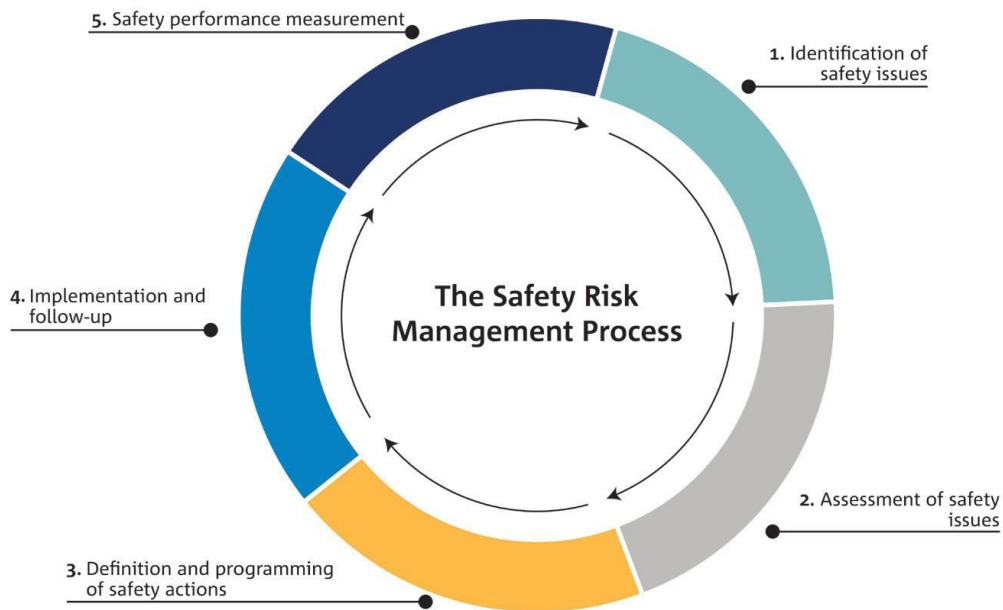


Figure 11 - SRM Process (EASA, 2020b)

As stated before in 3.4, the SRM process is divided in 3 main areas: hazard identification, risk assessment and risk mitigation.

3.4.2.1 Hazard identification

Hazard identification is the first step in any risk management process. It is the documentation of what the whole organisation is up against when is in a certain operation, whether in the air or in the ground. If a crew is well prepared for the risks that they will encounter, the odds of successfully surpassing them grow exponentially.

That is the main goal of a capable hazard identification process: gather the most information possible available about everything related to certain operation, so that incidents or accidents can be prevented. As operation is constantly changing, so the hazards faced, which makes this process an ongoing one that must be performed periodically and whenever the management personnel considers it to be crucial.

Hazards exist at all levels in the organisation and are detectable through various sources, including reporting systems, flight data monitoring, inspections, audits, brainstorming sessions and expert judgement. Hazard identification should also consider hazards that are generated outside of the organisation and hazards that are outside the direct control of the organisation (e.g. extreme weather), which frequently end up becoming the worst enemies of operational safety and, most of the times, causing serious events (ICAO, 2018).

EAA, in accordance with international bodies such as ICAO, proposes that the hazard identification process should consist of 2 different methods (EAA, 2020b):

- **Reactive:** involves the analysis of past outcomes or events. Hazards are identified through investigation of safety occurrences. Incidents and accidents are clear indicators of systems' deficiencies and therefore can be used to determine the hazards that were either, contributing to the event, or are latent;
- **Proactive:** through analysis of existing or real time situations. This is the primary job of the safety assurance function with its audits, evaluations, employee reporting and the associated analysis and assessment processes. This involves actively seeking hazards in the existing processes.

However, as there are things the human cannot control and predict, these two approaches need to be similarly improved to achieve the safety levels intended.

Internal and external sources for hazard identification can be used, namely the ones used by EAA presented below in table 5.

Table 5 - Sources used by EAA to hazard identification (EAA, 2020b)

INTERNAL SOURCES	EXTERNAL SOURCES
Reactive	Reactive
EAA Reporting System	Accident and incident reports
Occurrence Investigation	
Flight Data Monitoring	
Proactive	Proactive
Annual and quarterly Safety Reports	Accident and incident reports
EAA Reporting System	Technical publications from manufacturers
Flight Data Monitoring	Safety Publications
Safety Performance Indicators	Case studies/Industries occurrences
Audits	Incident Statistics
Management of Change	
Incident Statistics	

3.4.2.2 Risk assessment

Risk is generally assessed in terms of severity and probability of the consequences of a hazard occurring. A hazard has the potential to cause harm, while the risk is the

probability of that harm occurring within a specific timescale. Risk is only verified in the presence of a hazard, so following the identification of a hazard, a risk assessment is carried out to determine the potential for harm or damage.

This assessment is also used to rank the risk potential so priorities can be established. This allows the organisation to manage its resources in a more effective way, applying more efforts to reduce the high-risk level. All risk assessments are reliant on the quality of the information used to make the assessment, and the knowledge of the people performing it, so it is also important to standardize these processes so that the ones who conduct it know how to (CAA, 2010).

The safety risk assessment process is divided into two stages: first, the evaluation of the safety risk severity, and secondly, the evaluation of the safety risk probability based on the tables provided. During this evaluation, it is important to use whatever safety data and information are available at the moment.

This involves the following considerations (CAA, 2010):

- **Severity**: How bad will it be if the unwanted safety event occurs?
- **Probability**: How likely is the unwanted safety event to occur or reoccur?

Safety risk severity is defined as the extent of harm that might reasonably occur as a consequence or outcome of the identified hazard. The severity assessment should consider all possible consequences related to an unsafe condition or object, taking into account the worst foreseeable situation in terms of (ICAO, 2018):

- Fatalities or serious injury which would occur;
- Damage or structural failure sustained by the aircraft;
- Damage sustained by ATS or aerodrome equipment.

Severity classification in EAA is divided into 5 levels from Negligible to Catastrophic, as presented in table 6.

Table 6 - Safety risk severity (EAA, 2020b)

SAFETY RISK SEVERITY TABLE					
SEVERITY OF OCCURRENCE	MEANING				VALUE
	PERSONNEL	ENVIRONMENT	MATERIAL	IMAGE	
CATASTROPHIC	Multiple fatalities	Massive effects	Aircraft/Equipment destroyed	International impact	E
HAZARDOUS	Fatality	Effects difficult to repair	Major equipment damage	National impact	D
MAJOR	Serious injuries	Noteworthy local effects	Serious incident	Considerable impact	C
MINOR	Slight injuries	Little impact	Operating limitations	Limited impact	B
NEGLIGIBLE	Superficial or no injuries	Negligible or no effects	Few consequences	Light or no impact	A

Safety risk probability is the likelihood of a safety consequence or outcome occur. The following questions can assist in the determination of the probability (ICAO, 2018):

- Is there a history of occurrences like the one under consideration, or is this an isolated occurrence?
- What other equipment or component of the same type might have similar issues?
- What is the number of personnel following, or subject to, the procedures in question?

Probability classification in EAA is divided into 5 levels from Extremely Improbable to Frequent, as shown in table 7 below.

Table 7 - Safety risk probability (EAA, 2020b)

SAFETY RISK PROBABILITY TABLE		
RISK PROBABILITY	MEANING	VALUE
FREQUENT	Likely to occur many times (has occurred frequently in the company (Freq. > 3 x year))	5
OCCASIONAL	Likely to occur sometimes (has occurred infrequently in the company (Freq. < 3 x year))	4
REMOTE	Unlikely to occur, but possible (has already occurred in the company at least once)	3
IMPROBABLE	Very unlikely to occur (not known to have occurred in the company but has already occurred at least once in the industry)	2
EXTREMELY IMPROBABLE	Almost inconceivable that the event will occur (it has never occurred in the history of the aviation industry)	1

The safety risk probability and severity assessment process can be used to obtain a safety risk index. The index created through the methodology described above consists of an alpha-numeric designator, indicating the combined results of the probability and severity assessments. The respective severity/probability combinations are presented in the safety risk assessment matrix, as in table 8 (EAA, 2020b).

Table 8 - Safety risk assessment matrix (EAA, 2020b)

SAFETY RISK ASSESSMENT MATRIX					
RISK PROBABILITY	RISK SEVERITY				
	NEGLIGIBLE (A)	MINOR (B)	MAJOR (C)	HAZARDOUS (D)	CATASTROPHIC (E)
FREQUENT (5)	5 A	5 B	5 C	5 D	5 E
OCCASIONAL (4)	4 A	4 B	4 C	4 D	4 E
REMOTE (3)	3 A	3 B	3 C	3 D	3 E
IMPROBABLE (2)	2 A	2 B	2 C	2 D	2 E
EXTREMELY IMPROBABLE (1)	1 A	1 B	1 C	1 D	1 E

The Safety Risk Index obtained from the previous matrix must be exported to the Safety Risk Tolerability (see table 9) that will generate a more practical and user-friendly value. Using table 9 it is possible to prioritize the risks in terms of mitigation measures.

EAA uses this risk assessment method together with the Hazard Identification List to analyse whether or not the risk the company goes by, when in operation, is being successfully managed.

Table 9 - Safety risk tolerability (EAA, 2020b)

Risk Index	Tolerability	Action required
3E; 4D; 4E; 5C; 5D; 5E	Intolerable	Take immediate action to mitigate the risk or stop any activity until sufficient control measures have been implemented to reduce the risk as low as reasonably practicable (ALARP). If this is not possible, the activity may only resume after the Accountable Manager approval
1E; 2C; 2D; 2E; 3B; 3C; 3D; 4A; 4B; 4C; 5A; 5B	Tolerable	Can be tolerated based on the safety risk mitigation. The activity may resume after the Nominated Person approval.
1A; 1B; 1C; 1D; 2A; 2B; 3A	Acceptable	Acceptable (Risk mitigation or review is optional). Distributed to managers of departments involved.

3.4.2.3 Risk mitigation

A safety risk mitigation is often referred to as a safety risk control. Safety risks should be managed to an acceptable level by mitigating the safety risk through the application of appropriate safety risk controls. This should be balanced against the time, cost and difficulty of taking action to reduce or eliminate the safety risk (ICAO, 2018).

The level of safety risk can be lowered by reducing the severity of the potential consequences, reducing the probability of occurrence, or by reducing exposure to that safety risk. It is easier and more common to reduce the probability than it is to reduce the severity.

Safety risk mitigations are actions that often result in changes to operating procedures, equipment or infrastructure. Generally, safety risk mitigation strategies fall into three categories (ICAO, 2018):

- **Avoidance:** the operation or activity is cancelled or avoided because the safety risk exceeds the benefits of continuing the activity, thereby eliminating the safety risk entirely;
- **Reduction:** the frequency of the operation or activity is reduced, or action is taken to reduce the magnitude of the consequences of the safety risk;
- **Segregation:** action is taken to isolate the effects of the consequences of the safety risk or build in redundancy to protect against them.

It is important to consider that the full range of possible control measures to find an optimal solution implicates that each of the safety risk mitigation alternatives proposed should be evaluated considering its effectiveness, cost/benefit, practicality, acceptability, enforceability, durability, residual safety risks and unintended consequences.

3.4.3 Safety assurance

Safety Assurance consists of processes and activities undertaken to determine whether the SMS is operating according to expectations and requirements. EAA continually monitors internal processes as well as the operating environment to detect in advance changes or deviations that may introduce emerging safety risks or degradation of existing risk controls (ICAO, 2018).

The three more relevant aspects of safety assurance are safety performance monitoring and review, the management of change and the continuous improvement of the SMS.

With the purpose of improving the SMS, EAA proposes several measures (EAA, 2020b):

- a) Hazard identification and risk assessment processes and improved awareness of the risks;
- b) Reporting and analysis tools, such as the Safety Performance Indicators;
- c) Safety reviews (Safety Review Board and Safety Action Group), periodic reports, studies and internal audits;
- d) Communication processes, including feedback from all the staff and managers;
- e) Relations with the subcontractors, suppliers and customers regarding safety issues.

3.4.4 Safety promotion

Safety promotion encourages a positive safety culture and helps to enable achievement of the service provider's safety objectives. This is achieved through the combination of technical competence that is continually enhanced through training and education, effective communications and information sharing. Senior management, by the hand of the safety representatives and their deputies, provides the safety leadership to promote the safety culture throughout the organisation.

Effective safety management cannot be achieved solely by mandate or strict adherence to policies and procedures. Safety promotion affects both individual and organisational

behaviour and supplements the organisation's policies, procedures and processes, providing a value system that supports safety efforts (ICAO, 2018).

EAA is continuously worried in properly training its personnel and monitor its progress within the company's environment. For that, EAA establishes a well-organised and personalised training program so that everyone has access to the right training at the right time, to accomplish the safety standards proposed by the management.

An effective dissemination of the essential information regarding safety issues and related matters is also of the company's concern, to assure that everyone is aware of all the activities and evolutions in terms of safety procedures. This also eases its concern of spreading the commitment of all personnel to report occurrences or incidents and stating that safety is a responsibility of everyone.

3.5 Reporting system

From occurrences, it has been possible to learn that accidents are often preceded by safety-related incidents and deficiencies thereby revealing the existence of safety hazards. Therefore, safety data are an important resource for the detection of potential safety hazards. In addition, while the ability to learn from an accident is crucial, purely reactive systems have been found to be of limited use in continuing to bring forward improvements. Reactive systems should be complemented by proactive systems, which use other types of safety data, to make effective improvements in aviation safety.

Relevant aviation occurrences should be reported, collected, stored, protected, exchanged, disseminated and analysed, and appropriate safety actions should be taken based on the information collected.

At EAA, it is implemented an occurrence reporting system to enable the collection and assessment of relevant incident and accident reports in order to identify hazards, adverse trends or to address deficiencies in the interests of safety. As reporting all kinds of occurrences is strongly encouraged, EAA guarantees that the reporter will not be punished for reporting safety concerns. However, cases of proven gross negligence, reckless conduct, wilful deviations and unacceptable operational behaviours, shall not be tolerated (EAA, 2020b).

The objectives of such system are (EAA, 2020b):

- To enable an assessment of the safety implications of each occurrence to be made, including previous similar occurrences, so that any necessary action can be initiated. The assessment will determine how and why the occurrence has taken place and what might prevent a similar occurrence in the future;
- To ensure, through safety promotion actions, the dissemination of occurrence info related data, so that other people and operators can learn from the knowledge of relevant incidents and accidents.

The scope of this system includes 3 types of reports: mandatory, voluntary and confidential (this last type only the safety manager has access to).

To do so, all employees have at their disposal the IQSMS system, where they can enter any type of report. The traditional forms in paper format or e-mail are only available for voluntary and confidential reports. The safety department always encourages all the staff to use the digital platform because it registers and parametrizes automatically all the data and displays it in a more user-friendly way.

Every occurrence identified through all occurrence reports or other sources provides the opportunity to draw safety lessons. Learning from experience is only possible if all events are reported and analysed and their causes and factors (technical, operational, or environmental) are determined and investigated.

3.5.1 IQSMS

IQSMS is an integrated, web-based safety, quality and risk management platform created by ASQS used specially by the Safety and Compliance Monitoring departments as a tool for managing safety and quality issues, always in compliance with ICAO DOC 9859, ICAO Annex 19, EASA and enhanced IOSA requirements. Access is granted to all EAA employee so that they can easily report occurrences and consult any issue related to those reports.

Although the system is composed by more modules, EAA only has contracted the following ones that satisfy its needs (EAA, 2019):

- a) Reporting module;
- b) Quality module;
- c) Risk management module;
- d) Flight risk module.

In the reporting module is possible to enter new reports (figure 12), process current reports and see already published ones. The platform also provides statistics, organised in relevant categories, which may posteriorly be analysed to identify trends or patterns that can help to prevent possible incidents or accidents.

The screenshot displays a web interface titled "What kind of Report do you want to enter?". It features a list of report categories, each with a corresponding button and a brief description. The categories are:

Report Type	Description
Hazard	For all personnel
Air Safety Report	Air Safety Report
Confidential Report	This form may be used of staff to confidentially report any operational, maintenance, administrative, training or safety related event or concern to the Safety Office.
Cabin Safety Report	Cabin Safety Report
Dangerous Goods Report	Dangerous Goods Report
Engineering Safety Report	Engineering Safety Report
ATM Contribution Report	ATM Contribution Report
Bird Strike Report	Bird Strike Report
Ground Safety Report	Ground Safety Report
Runway Incursion Report	Runway Incursion Report
Fatigue Report	Fatigue Report
Security Report	Security Report

Figure 12 - Types of report available in IQSMS (ASQS, 2020)

The command of processing reports is where one of the key components of this dissertation is: the risk assessment of the reports registered in the IQSMS. To complete this risk assessment, it can be chosen between using the current method (System Related) or the Bowtie methodology. Which one is the more effective for EAA's needs is what this dissertation is all about.

In the risk management module, new Bowtie methodology processes can be added and analyse already existent ones in order to process the risk assessment analysis the best way possible.

Whenever an accident/incident reported requires sending to ANAC and GPIAAF, that can be done recurring to the IQSMS that automatically sends it to the proper authority, considering, that the period from the event identification to the submission of the form cannot exceed 6 hours. In case of a mandatory report occurrence, that only requires sending to ANAC, it can also be done through the system, without exceeding the timeline of 72 hours.

3.6 EAA risk assessment methodology

As referred before in 3.5.1, EAA uses the IQSMS software so all staff can submit and consult reports. After a report has been submitted, the safety department processes it and makes the risk assessment following an approach previously defined. Depending on the results of this analysis, it may be mandatory to take the necessary actions and to communicate it to the responsible managers and/or authorities.

Currently, EAA uses the approach that ASQS provide in the IQSMS called “System Related”. It is based on a list of root causes, effects and descriptors that allow to classify the reports in terms of these parameters by manually selecting the option that more properly describes the hazards involved.

Afterwards, the system automatically calculates a risk index based on the matrixes presented above in 3.4.2.2, that were previously uploaded into the software. However, if the person in charge of the analysis does not agree with the risk index given, it can manually select the value that considers more suitable.

A more detailed description and study of this topic is made in the following Chapter 4.

3.7 Bowtie methodology

The Bowtie methodology method is a risk assessment method that can be used to analyse and communicate how high-risk scenarios develop. The essence of the Bowtie methodology consists of plausible risk scenarios around a certain hazard, and ways in which the organisation stops those scenarios from happening. The method takes its name from the shape of the diagram that is created, which looks like a men's bowtie.

The Bowtie methodology has several goals (IP Bank B.V., 2015):

- a) Provide a structure to systematically analyse a hazard;
- b) Help decide whether the current level of control is sufficient (or whether risks are as low as reasonably practicable);
- c) Help identify where and how investing resources would have the greatest impact;
- d) Increase risk communication and awareness.

This method is also referred to in ICAO’s Safety Management Manual (SMM) document referencing defensive barriers in accident causation with ICAO Annex 19 referring to understanding and appreciating safety risk controls.

Bowtie methodology achieves this by not only identifying the controls (or barriers) in place but also looking at control failure mechanisms (as escalation factors) and in how these are managed (as escalation factor controls). Based on these considerations, insights are gained into the organisation's risk mitigation strategies and therefore into the appropriate management of safety resources.

The main strength of the barrier approach is as a qualitative tool, which is a practical solution for the challenges of risk assessment in the dynamic operating environments of the aviation industry (CAA, 2020).

The Bowtie methodology model consists of different elements that build up the safety risk picture. The safety risk picture revolves around the hazard and the top event (the release or loss of control over a hazard known as the undesired system state).

Consideration is then turned to the threats (a possible direct cause for the top event), consequences (results of the top event directly ending in loss or damage) and the controls (any measure taken which acts against some undesirable force or intention).

The controls can be grouped on either side of the model showing:

- Left hand side of the model: preventative measures which eliminate the threat entirely or prevent the threat from causing the top event recovery;
- Right hand side of the model: measures which reduce the likelihood of the consequence owing to the top event being "live" or mitigate the severity of the consequence.

The Bowtie methodology model explores the escalation factors (the reasoning to why a control may be defeated or less effective) of all controls allowing the allocation of escalation factor controls. These prevent the escalation factors of having an impact on both the prevention and recovery controls. Further attributes, such as control effectiveness or criticality can be allocated to the Bowtie methodology model to evaluate the safety risk picture as part of an effective SMS (CAA, 2020). An example of a complete Bowtie methodology diagram is represented in figure 13.

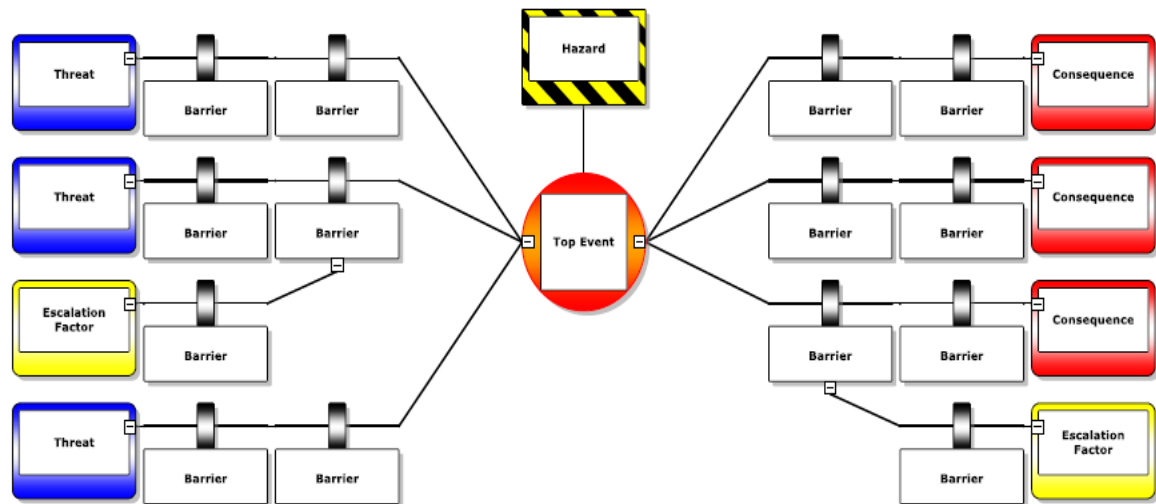


Figure 13 - Complete Bowtie methodology diagram (IP Bank B.V., 2015)

To get to this complete diagram, there are several steps to go through in order to create a successful and effective Bowtie methodology process. These 8 quick steps are listed in the table 10 below.

Table 10 - Steps to build a proper Bowtie methodology diagram (IP Bank B.V., 2015)

Step	Description
1. Identify hazard	The first step in managing risks is to identify what their sources are.
2. Identify top event	When we know what is potentially hazardous, we need to know how we could lose control over it.
3. Identify threats	Next we need to consider the scenarios or events which could directly cause the occurrence of the top event.
4. Evaluate consequences	After the top event occurs, subsequent scenarios or events are now possible. These consequences can lead to losses and damage.
5. Identify preventive barriers	The next step is to identify the barriers which should prevent the threats from reaching or causing the top event. These are preventative barriers.
6. Identify recovery barriers	Barriers on the right side try to recover from the occurrence of the top event. These barriers should prevent or mitigate the consequences and/or the resulting losses and damage.
7. Identify escalation factors	The next step is to identify the specific situations or conditions under which the barriers are less or not effective.
8. Identify escalation factor barriers	The last step is to look at what barriers you have to prevent or manage these escalation factors.

3.8 ARMS methodology

The ARMS methodology, established by the ARMS group¹⁵, in order to develop a new and better methodology, is an operational risk assessment method, which primary target

¹⁵ Aviation Risk Management Solutions, the industry group responsible for the development of the ARMS methodology.

group are airlines but is also fully applicable to other aviation organisations and even businesses outside aeronautics.

This methodology was created with the purpose of attempting to overcome the classic difficulties and support the new SMS requirements in an effective manner, by helping operators to regulate risk in the best way possible. Briefly, risk assessment is made at three different contexts (McKim, 2017):

1. Individual safety events may reflect a high level of risk and consequently require urgent action. Therefore, all incoming events need to be risk assessed. This step is called Event Risk Classification (ERC);
2. The Hazard Identification process may lead to the identification of safety issues, which need to be risk assessed to determine what actions to take, if any are needed. This step is called Safety Issue Risk Assessment (SIRA);
3. From time to time there will be a need to carry out safety assessments, typically related to a new or revised operational activity (e.g., a new airport to operate). The activity needs to be risk assessed at the planning stage, according to the “Management of Change” process of the company.

The ARMS methodology can be summarised in the following points (McKim, 2017):

- a) The overall end to end Risk Assessment process, starting from Hazard Identification and leading up to Safety Actions has been defined and acts as the backbone for the methodology;
- b) All new incoming Safety Event Data needs to be reviewed within an acceptable timeframe so that there can be an immediate reaction to any urgent issues. The ERC is the first step in the ARMS Risk Assessment process and makes a quick initial estimate of the risk inherent to the event. The new concept of “event-based risk” is used to estimate the risk. The result is both a risk class (colour) indicating what needs to be done with the event - and a numerical value of risk (the ERC risk index value) which can be used in quantitative risk analysis. Once risk assessed, all events are stored in a safety event database;
- c) Since an historical event has no risk today, the actual event is extrapolated into what accident outcome could credibly have occurred. This is then risk classified taking into consideration the barriers that avoided this event being that accident outcome. The question is: what was the risk, at the time when the event occurred?

- d) When the Safety Data in the database is analysed (Data Analysis), the main focus is identifying any Safety Issues that affect the current operation;
- e) All identified Safety Issues are risk assessed using the Safety Issue Risk Assessment (SIRA) technique. The conceptual framework for this risk assessment is again a new one: risk is calculated as the product of four factors, (prevention, avoidance, recovery and minimisation of losses) instead of the old severity x likelihood formula. This new framework includes the risk controls (barriers) in the risk assessment. The output from SIRA is a risk value for each Safety Issue.

A process summary can be seen in figure 14.

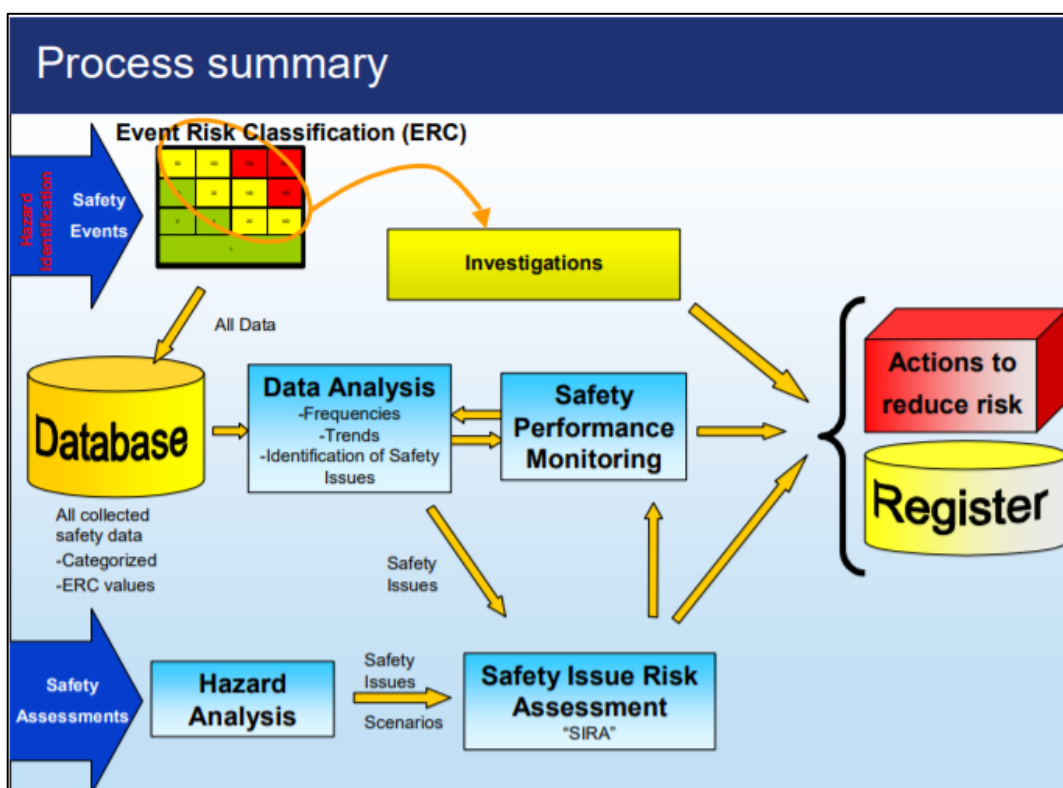


Figure 14 - ARMS methodology (McKim, 2017)

3.9 Other operators risk assessment methods

With the purpose of assessing choices regarding the risk assessment methods, various meetings took place with key personnel of the safety departments of other 3 national

aircraft operators¹⁶, to exchange knowledge regarding their risk assessment methodology and how they perform it. Below it is presented a brief review about what was concluded from that meetings.

Operator A: uses the Event Risk Classification (ERC), without Bowtie methodology analysis, which is less complex than the one used by EAA.

Advantages, according to the operator's opinion:

- Due to the low number of reports registered, they consider their approach perfectly sufficient for their needs.

Disadvantages, according to the operator's opinion:

- Too subjective, as each report is individually investigated by one single person;
- As they are perfectly aware of the method EAA uses, they consider their method to be more effective at hazard and root causes categorization.

Operator B: uses the ARMS method (with own adaptations similar to ERC), also less complex than the one used by EAA.

Advantages, according to the operator's opinion:

- Use a risk matrix like the EAA's one for the risk assessment, with slightly adaptations that they consider very beneficial and adequate for their operation;
- To prevent a subjective analysis, they have as a rule the need of 2 people to analyse each report;
- Use the basis parameters of the Bowtie methodology, but without the respective diagrams.

As no disadvantages of their method were referred, this operator opted for indicating some disadvantages regarding the Bowtie methodology that made them decide not to adopt it:

- Consider it too complex for their needs. Also refer that it becomes too hard to update and for that do not consider it a good tool for them;

¹⁶ For reasons of confidentiality, the operators will be referred as "A", "B", "C" and not their real names.

- Considering that the Bowtie methodology method is extremely inconvenient in terms of linking it with other methods they use, it becomes a disadvantage in terms of IOSA certifications.

Operator C: uses the same exact method as EAA, in the same pattern.

In the present chapter, it was introduced all the subjects important to understand the history of aviation safety and how a proper implemented SMS works. The knowledge acquired with this literature review allowed to carry out the work described in the following chapter 4.

Folha em Branco

Chapter 4 - The viability study

As referred in 1.1, this study was motivated by the need of euroAtlantic airways to improve its own risk management process. In order to do so, it was necessary to study the different methods available in the company's reporting software, compare them (benchmark), draw conclusions and make consequent decisions.

This chapter describes the study made in order to determine the viability of introducing the Bowtie methodology at EAA, regarding the risk management process.

As such, this chapter discusses the following aspects:

- How to approve reports in the IQSMS system;
- The currently used method at EAA and the Bowtie methodology;
- An example of a real event analysed to compare both systems.

4.1 Approving reports in IQSMS

Every single employee of EAA has access to the IQSMS using their private log-in and can report any issue regarding the safety of the company, its staff or its infrastructures. By this the company keeps its policy well-presented within the employee's environment.

In the Reporting Module (figure 15) it is where it is possible to enter reports and see the published ones and, for those authorised, to obtain statistics and other data about them. For the ones responsible, it is also possible to see every report in the software and to take further actions over them, such as perform risk assessment analysis, investigate the cause behind the reports, take corrective actions and assign mitigation measures.

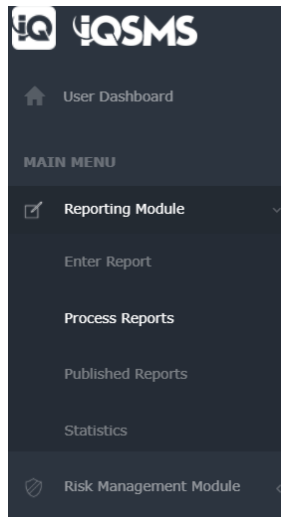


Figure 15 - IQSMS dashboard (ASQS, 2021)

The first thing to do when a report is made in IQSMS is to analyse the subject, who made it, why it was made and when it was made, so that the person in charge can approve it and take the proper actions.

Then, it is necessary to assign a responsible, or grant access to someone within the safety department to monitor its development, see if corrective actions are required, add some comment for the person responsible for this report and select the type of risk assessment to be performed, as in figure 16.

Corrective Actions required?	Yes
Enter a due date	2021-01-19
Assign Responsible to this report	SAF <small>Disclaimer: Users who are already assigned via a department will be removed. No duplicate assignments are possible</small>
Grant informational access	DOV
Comment for Responsible	<div style="border: 1px solid #ccc; height: 40px;"></div>
Define Type of Report	Hazard
Select Type of Risk Assessment	System related
Save & Approve Report	

Figure 16 - Risk assessment (ASQS, 2021)

Following this action, the report is saved and approved by the software user. This first stage is equal for every report registered in the software, regardless of which method is used later in the risk assessment.

The next step is where the core of this dissertation is, that is to determine whether or not the proposed method is more efficient than the current one used at EAA.

4.2 System Related method

As mentioned in 3.6, EAA currently uses the risk assessment method provided by ASQS in the IQSMS software, called “System Related”. This approach is based on a list that groups all the information the software manufacturer has on hazards and allows the system operator to better categorize the report in analysis. This list (presented in Annex 1) and, consequently, the method used to assess the risk is divided in 3 major areas:

1. Root cause group;
2. Effect group;
3. Descriptor group.

Each one of the previous groups is composed by several topics that describe different hazards and risks in the company’s operation. The job of the person in charge of the risk assessment is to choose which description is more suitable for the report in question, based on experience or on directives previously defined by the safety department. Generally, there is someone within the safety department that is responsible for performing such analysis. However, depending on the complexity of the matter reported, that person can request the help of someone else to prevent the analysis to have errors or become subjective.

The matrixes involved in the risk index calculation are previously inserted in the software and are for the exclusive use of EAA staff. The original tables were adopted from EASA and ICAO documents and adapted by the safety personnel having in account several factors based on the company’s operation and experience. In this way it is guaranteed that the analyses performed are always in accordance with the standards defined by the safety department of euroAtlantic airways.

The previous list presented in Annex 1 also helps to organise another one, called “Hazard Identification List”, that plays a key role in the whole Safety Risk Management process of euroAtlantic airways. However, this list is not part of the IQSMS system and it is manually

updated by the safety personnel. It allows to split all the hazards in five Hazard Groups, and subgroups, and eases the search for a specific one when needed. The five main groups are:

- a) Environmental (ENV);
- b) Human Factors (HF);
- c) Operations (OPS);
- d) Organisation (ORG);
- e) Technical (TEC).

The Safety department is continuously concerned in assuring this list is updated and efficient in dividing the hazards and relating them to the respective reports.

4.2.1 System related in IQSMS

The tool to perform risk assessments in reports is also in the Reporting Module, in the Process reports function.

By clicking in the report wanted and in the risk assessment icon, a small menu with the fields presented in figure 17 appears.

Risk Assessment	
Risk Assessment	System related
Report type	Occurrence
Root Cause Group	Airplane / Equipment Damage Error
Root Cause	Struck by / against
Effect Group	Continuing Airworthiness
Effect	no effect
Descriptor Group	Aircraft System
Descriptor	Nothing selected
Descriptors	

Figure 17 - Risk assessment System Related (ASQS, 2021)

The system operator may then select, for each field, the information presented by the software that better reflects what happened in the occurrence reported. As the system

already has a risk associated to each topic, it automatically calculates the risk value associated with the options the person in charge chose.

However, as it was already mentioned in 3.6, if the software operator thinks that a different risk value may be associated with that specific hazard, it is possible to manually modify it.

A more specific analysis using this method is presented in 4.4 Hard landing event, as it is a critical event for the company's operation in terms of safety.

4.3 Integration of the Bowtie methodology in the SMS

The use of this method requires to treat each occurrence individually and in direct association with an undesirable event. Connected to this event are several roles of threats (that could possibly have led to the event happening) and consequences (that happened after the top event and as an outcome of this situation).

In order to prevent the threats from happening and consequently damaging the system, control measures need to be defined. The same thing happens on the other side of the Bowtie diagram. In the eventuality of the undesirable event happening, control measures need to be well determined, so that the company is able to reduce the consequences of such occurrence. In this way, the safety and proper functioning of the system is assured in a better way than in a system that is not prepared for this kind of situations or for the eventual happening of an event.

Regarding this method, the key to well-perform a Bowtie methodology analysis is to be able to keep the Bowtie diagrams updated and according to the specifications that the company's operation requires.

4.3.1 Use of the Bowtie methodology in the EAA IQSMS

The Bowtie methodology option is available in the Risk Management Module where, as presented before in 3.5.1, it is possible to design a complete and specific Bowtie diagram for the issue in question. The software operator follows the steps previewed by the methodology in 3.7, by starting to select, or add, the undesirable event (figure 18) that would like to manage.

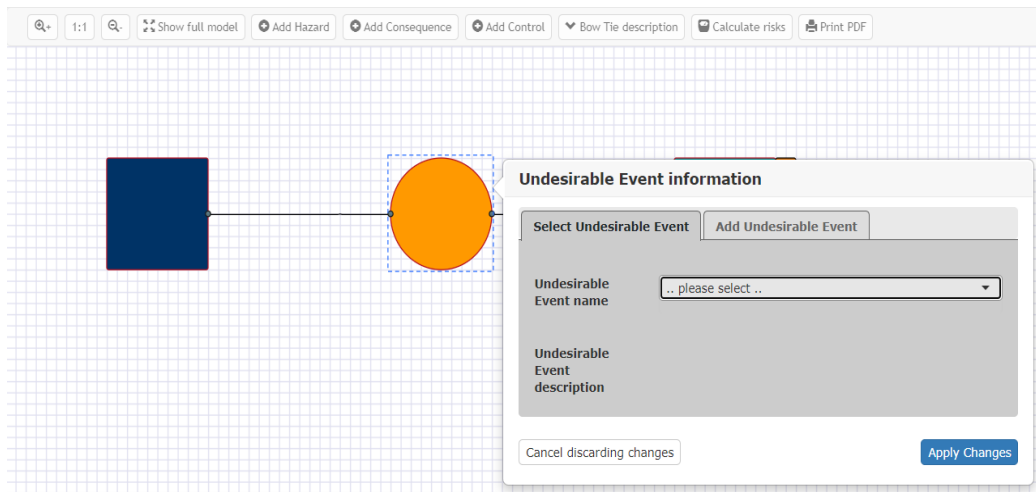


Figure 18 - Bowtie methodology diagram - undesirable event (ASQS, 2021)

Following this, the software operator continues adding hazards (figure 19) that can lead to the occurrence of this specific event or that jeopardize the whole system, as well as the frequency with which the referred situation occurs, within the company's scenario.

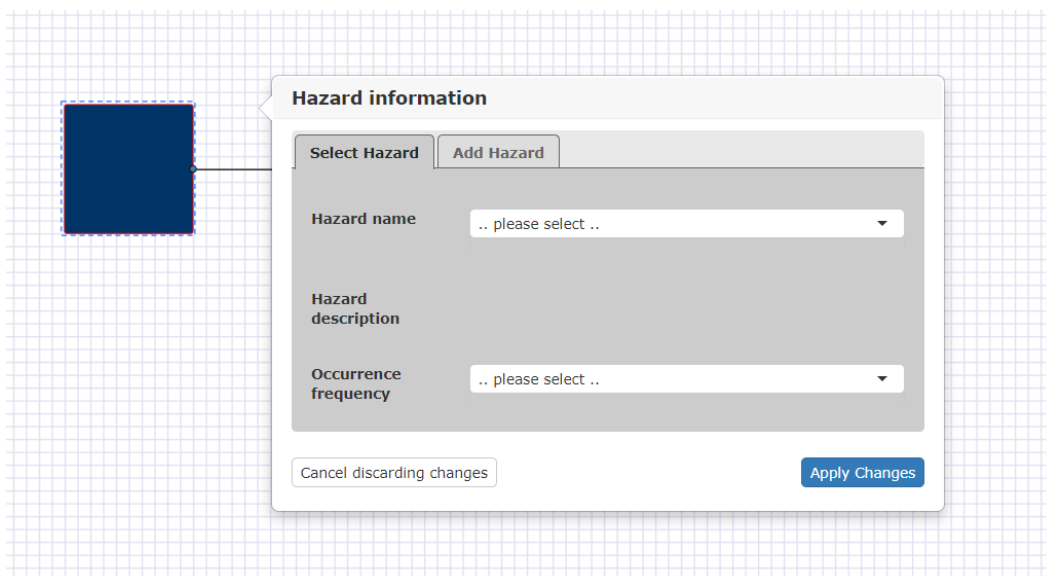


Figure 19 - Bowtie methodology diagram - hazard (ASQS, 2021)

On the other side of diagram, it is required to qualify the consequences (figure 20) in case the referred undesirable event actually happens. Also, the severity of the eventual consequence happening is selected, according to EAA's safety risk severity table.

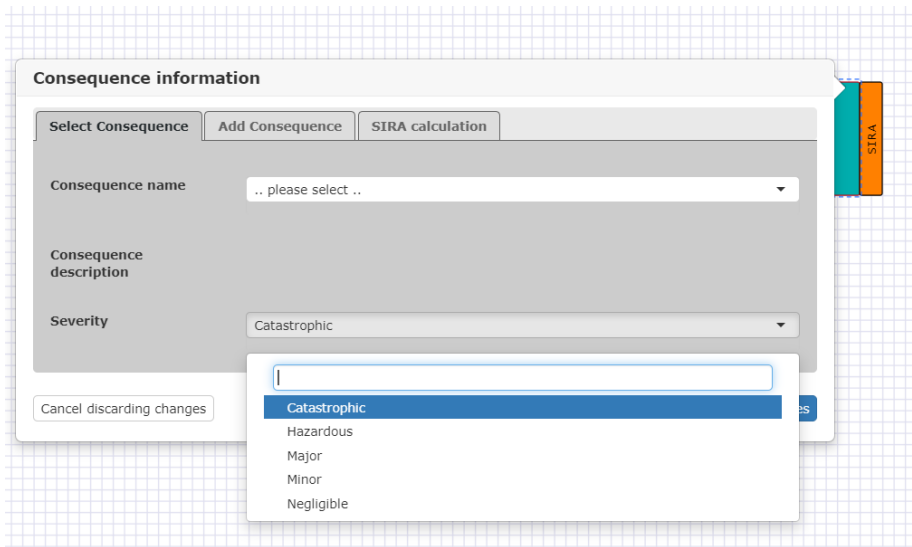


Figure 20 - Bowtie methodology diagram - consequence (ASQS, 2021)

Both hazards and consequences are accompanied by control measures. In the case in which the control will prevent a hazard from causing harm, it is called an avoidance control. When the purpose of the control is to prevent the effect of a potential harming consequence, it is called a recovery control.

In the case of figure 21 below, it is included an avoidance control menu for a hazard. The menu represented is the same for both types of controls, with the only difference being the name at the top of the page.

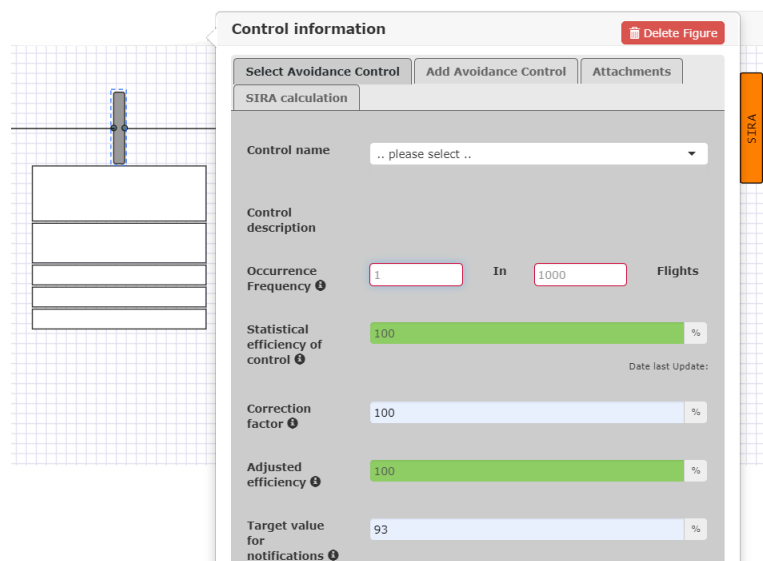


Figure 21 - Bowtie methodology diagram - controls (ASQS, 2021)

Whether it is a control for a hazard or a consequence, the correction factor and the target value for notifications need to be manually selected by the user. As the company had never used the Bowtie methodology before, it was held a meeting with ASQS customer service to better understand which values to select.

In case of the correction factor, the software manufacturer recommends to use 100. For the target value, ASQS refers to “as soon as the adjusted efficiency value falls below the target value the responsible user gets notified”.

It was decided to use 93 for the target value to fill in the blank, as it is a value also used in other target values by EAA, because this value only makes a difference in the system when the Bowtie methodology is fully implemented and a significant number of reports is registered. All the other values in figure 21 above are automatically set by the software.

Once the diagram is complete, this means that all the hazards and respective controls are in place and that all the possible consequences and respective controls are contemplated, the diagram is finished and put at the disposal of the safety department to be used in analysis.

But the work is just 50% done regarding the Bowtie methodology because the only thing that was made was the creation and design of the diagram itself and its respective components. Now, it is mandatory to go to the Reporting Module and proceed to the risk assessment of a given report made in the IQSMS.

By clicking in the report wanted and in the risk assessment icon, a menu with the following fields as in figure 22 appears.

The screenshot shows a web interface titled "Risk Assessment". At the top, there are two dropdown menus: "Risk Assessment" with the value "Assign Bow Tie (Risk Management Module)" and "Report type" with the value "Hazard". Below these are four rows of dropdown menus, each with a small edit icon to its right: "Bow Tie Process" (value: ".. please select .."), "Undesirable Event" (value: "Nothing selected"), "Hazard" (value: "Nothing selected"), and "Consequence" (value: "Nothing selected"). Below these are three rows of text labels: "Avoidance Controls" (value: "Not available yet"), "Recovery Controls" (value: "Not available yet"), and "Preview" (value: "Not available yet"). At the bottom center is a button labeled "Save and submit".

Figure 22 - Risk assessment Bowtie methodology (ASQS, 2021)

Then, it is necessary to choose the options to categorize the situation. Firstly, it is chosen the Bowtie methodology process suitable to the event reported. Then, it is selected the undesirable event that was verified or the one more similar to it. Afterwards, the hazards and consequences verified are chosen, as well as its respective controls, that can be selected as successfully applied or not.

Finally, the system automatically generates a risk index that can be manually modified if not in accordance with the safety standards of the company.

It is important to clarify that each event requires a Bowtie diagram specifically suited for that event and that if a hazard or consequence of the event reported do not appear in the diagram, it has to be manually edited in the Bowtie methodology creator page, so that the diagram is updated. This is repeated whenever the diagram or any part of it is not updated.

The same is verified in terms of the Bowtie methodology process itself. If an event happens and it is not on the company history or does not belong to the list of processes the company considers important to figure in the Bowtie methodology library, then there is no Bowtie methodology diagram prepared for this issue and it has to be manually created.

The system also provides integrated statistics, for use of the company. These statistics automatically render the top number of undesirable events, hazards, consequences and failed safety controls in the organisation.

It is possible to define the time frame the statistics will use. It is also available the option of selecting in which chart type the user wants do display the information presented. Then, the user generates the chart and downloads the document so that it can be used in the future. A preview of the statistics menu is presented in figure 23.

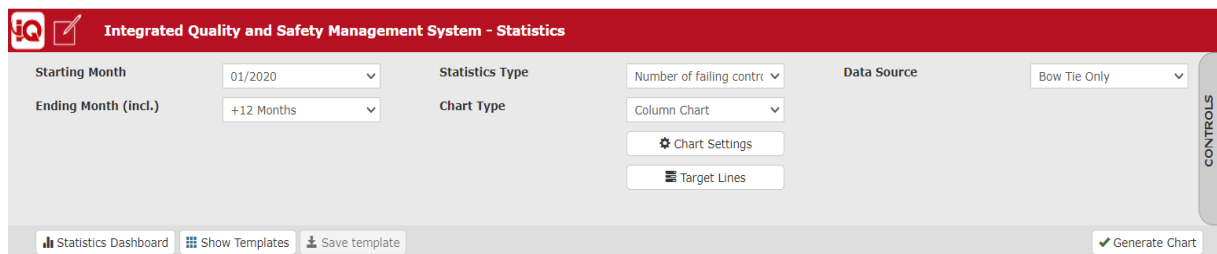


Figure 23 - Statistics menu (ASQS, 2021)

To better analyse both risk assessment methods, a critical event in the company's environment was chosen (considering EAA guidance), so that it could be possible to evaluate each method individually on the same conditions.

4.4 Hard landing event

The hard landing is an event in which the sensors of the aircraft detect an excessive acceleration, in relation to the pre-established values in the aircraft flight manual, when the main landing gear touches the runway.

The resultant landing approach can cause damage to the aircraft structure, especially to the undercarriages (in particular to the main landing gear). An aircraft must be inspected thoroughly according to the manufacturer's instructions for continued airworthiness after a hard landing (ANAC, 2021).

In other words, a hard landing is when an aircraft hits the runway with greater vertical speed and force than what is prescribed in the applicable aircraft flight manual. This can be caused by several different factors like weather conditions, over-weighted aircraft or pilot error. Also, it presents the most diverse type of consequences, aircraft damage being one of the most frequent and most worrisome.

Therefore, a hard landing is an event that, no matter its frequency or severity, no one likes to see happening. It is an occurrence that is always carefully managed within the airlines and euroAtlantic airways is no exception.

For these reasons, the hard landing event was the one chosen to be analysed with the different methodologies.

EAA has at its disposal a trial version of IQSMS, which is used to simulate all kinds of occurrences and respective analysis. In this study, all the diagrams and analysis were simulated in this version in an attempt to recreate a real situation of a hard landing the best way possible and also, to not disturb the normal functioning of the company’s day-to-day activity.

Thus, a real event of a hard landing (figure 24) reported in the original version was transferred and slightly modified, for confidentiality reasons, to the IQSMS trial version to allow to simulate the process of risk assessment of reports and, this way, draw trustworthy conclusions that can lead to the answer of which methodology presented is better for EAA’s reality.

A more detailed description of the report mentioned is presented in Annex 2.

Review Report #1117	
Kind of Report	Air Safety Report
Area of Occurrence	Safety Report
Type of Occurrence	Flight Operations
Event Classification	Suspected hard landing
Report Text	
Report Text *	<p>Stabilized approach with tail wind until approaching the threshold. Then speed increased and also the RoD.</p> <p>PF removed power to correct for the speed, at the same time, didn't correct for the RoD high (never above 1000ft/min) I applied power, but was too late, as the aircraft impacted hard on the ground (even with power on).</p> <p>Event reported on TLB, for maintenance inspection. As no faults or damages were founded, we continued for the remaining flights that day.</p>

Figure 24 - Report #1117 - Hard landing (ASQS, 2021)

The process of approval of reports is the same for the two methodologies, as shown previously in figure 16, with the only difference being the selection of risk assessment type at the bottom of the page.

4.4.1 Hard landing - System Related

The hard landing event was analysed using the System Related method. For the root cause group it was selected “aircraft control/performance”, and for the specific root cause it

was chosen “unable to maintain speed/height or achieve scheduled performance”¹⁷, as it is the option that better reflects what happens in a hard landing.

Regarding the effect group, it was selected “flight” as it is the phase in which the event occurred, more specifically in the landing phase. Therefore, it is easy to understand that a hard landing is categorized as an “abnormal landing”, as it is one of the worst scenarios when talking about a landing outside the usual or acceptable situations.

The descriptor group selected was “flight operation”, more specifically “hard/heavy landing”. In order to prevent pilots from performing a hard landing again, it is suggested to make a debriefing with the flight-crew on board to discuss what went wrong, and constructively educate for the importance of avoiding such occurrences. Also, an analysis of the flight data shall be done to try to understand what led to the occurrence of the hard landing.

The result of the analysis is presented in the table 11.

Table 11 - Hard landing System Related (ASQS, 2021)

Risk analysis	
Type of Evaluation	System related
Root Cause	Unable to maintain speed/height or achieve scheduled performance
Root Cause Group	Aircraft Control / Performance
Effect	Abnormal Landing
Effect Group	Flight
Descriptors	Flight Operation (Hard/Heavy Landing)
Likelihood of occurrence	Remote
Severity of consequences	Hazardous
Risk level	tolerable
Risk analysis by	Confidential

The system automatically generated an acceptable (green) risk level. However, according to the company’s operation and in coordination with the safety department it was decided

¹⁷ The more correct term should be “as defined in the applicable aircraft manuals”

that for this type of occurrence, it should be defined as a tolerable (yellow) risk level, as defined by EAA criteria.

4.4.2 Hard landing - Bowtie methodology

A Bowtie methodology diagram (presented in Annex 3) was created to analyse hard landing events. The process followed for its creation was the one already described in 4.3.1. The diagram was filled out based on bibliography researched about hard landing and field experience of EAA professionals.

It counted with the participation of Safety department members as well as with pilots from EAA, so that it could be guaranteed that the diagram is consistent with reality and reflects the risks the EAA fleet faces in its operation. This was a huge contribute for the efficiency of the diagram and consequent risk assessment, because it guaranteed the reliability of the process.

For each hazard and consequence, it was necessary to establish the best avoidance and recovery controls possible in order to build an effective diagram. For each one it was established at least 2 controls manually inserted by the software user. Then, the hard landing event was analysed using the previously created Bowtie diagram.

The Bowtie methodology process and diagram selected was the one for hard landing. Then, the hazard that most likely caused the present occurrence was “tail wind”, as it is described in the report text already presented. For this reason, it was selected the hazard “tail wind”.

As described in the reporting process, regarding the avoidance controls for the hazard in question:

1. **Weather evaluation**: it was considered to be successfully applied as the crew on board early acknowledged the presence of tail wind;
2. **Adjust approximation speed**: it has partially failed as the pilot only adjusted speed for one command and this action did not prevent the aircraft from hard landing;
3. **Apply wind correction technique**: also failed, as it is not even mentioned on the report.

Then, the consequence selected was “asset damage”.

For the recovery controls regarding the consequence chosen:

1. **Report Technical Logbook:** to alert the maintenance personnel of a possible damage on the aircraft;
2. **Defect rectification:** it was considered necessary to execute, in order to prevent the aircraft to perform with further damages.

Both were considered to be successfully applied as the aircraft was intervened by the maintenance staff.

The result of the analysis is presented in table 12 below.

Table 12 - Hard landing Bowtie methodology (ASQS, 2021)

Risk analysis	
Type of Evaluation	Assign Bow Tie (Risk Management Module)
Likelihood of occurrence	Remote
Severity of consequences	Hazardous
Risk level	tolerable
Bow Tie Process	Hard Landing
Undesirable Event	Hard landing
Hazard	Tailwind
Consequence	Asset Damage
Failed Avoidance Controls	- Adjust approximation speed - Apply wind correction technique
Failed Recovery Controls	Not available
Risk analysis by	Confidential

4.5 System Related vs Bowtie methodology

After the hard landing event was analysed using both methods, it is now possible to draw some conclusions about each one and to compare them, stating advantages and disadvantages of both in table 13 below.

Table 13 - System Related vs Bowtie methodology

System Related	Bowtie methodology
Advantages	
<ul style="list-style-type: none"> • Easy to keep database updated; • Simple, intuitive and easy to use; • Serves the needs of EAA, based on its extensive operation; • Provides limited statistics within the IQSMS. 	<ul style="list-style-type: none"> • Completed and precise, when analysing a single event; • Easy to read, even for someone who is not within the subject; • Well organised, as it clearly divides threats and consequences on each side of the diagram; • Provides top hazards statistics in the IQSMS.
Disadvantages	
<ul style="list-style-type: none"> • Lack of precision when analysing some events; • Can be subjective when different people are analysing a report. 	<ul style="list-style-type: none"> • Hard to keep updated, as operation is not regular; • Requires too much manpower to use, to update and to take proper benefit from.

Each method has its pros and cons, both were presented and tested in this chapter to generate the maximum information possible to attest which one better serves the interests of the company, according to its dimension and respective operation.

The work carried out in this dissertation was very important for the risk management process of EAA, in which an important component was studied. The company intends to apply the outcomes that this study generated. All the work described in this document was properly validated by the Safety Manager and the Accountable Manager of euroAtlantic airways.

This chapter described, namely it was shown how to approve reports in IQSMS, the first step in the risk management process. An extensive description of both methodologies presented in the course of this study was also made, giving particular attention to its specifications within the software EAA uses.

A crucial point for the outcome of the present study was the assessment of hard landing event, which was analysed with both methodologies allowing to compare them.

The comparison between the existent method at EAA and the Bowtie methodology revealed that even though the latter is a valuable tool for the risk management process, it does not pay of the work necessary to fully implement it in the company's SMS. The current used method can still serve the needs of EAA, considering its size and extensive operation.

Chapter 5 - Conclusions and future work

This chapter concludes the dissertation, presenting conclusions, challenges and future work that can be done to improve what was accomplished with this study.

5.1 Conclusions

As the concern for safety keeps growing within the aviation industry, it is mandatory to continue the work of improving the safety of aircraft, facilities and everyone taking part of this world, which continues to prove to be one of the safest environments. EAA particularly, as a high reputation airline with several aeronautical certificates and high extensive operation, needs to assure that it gives the maximum attention to hazards that is subject to.

euroAtlantic airways was already dedicating a significant amount of time to identifying hazards, proof of this is its *Hazard Identification List*, which the company, particularly the Safety department, has invested in effectively identifying hazards the company was exposed to in its reports and successfully risk assessing them to better protect its fleet and staff from the harm they could cause.

Nevertheless, the Safety department felt that some improvement could take place regarding the way the company was doing the reports risk assessment. As the Bowtie methodology is so well-known and accepted in the aeronautical industry, EAA's Safety department decided that it could bring encouraging advantages and significant improvements to the safety risk management process of reports. Therefore, this study was proposed.

In order to improve this matter, it was required to do bibliographic research to allow for a better knowledge concerning the subjects studied, the company and its procedures. A brief study about human factors and aircraft accidents was made, as well as two models about the human influence in a safety system aimed at minimizing the risks in the operation of an airline. It was also given attention to the whole framework of Safety Management System in general and, in particular, at EAA in terms of the safety pillars of the organisation, its reporting system and risk management process. Practical data regarding the hard landing event analysed, which was an event specifically selected for its characteristics and importance for the company's

operation, was mainly gathered through IQSMS, being manually treated to analyse which method best fits EAA.

Regarding the risk assessment process of reports, some conclusions were drawn. About the System Related method:

1. It is a good tool that currently plays its role within the company according to its dimension and respective operation. It is simple to use and user-friendly, as all the information available is presented in the same window in the software and the whole process of categorizing a report and obtaining the risk index is effective and quick;
2. However, this method could use some updating regarding the root cause list that is the base for the options selectable in the software for each parameter. Sometimes, the list lacks options that better reflect what happened in the occurrence and consequently affects the risk analysis of the reports.

About the Bowtie methodology:

3. It is a well-conceived method that, when used to its fullest capacity, presents itself as a strong tool to reduce and to better assess the risks the company faces. It is of common understanding in the aeronautical industry, according to the bibliography analysed, that the Bowtie methodology is a great instrument for airlines and their Safety departments;
4. Regardless of the advantages of the Bowtie methodology, its complexity and difficulty to keep it updated consist huge obstacles for EAA to use this method and make it its primary risk assessment method. For a company with the dimension of fleet and operation like EAA, it does not pay off the work and commitment necessary to operate a tool like the Bowtie methodology. Its requirements in terms of manpower and time spent do not compensate the outcomes the company would eventually take from using it;
5. As the Bowtie methodology is not fully implemented in the company, it is not possible to present a preview of a statistic chart or even use this function individually because the system requires a significant number of reports analysed with it in order to generate consistent information;
6. Following the diagram for hard landing that was created, it was concluded that the same could be useful for the company's safety risk management. As it is so

efficient in particular events, it could be used to analyse critical events, like for example hard landings.

With this study, it was concluded that euroAtlantic airways should not convert its operational risk management process of reports into Bowtie methodology, as the advantages of using it would not overlap the extra amount of work it would take to fully implementing it in the company.

Nevertheless, this dissertation also showed that EAA would take great benefits if it decides to implement a hybrid system, in which it would continue to use the current method as its primary tool but would also adopt the Bowtie methodology to analyse specific events considered high-risk.

5.2 Future work

With this dissertation, it was possible to conclude that besides the System Related method being a good tool, to keep playing its role in EAA's Safety Management System it is necessary to update the list on which it is based.

It would be important to better standardize the way risk assessments are performed, so that the risk values obtained are more uniform and therefore easier to catalogue.

In the follow-up of the description of the Bowtie methodology and all its potential advantages, the company could benefit from analysing some events, frequent and of concern, through a Bowtie diagram, due to its relation between event, threats and consequences.

The safety risk management process would become more effective and the risk would be better mitigated, if all the critical events as the hard landing and all the recurrently reported hazards started to be analysed using a Bowtie diagram for each one.

It is recommended to continue using the *Hazard Identification List* which has an indicator where relevant information about recurrently reported hazards can be found. This would make the report investigation easier and faster, once it already has mitigation measures that can be put in place.

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ANNEXES

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ANNEX 1 - Root Causes List

Root Cause Group	Root Cause	Hazard Group
Aircraft Control / Performance	Unable to maintain speed/height or achieve scheduled performance Aircraft becomes uncontrollable Structural overload	OPS
Aircraft Design	Design shortcomings Unapproved modification Manufacturing defect	TEC
Aircraft Structure	Corrosion or fatigue Overload failure Flutter Damaged or missing part	TEC
Aircraft Systems	System failure - affecting controllability System Failure - flight deck information System failure - other	TEC
Airplane / Equipment Damage Error	Tools / equipment used improperly Defective tools / equipment used Struck by / against Pulled / pushed / drove into	TEC
Airside Operations	Lack of safety awareness regarding Hearing Protection Lack of security awareness regarding Ramp Pass (ID) Lack of SMS awareness Lack of loader discipline during loading operations Lack of driver speed of vehicle awareness Lack of Towing/Pushing vehicle driver safety awareness Lack of FOD awareness Lack of vehicle diver parking awareness Lack of safety awareness on Apron/Ramp Lack of knowledge of chock suitability Lack of Safety awareness of GPU operation Lack of safety awareness of aircraft external inspection Lack of adequate lighting for night operations Lack of security awareness on Ramp/Apron	OPS
Appointment of Key Personnel	Lack of hazard identification Lack of documentation & records Lack of Operational planning Lack of Process design Lack of appointment of key safety personnel Lack of communication systems Lack of English language effectiveness Lack of provision of resources Inappropriate Qualification, Training and Promotion of Personnel Lack of Knowledge Lack of reporting system Lack of monitoring and measurement system Lack of data analysis Lack of management review	ORG
Appointment of Key Personnel Management responsibility and accountability	Lack of data analysis Lack of management review Lack of reporting system Lack of monitoring and measurement system Lack of hazard identification Lack of Process design Lack of Operational planning Lack of documentation & records Lack of appointment of key safety personnel Lack of English language effectiveness Lack of communication systems Lack of provision of resources Inappropriate Qualification, Training and Promotion of Personnel Lack of Knowledge	ORG
ATC / Ground Aids	Incorrect or inadequate instruction/advice Misunderstood or missed communication Failure to provide separation - air Failure to provide separation - ground Ground aid malfunction or unavailable	OPS
Cargo Handling	Lack of Manual Custodian Lack of awareness to update Org Chart Lack of knowledge to update Contract Lack of special cargo handling knowledge Lack of documented process Lack of comprehensive training program Lack of Instructor Lack of training aids Lack of training facilities Lack of knowledge of record control	OPS
Communication	Lack of Knowledge Inappropriate Qualification, Training and Promotion of Personnel Lack of provision of resources Lack of communication systems Lack of English language effectiveness Lack of appointment of key safety personnel Lack of Process design Lack of Operational planning Lack of documentation & records Lack of hazard identification Lack of reporting system Lack of monitoring and measurement system Lack of data analysis Lack of management review	ORG
Documentation	No Approval or expired approval due lack of reminder process Lack of Distribution Lack of LEP Lack of updated documents (Currency) Lack of Amendment by document owner Lack of Revision by document owner Lack of knowledge of Copy Number Lack of knowledge of Retention requirements Lack of knowledge Disposal process Lack of Manual List Unavailable Contract	ORG

Root Cause Group	Hazard Group
Aircraft Control / Performance	OPS
Aircraft Design	TEC
Aircraft Structure	TEC
Aircraft Systems	TEC
Airplane / Equipment Damage Error	TEC
Airside Operations	OPS
Appointment of Key Personnel	ORG
Appointment of Key Personnel Management responsibility and accountability	ORG
ATC / Ground Aids	OPS
Cargo Handling	OPS
Communication	OPS/ORG
Documentation	ORG
Documentation & Records	ORG
Emergency Response Program	ORG
Engine	TEC
Environmental / Weather	ENV
External Entity Management	ORG
Fault Isolation / Test / Inspection Error	TEC
Fire	OPS
Flight Crew	HF
Foreign Object Damage Error	OPS/TEC
Fuelling	TEC
Ground Handling	OPS
GSE Maintenance	TEC
Human Factor	HF
Infrastructure	ENV
Installation Error	TEC
Leadership & Management	ORG
Load Control	OPS
Maintenance General	TEC
Management	ORG
Managing Change	ORG
Organisation	ORG
Passenger	OPS
Passenger & Baggage Handling	OPS
Performance Monitoring & Measuring	ORG
Personal Injury Error	HF
Process & Activity Management	ORG
Qualification Training Program & Promotion Selection	ORG
Risk Management	ORG
Safety & Quality Assurance	ORG/OPS
Servicing Error	OPS
Smoke	OPS
Training & Qualification	ORG

Root Cause Group	Root Cause	Hazard Group
Documentation & Records	Lack of Knowledge Inappropriate Qualification, Training and Promotion of Personnel Lack of provision of resources Lack of communication systems Lack of English language effectiveness Lack of appointment of key safety personnel Lack of Process design Lack of Operational planning Lack of documentation & records Lack of hazard identification Lack of reporting system Lack of monitoring and measurement system Lack of data analysis Lack of management review	ORG
Emergency Response Program	Lack of Emergency Phone List Lack of Emergency response plan Lack of S-CERM latest revision	ORG
Engine	Engine failure or malfunction Propeller failure Damage due to non-containment Fuel contamination Engine failure simulated	TEC
Environmental / Weather	Heavy rain Wind shear, upset or turbulence Icing, snow, freezing rain Wake turbulence Volcanic ash, sand Birds Lightning, thunderstorm Runway contaminated Mist, fog, smoke, haze Tropical Cyclone, mountain waves	ENV
External Entity Management	Lack of Knowledge Inappropriate Qualification, Training and Promotion of Personnel Lack of provision of resources Lack of communication systems Lack of English language effectiveness Lack of appointment of key safety personnel Lack of Process design Lack of Operational planning Lack of documentation & records Lack of hazard identification Lack of reporting system Lack of monitoring and measurement system Lack of data analysis Lack of management review	ORG
Fault Isolation / Test / Inspection Error	Did not detect fault Not found by fault isolation Not found by operational / functional test Not found by inspection Access not closed System / equipment not reactivated / deactivated	TEC
Fire	Engine fire or overheat Fire due to aircraft systems Fire - other cause	OPS
Flight Crew	Lack of positional awareness - in air Lack of positional awareness - on ground Lack of awareness of circumstances in flight Incorrect selection on instrument or navaid Action on wrong control or instrument Slow or delayed action Omission of action or inappropriate action Press-on-itis Failure in CRM Poor professional judgement or airmanship Disorientation or visual illusion Fatigue State of mind Interaction with automation Fast and/or high on approach Slow and/or low on approach Landing incorrect Lack of/inadequate qualification, training or experience Incapacitation, medical or other factors reducing crew performance Failure in look-out Deliberate non-adherence to procedure Proficiency Low altitude above terrain Unstabilized approach SOP Steep approach / ATC request	HF
Foreign Object Damage Error	Material left in aircraft / engine Debris on ramp Debris falling into open system	OPS
Fuelling	Lack of document control Lack of fuel quality process at fuel farm Lack of fuel tank maintenance Lack of fuel filter replacement program Lack of water sampling process Lack of fuel quality process at aircraft Lack of fuel truck maintenance Lack of fuel quality supervision Lack of comprehensive training program Lack of Instructor Lack of training aids Lack of training facilities Lack of knowledge of record control Lack of safety (SMS) awareness Lack of security awareness Lack of reporting of safety occurrence process (SMS) Lack of knowledge Lack of fuelling discipline by fuelling operator Lack of notification to aircraft crew of refuelling with pax onboard Lack of fuel spillage knowledge	TEC

Root Cause Group	Root Cause	Hazard Group
Ground Handling	Ground staff or passenger(s) struck by aircraft Loading error	OPS
GSE Maintenance	Lack of GSE maintenance program Lack of suitable GSE Lack of GSE staff training program Lack of GSE staff training records Lack of maintenance records Lack of security awareness Lack of SMS awareness Lack of knowledge Lack of potable water servicing equipment cleanliness Lack of potable water bacteriological inspection	TEC
Human Factor	Lack of leadership and managerial skills - Workload management Lack of leadership and managerial skills - Planning and coordination Lack of leadership and managerial skills - Providing and maintaining standard Lack of leadership and managerial skills - Use of authority and assertiveness Lack of teamwork - Conflict Solving Lack of teamwork - Supporting others Lack of teamwork - Considering others Lack of teamwork - Team building and maintaining Lack of Decision Making - Outcome review Lack of Decision Making - Risk assessment / Option choice Lack of Decision Making - Option generation Lack of Decision Making - Problem definition diagnosis Lack of situational awareness - Anticipation Lack of situational awareness - Environment Lack of situational awareness - Systems	HF
Infrastructure	Incorrect, inadequate or misleading information to crew Inadequate aerodrome support Inadequate or incorrect performance of ancillary equipment Inadequate or incorrect airport departure or arrival procedure design Landing site other than airport Public interest site	ENV
Installation Error	Equipment / Part not installed Wrong equipment / part installed Wrong orientation Improper location Incomplete installation Extra parts installed Access not closed System / equipment not reactivated / deactivated Damaged on installation Cross connection	TEC
Leadership & Management	Lack of data analysis Lack of management review Lack of monitoring and measurement system Lack of reporting system Lack of hazard identification Lack of documentation & records Lack of Process design Lack of Operational planning Lack of appointment of key safety personnel Lack of English language effectiveness Lack of communication systems Lack of provision of resources Inappropriate Qualification, Training and Promotion of Personnel Lack of Knowledge	ORG
Load Control	Loadmaster lack of discipline Lack of awareness of record control Lack of knowledge for weight & balance computation Error on Load sheet compilation Unavailability of Backup System Lack of red cap awareness of load supervision Lack of knowledge of LMC process Lack of knowledge of DG spillage or leakage Lack of Safety Awareness for DG Spillage or Leakage Lack of reporting of DG spillage or leakage Unavailability of DGR Sign Unavailability of DGR Manual Lack of security awareness regarding screening process Lack of Xray screener machine Lack of screener knowledge Lack of safety awareness Lack of known shipper or regulated agent cargo screening Lack of knowledge of known shipper and regulated agent Unavailability of Weight Machine Calibration Service	OPS
Maintenance General	Failure to carry-out due maintenance Maintenance or repair error, oversight or inadequacy Bogus parts	TEC
Management	Lack of management direction- Job Description Lack of management direction- Work Instruction Lack of Communication knowledge Unavailable Contract Unavailable SLA Unavailable Agreement Lack of discipline regarding monitoring of External Provider Failure to comply with Local Authority Insufficient training for Fire Fighting personnel Inadequate Medical facilities available Lack of knowledge of Safety Management System (SMS) Lack of knowledge of Safety Action group (SAG) Lack of Incident Accident Reporting System Lack of Hazard Report system Lack of Proactive Safety System Lack of knowledge of Safety Concept & projects Lack of Safety Promotion Lack of Safety Instructions	ORG

Root Cause Group	Root Cause	Hazard Group
Managing Change	Lack of Knowledge Inappropriate Qualification, Training and Promotion of Personnel Lack of provision of resources Lack of communication systems Lack of English language effectiveness Lack of appointment of key safety personnel Lack of Process design Lack of Operational planning Lack of documentation & records Lack of hazard identification Lack of reporting system Lack of monitoring and measurement system Lack of data analysis Lack of management review	ORG
Organisation	Safety and Security Management Training /Systems Standard Operating Procedures (SOP) Operational regulations and/or policies Controls to assess compliance with regulations and SOPs Operational information Charts and FMS database Cabin Operations Technology and equipment Operational planning and scheduling Change management Selections systems Continuing Airworthiness Dangerous Goods Dispatch Documentation Ground Operations Quality/Compliance Other Organisation involved Lack of knowledge of Organisation Chart Lack of understanding of lines of accountability & responsibility	ORG
Other	Caused by other aircraft or vehicle Non-adherence to cabin safety procedures Unsafe action by third parties Security related occurrence Regulatory oversight Medical Other hazards	
Passenger	Delay Unruly Baggage Medical	OPS
Passenger & Baggage Handling	Insufficient knowledge Unavailability of DGR Sign Airport does not provide Sign No safety Awareness No Security Awareness No passenger handling awareness Unavailability of Weight Machine Calibration Service	OPS
Performance Monitoring & Measuring	Lack of Knowledge Inappropriate Qualification, Training and Promotion of Personnel Lack of provision of resources Lack of communication systems Lack of English language effectiveness Lack of appointment of key safety personnel Lack of Process design Lack of Operational planning Lack of documentation & records Lack of hazard identification Lack of reporting system Lack of monitoring and measurement system Lack of data analysis Lack of management review	ORG
Personal Injury Error	Slip / trip / fall Caught in / on / between Struck by / against Hazard contacted (e.g. electricity, hot or cold surface, sharp surface) Hazardous thermal environment exposure (heat, cold or humidity)	HF
Process & Activity Management	Lack of Knowledge Inappropriate Qualification, Training and Promotion of Personnel Lack of provision of resources Lack of communication systems Lack of English language effectiveness Lack of appointment of key safety personnel Lack of Process design Lack of Operational planning Lack of documentation & records Lack of hazard identification Lack of reporting system Lack of monitoring and measurement system Lack of data analysis Lack of management review	ORG

Root Cause Group	Root Cause	Hazard Group
Qualification Training Program & Promotion Selection	Lack of management review Lack of data analysis Lack of monitoring and measurement system Lack of hazard identification Lack of reporting system Lack of documentation & records Lack of Process design Lack of Operational planning Lack of appointment of key safety personnel Lack of English language effectiveness Lack of communication systems Lack of provision of resources Lack of Knowledge Inappropriate Qualification, Training and Promotion of Personnel	ORG
Risk Management	Lack of Knowledge Inappropriate Qualification, Training and Promotion of Personnel Lack of provision of resources Lack of communication systems Lack of English language effectiveness Lack of appointment of key safety personnel Lack of Process design Lack of Operational planning Lack of documentation & records Lack of hazard identification Lack of reporting system Lack of monitoring and measurement system Lack of data analysis Lack of management review	ORG
Safety & Quality Assurance	Lack of Knowledge Inappropriate Qualification, Training and Promotion of Personnel Lack of provision of resources Lack of communication systems Lack of English language effectiveness Lack of appointment of key safety personnel Lack of Process design Lack of Operational planning Lack of documentation & records Lack of hazard identification Lack of reporting system Lack of monitoring and measurement system Lack of data analysis Lack of management review	ORG
Servicing Error	Not enough fluid Too much fluid Wrong fluid type Required servicing not performed Access not closed System / equipment not reactivated / deactivated	OPS
Smoke	Smoke in Cockpit Smoke in Cabin Smoke in Toilet	OPS
Training & Qualification	Unacceptable Training Program Unacceptable Syllabus No Qualified Instructors Unacceptable Instructor Training Program Unacceptable Instructor Evaluation Program Insufficient number of Instructors	ORG

Effect Group	Effect	Hazard Group
Admin Staff	Injury on Head Injury on Leg Injury on Arm Injury on Body	Human factors
Aircraft Technical Status	Aircraft Unfit to fly Fire Extinguisher System Activated Maintenance Action Aircraft Systems Inhibited Damage - Ground Equipment/Vehicle Damage - Major Damage - Minor Damage - Other Aircraft Smoke/Fire Detector Activated Standby System Used Temporary Loss of Control Engine Operated at Reduced Power Engine Shutdown Engine Run-down Engine Shutdown Fire Extinguisher - Portable Discharged Other Automatic System Activated RAT Deployment no effect	Technical
Airport	Medical Procedure On-Board Oxygen - Passengers Passenger Caution Passenger Off-Loaded Passenger Restraint Extra Security Checks Ambulance/Paramedic Police/Security Services no effect	Operations
Continuing Airworthiness	Incorrect work report - no effect on AMP compliance Incorrect work report - effect on AMP compliance Work Report received late - no effect on AMP compliance Work Report received late - effect on AMP compliance no effect	Technical
Crew	Emergency Checklist Emergency Declaration - Mayday Emergency Declaration - Unspecified Emergency Evacuation Flight Duty Time exceedence Incapacitation - Cabin Crew Incapacitation - Flight Crew Injured person no effect Not properly trained Oxygen used in flight Rapid Disembarkation	Human factors
Flight	Air Turnback Cancellation Delay Diversion Ferry Flight Return to Stand Abnormal Landing Aircraft Out of Trim Altitude Deviation Avoidance Manoeuvre Emergency Descent Flight Path Deviation - Lateral Fuel Imbalance Fuel Jettison Fuel Low State Fuel Spillage Go Around RTO - High Speed RTO - Low Speed Stall Warning Stall/Alpha Protection no effect Fatal accident Too low terrain warning Damage to third party loss or malfunction of any essential system/part aborted take-off Unstable Approach Bank Angle	Operations
Ground Crew	Injury on Head Injury on Leg Injury on Arm Injury on Body	Human Factors
Passenger	Fire/Rescue Services Threat/Violeance to third parties no effect	Operations

Effect Group	Hazard Group
Admin Staff	HF
Aircraft Technical Status	TEC
Airport	OPS
Continuing Airworthiness	TEC
Crew	HF
Flight	OPS
Ground Crew	HF
Passenger	OPS

Descriptor Group	Descriptor
ACARS	ACARS ACARS Uplink other
ADC	ADC ADC/CADC other
AFCS	EEC/FADEC other
Air Traffic Control	ATC Congestion ATC English ATC error # ATC Service Standard ATC Violation Filed Barometric Information Error Callsign Confusion Excessive Hold Delays Inadequate Separation Landing Clearance Not Received Landing Clearance with Runway In Use Runway - Blocked Runway/Taxiway Excursion Runway/Taxiway Incursion Take Off Clearance Cancelled Take Off Clearance with Runway In Use Taxi Clearance with TWY/RWY in use Taxiway Incursion by Ground Vehicle Transponder other Traffic Flow
Aircraft Interior	Cabin Trim and Fittings Cabin Trolley Cabin Window Crack/Craze/Delam Crew Rest Area Flight Deck Seat Floor Covering Flight Deck Window Crack/Craze/Delam Galley Equipment Overhead Lockers Seat Belts Toilets Toilets Full/Inoperative other
Aircraft Surfaces	Nacelle/Pylon Overheat - Wing/Body Radome Tailplane Tailscrape Damage Window - Defective window heat other Fuselage
Aircraft System	Autobrake other
Airport	HALS Detop OPS Hazardous AP layout Parking Guidance Control Ramp - Markings Ramp Surface Contamination Runway - Lighting Runway - Markings Runway - Surface Conditions Runway Incursion by Ground Vehicle Runway/Taxiway - Activities Skid - Apron # Skid - Taxiway Skid/Aquaplane - Runway Spillage of cargo loading Taxiway - Contamination Taxiway - Lighting Taxiway - Markings Taxiway - Surface Conditions other Runway incursion by other aircraft
Automatic Flight Control System	A/P or F/D Height Control A/P or F/D ILS Capture A/P or F/D Lateral Control A/P or F/D Mode Control Panel A/P or F/D Pitch Up/Down A/P or F/D Roll Exceedence Autoland Autothrottle/Autothrust False Autopilot Indications Flight Control Computer Total Autopilot Failure Unable to Disengage Autopilot Uncommanded A/P Disconnect Unselected Autoflight Commands other
Bird	Multiple Birdstrike - Damage Multiple Birdstrike - No Damage Single Birdstrike - Damage Single Birdstrike - No Damage other

Descriptor Group	Descriptor
Cabin Crew Training	CBT Classroom other
Cabin Systems and Equipments	Provision of required ELT's on aircraft appropriate to type of aircraft Cockpit & Cabin emergency equipment location and serviceability Ramp Operations- Use of Safety Equipment Ramp Operations- Use of Ground Equipment Ramp operations- FOD Ramp Operations- Use of safety zones Ramp Operations- TCO performance Passenger Check-in- Dangerous Goods/Security Signage-Questions Passenger Check-in- Baggage Weight & Tag Procedures Passenger Check-in- Oversize and heavy baggage procedures GSE maintenance & repair facilities GSE Potable water procedures GSE Waste liquids procedures (Toilet) GSE Driver Qualification & training
Cargo Operations	Acceptance & Carriage of COMAT Acceptance & Carriage of Dangerous Goods (Allowable Quantities) Acceptance & carriage of General Cargo Perishable goods, live animals, oversize baggage and special cargo, storage
Clock	Clock other
COM	Audio Integrating System Audio Select Panels Breakthrough/Crosstalk Cockpit Loudspeaker Cockpit Voice Recorder Communication with ATC Lost FANS Communication Flight Deck Volume Control Headsets/Microphones HF Interphone Loss of Comms Mobile Phone/PED Multiple Radio Comms Failure Non ATC Communications Pre-recorded Announcement Radio Comms Controller Radio Interference Radio PTT switch Satcom Selcal VHF other
Cooling	Recirculation Fan other
Crew	Cabin Crew - Fatigue/Stress Cabin Crew - Illness Cabin Crew - Injury Cabin Crew Procedures Cabin Crew Seat Cabin Door Procedure Flight/Cabin Crew Comms Flight/Ground Crew Comms other Flight Crew - Fatigue/Stress Flight Crew - Illness Flight Crew - Injury Flight Crew Procedures Flight Crew - Incapacitation Cabin Crew - Incapacitation Flight Crew - Misinterpretation Flight Crew - Wrong Decision
De- /Anti-Icing System	De- /Anti Icing System Airframe Anti-Icing Valve failure other
Documentation	Aircraft library Incorrect Checklist Tech. / Journey Log Other Manuals Checklist/SOP Use
Documentation & Records	Uncontrolled documents & records Operational manuals
Door	Door - Flight Deck Door - Hold Door - Internal Door - Passenger Door - Power Assist Door - Seals Door and Door Area Door Handle - Exterior/Interior Door/Hatch - Emergency Exit Door/Hatch - False Warning other
EICAS	Central Warning System EICAS/ECAM other

Descriptor Group	Descriptor
Electrical System	Battery Cabin Lighting Circuit Breaker Tripped Electrical Bus inop Electrical Relay Emergency Lights Emergency/Standby Electrics EMI# Flight Deck/Instrument Lighting IDG IDG/CSD/CSMG Landing/Taxi Lights Multiple Electrical Failures Multiple Generator Failure Single Generator Failure Total Electrical Failure Wiring Damage other
Emergency Equipment	Emergency Torches Escape Rope Escape Slide/Raft Flash Light Inadvertent Slide Activation Jemmy/Fire Axe Life Jackets Medical Kit Megaphones Portable fire extinguisher Portable Fire Extinguishers Portable Oxygen Safety Equipment Incorrectly Stowed Safety Equipment Missing Safety Equipment of Incorrect Type other
Emergency response	Aircraft emergency evacuation cabin and lack of task sharing procedures Clear policy, process and procedures to ensure communications between flight deck and cabin crew during flight are effective in normal, non-normal and Carriage of sufficient water for survival in the event of ditching or crash landing in remote areas
Engine & APU	APU - Air Supply Contaminated APU - Air Supply Pressure Low APU - Failure APU - Fuel Leak APU - Oil Leak APU - Operated Outside Limits APU - Surge APU - Uncontained Failure APU Left Running Unattended ENG - Valve failure Engine - Asymmetric Power Engine - Cowl/Panels Insecure/Detach Engine - Damage Engine - EGT Engine - Failed to Shutdown Engine - Failure Engine - Flame out Engine - Fluctuating Power Engine - Fuel leak Engine - High Oil Consumption Engine - HMU / MEC Engine - Hot Start Engine - Indication Engine - Intake Doors/Ramps Engine - Limit Exceedence Engine - Low Thrust/Power Engine - Oil Contamination Engine - Oil Filter Engine - Oil Leak Engine - Oil Pressure Engine - Oil Quantity Engine - Placard Incorrect Engine - Reheat Engine - Start/Ignition Engine - Surge/Stall Engine - Thrust Reverser fail Engine - Thrust Reverser Unlock/Unstow Engine - Uncommanded Power Change Engine - Uncontained Failure Engine - Vibration Engine Anti-icing Engine Anti-icing Valve failure Engine De-icing EPR/Power Shortfall Overheat - APU Overheat - Engine Throttle Stagger Thrust Lever/Throttle Jam/Stiff other

Descriptor Group	Descriptor
Environmental Control System	Air Conditioning Double System Failure Air Conditioning Noise/Vibration Air Conditioning Overheat AIR/GND Sensing Auto Pressurisation Bleed Valve Cabin Altitude Control Condensation Water Duct - Contaminated Duct - Failure Duct - Leak Duct - Overheat Outflow Valve Pack Control Pressurisation Control Erratic Temperature Control Total Pressurisation System Failure Valve Failure other
Fire	Fire - APU Tailpipe Fire - Engine Tailpipe Fire - External Fire - Fuel Fire - Wheel/Brake Fire Brigade support on Ramp Fire Detection System - APU Fire Detection System - Avionics Bay Fire Detection System - Crew Rest Area Fire Detection System - Engine Fire Detection System - Hold Fire Detection System - IFE# Fire Detection System - Toilet Fire Detection System - Wheel Well Fire False Warning - APU Fire False Warning - Avionics Bay Fire False Warning - Crew Rest Area Fire False Warning - Engine Fire False Warning - Hold Fire False Warning - IFE Fire False Warning - Toilet Fire False Warning - Wheel Well Fire Protection System - APU Fire Protection System - Engine Fire Protection System - Hold Fire Protection System - IFE Fire Protection System - Toilet Fire/Smoke - APU Fire/Smoke - Engine Fire/Smoke - Galley Fire/Smoke - Gear Fire/Smoke - Oven Fire/Sparks - Avionics Bay Fire/Sparks - Cabin Fire/Sparks - Crew Rest Area Fire/Sparks - Flight Deck Fire/Sparks - Galley Fire/Sparks - Hold Fire/Sparks - Toilet Fire/Sparks/Smoke - IFE other
Flight Control	Aileron/Aileron trim Asymmetric/Split Flaps Autostab System Elevon Fin Flap - Leading Edge Flap/Flaperon - Trailing Edge Rudder Pedal Rudder/Rudder Trim Spoiler/Speedbrake Stabiliser Trim Yaw Damper Yaw Damper other
Flight Crew Training	Classroom CBT STD other

Descriptor Group	Descriptor
Flight Operation	Airport Closed
	Airport Congestion
	Animal Strike
	Anti-Collision Light
	Anti-Skid
	Bird/Animal Control
	Bounced Landing
	Cabin Floor
	Cabin Not Secure
	Configuration - False Warning
	Configuration - Flaps
	Configuration - Gear
	Configuration - Not Specified
	Configuration - Other
	Configuration - Speedbrake
	Configuration - Trim
	Control Column/Side Stick
	Cowl/Panels Insecure/Detached
	Crosswind
	Dangerous Goods
	Deep Landing
	Defective Plug / Receptacle
	Dutch Roll
	Flight Crew Auto Handling
	Flight Crew Fatigue/Stress
	Flight Crew Illness
	Flight Crew Injury
	Flight Crew Manual Handling
	Flight Crew misinterpreted ATC instruction
	Flight Crew Mis-Selection
	Flight Crew Procedure adherence
	Flight Deck Procedures
	Flight Plan
	Fuel Management
	Fuel Plan
	High Energy/Unstable Approach
	Hold
	Elevator/Elevator trim
	Gravity extension
	Hard/Heavy Landing
	Insufficient Crew Rest
Insufficient Visual Reference	
LAHSO/SIRO	
MEL/CDL	
Met Info/Briefing	
Meteorological Data	
Military Influence	
Navigation Charts	
Noise abatement	
NOTAM	
NOTOC	
Operational Procedures	
Other A/C - Go around	
Other Aircraft - Altitude bust	
Other Aircraft - Altitude Error	
Other Aircraft - Collision	
Other Aircraft - Emergency Declaration	
Other Aircraft - Position Error	
Other Aircraft - Runway/Taxiway Incursion	
Other Aircraft - Slow to Clear Runway	
Other Operational Data	
Override/Jettison Pump	
Overweight Landing	
Oxygen - Leak	
Oxygen - Low Quantity	
Oxygen Masks	
Placarding Incorrect	
Precautionary Avoidance - No Damage	
Seat belt signs on	
Single Animalstrike - Damage	
Single Animalstrike - No Damage	
Tail Strike	
Training Flight	
Uncoordinated A/C movement - FLT Crew	
Use of wrong RWY / TWY	
Wrong T/O calculation	
Bounced Landing	
Flight Planning	AIS other
FOD	FOD (Runway/Taxiway) FOD on Ramp other
Fuel System	Fuel Crossfeed Valve Fuel Filter Fuel Jettison Failure Fuel Leak Fuel Pressure Fuel Quantity Indication Fuel Temperature Fuel Valve Fuel cap open other

Descriptor Group	Descriptor
Gear	Body Gear Steering
	Brake Overheat
	Brake/Gear Computer
	Brakes
	Gear - False Indication
	Gear - Vibration/Shimmy
	Gear Collapsed
	Gear Doors Insecure
	Gear Failed to Extend
	Gear Failed to Lock Down/Up
Gear Failed to Retract	
Gear Slow to Retract/Extend	
Landing Gear	
Landing Gear Lever	
Nosewheel Steering	
Overheat - Wheel/Brake	
Parking Brake	
Steering/Ground Lock Pin	
TPIS	
Tyre Deflated	
Tyres/Wheels	
other	
Ground Handling	External Utilities
	Incorrect chocks
	Incorrect Loading other
Ground Operations	Airbridge/Jetty
	Airbridge/Jetway Door Open
	Aircraft Anti/De-icing
	Aircraft Collision with Other Aircraft
	Aircraft Collision with Vehicle/Equipment
	Aircraft Servicing
	Airframe De-icing
	Airport Fire Service
	Airstairs
	Baggage Handling
	Cabin Baggage
	Catering Supplies
	Fuel - Precautionary refueling
	Fuel Contamination
	Ground Equip Collision with Aircraft
	Ground Equipment Unsecured
	Ground Vehicle Collision with Aircraft
	Groundprox
	Hatches/Ports
	Hold Baggage Screening
	Hold Door Procedure
	Hold Loading
	Jet Blast - Encountered
	Jet Blast - Generated
	Marshalling
	Potable Water Contaminated
	Pushback Procedure
	Ramp - Injury
	Refuelling Procedure
	Staff Approached Aircraft with Anti-Col Light On
	Stand Obstructed by Ground Equipment
	Toilet Fluid Leak in Cabin
Tow Bar Shear Pin Failed	
Uncoordinated A/C movement - GND Crew	
Unsecured Container	
Unsecured Items in the Hold	
Unsecured Items on Main Deck	
Vehicle Operating Standards	
other	
Damage caused by rotor downwash	
Hydraulic	Hydraulic - System Loss
	Hydraulic - Total System Loss
	Hydraulic Electric Pump
	Hydraulic Filter #
	Hydraulic Fluid Temperature
	Hydraulic Leak
	Hydraulic Low Pressure
	Hydraulic Low Reservoir Pressure
	Hydraulic Main Pump
	Hydraulic Noise
	Hydraulic Quantity
Hydraulic Standby Pump	
other	
Instruments	Flight Data Recorder
	other
Line Operation	Stable Approach policy violations handling
	Misuse of standard phraseology by flight crew
	TCAS training to ensure proper use of TCAS procedures
	Takeoff, climb and landing performance calculation accuracy
	FDA misuse of data by fleet management
	Lack of en-route emergency airfield information
Non-precision Approach constant rate of descent policy and procedure occurrences	
Destination airport alternate fuel standard (IOSA) compliance issues	
Stored breathing Oxygen policy and procedure for FOO/FOA compliance with DSP standard 4.4	
Load	Catering Lift
	other
Maintenance	Cross Connection
	Incorrect Parts/Fluid Used
	Maintenance Equipment Left on Aircraft
	Maintenance Inspection
	Maintenance Standards
	Panels/Plugs/Caps Insecure/Detached
	Repetitive Significant Defect
Technician/Mechanic English	
other	

Descriptor Group	Descriptor
Management & Control	<p>Organization Chart Job Description Authority and responsibility Duties & Responsibilities Management continuity Record system Inadequate resources Cabin Crew management liaison with Regulators, OEM and external entities providing services or products to cabin operations Cabin crew external entity monitoring process events Cabin operations issues affecting safety and security are brought to the attention of senior management for bi-annual review Clear supernumerary policy, process and procedures that ensure safety and security of the aircraft and passengers as well as the supernumeraries is ac Delegation of management function to ensure managerial continuity within operational control and dispatch department issues Clear policy, process and procedures to ensure a shared PIC-FOO system of control is implemented Process to ensure FOO/FOA records system that provides management with accurate and current information regarding the status of FOO/FOA license validi FOA currency</p>
Medical passenger training	<p>other ADF ADI/ PFD Airspeed Indicator Altimeter AOA Sensor Approach/Landing Aids CDU/MCDU DME EGPWS - Database error EGPWS/GPWS - Bankangle EGPWS/GPWS - Don't Sink EGPWS/GPWS - False warning EGPWS/GPWS - Gear/Flap EGPWS/GPWS - Glideslope EGPWS/GPWS - Pull Up EGPWS/GPWS - Sink Rate EGPWS/GPWS - System Limitation EGPWS/GPWS - Terrain Closure EGPWS/GPWS - Unwanted Warning EGPWS/GPWS - WindShear EGPWS/GPWS Failure EGPWS/GPWS hard warning EGPWS/GPWS soft warning Electronic Flightbag Emergency Locator Transmitter False Autoland Warnings FMGC FMS/FMC FMS/RNAV Data GPS HSI/ND ILS/MLS INS/IRS Instrument Panel Machmeter Map Shift Multiple Instrument Failures Navigation/Strobe Lights Pitot Probe Pitot/Static/Temp Probe Heat Radio Altimeter Standby Instruments Static Vents VOR VSI other</p>
Navigation System	
NVIS	NVIS
Operational Engineering & Specification	Specification of takeoff alternate on OFP by FOO/FOA policy, process and procedures issues
other	<p>Earthquake Equipment Cooling Flood Fuselage Insect Laser beam Missile Launch Potable Water Leak Strut Overheat Suicide Unreported Aircraft Damage War Zone Wing/Body Overheat other Main rotor transmission Tail rotor transmission Main rotor Tail rotor NVG</p>
Oxygen System	<p>Crew Mask Crew Oxygen other</p>

Descriptor Group	Descriptor
Passenger	<p>Apparent Intoxication Cabin Divider Deportee/Inad Passenger Inappropriate Behaviour Passenger - Abusive Passenger - Assault Passenger - Fatality Passenger - Illness Passenger - Injury Passenger Address Passenger Boarded Incorrect Aircraft Passenger Boarded with Prohibited Articles Passenger Handling Passenger Mask Passenger Oxygen Passenger Seat Passenger Service Units Passenger Signs other Passenger - delay Passenger - baggage Passenger - heavy drunken Passenger - physically or mentally retarded</p>
Performance	<p>Aircraft Limit Exceedence other</p>
Propeller	<p>Propeller - Autofeather System Propeller - Control Propeller - Damage Propeller - Failed to Feather Propeller - Insecure Propeller - Oil Propeller - Overspeed Propeller - Restraint Propeller - Separation Propeller - Uncommanded Feather other</p>
Rotor	<p>Main Rotor Tail Rotor other</p>
Route & Route Performance Manual	<p>Aerodrome Chart other</p>
Safety Management	<p>Pilot license violations Fuel policy misunderstanding Pre-flight aircraft inspection performance</p>
Security	<p>Aircraft Security Check Airport Security Bomb Threat Flight Deck Intrusion Stowaway Suspicious Object in Cabin Terminal Security Unattended Aircraft Security Hijacking Unauthorised Aircraft Access other</p>
Security Operation	<p>Sterile cockpit policy & procedure non-compliance Use of flight deck door security situations Cockpit entry rules and procedures to prevent unlawful access events Process for carriage of weapons on-board aircraft Outsource provider monitoring process for Operational Control department service product providers Fuel farm quality checks- water and contaminant checks Fuel farm facility physical condition check Aircraft fueling procedures- Checklist Fuel truck procedures- Checklist</p>
Smoke	<p>Smoke / Fumes outside A/C Smoke Hoods/Masks Smoke/Fumes - Avionics Bay Smoke/Fumes - Cabin Smoke/Fumes - Crew Rest Area Smoke/Fumes - External Smoke/Fumes - Flight Deck Smoke/Fumes - Galley Smoke/Fumes - Hold Smoke/Fumes - IFE Smoke/Fumes - Oven Smoke/Fumes - Toilet Smoke/Fumes - Wheel/Brake Smoking in Cabin Smoking in Toilet other</p>

Descriptor Group	Descriptor
TCAS	Airborne Object Airprox Balloon/Kite TCAS - False Warning TCAS - RA TCAS - Reversal RA TCAS - TA TCAS Failure TCAS RA - Adjust V/S TCAS RA - Climb TCAS RA - Descend TCAS RA - Maintain V/S TCAS RA - Monitor V/S TCAS RA - Multiple Messages TCAS RA - System Limitation other
Technical crew member training	other
Training & Qualification	Low visibility operations qualifications monitoring Proper use of LOFT & LOS training details in the simulator Simulator monitoring to ensure representative status of simulator and aircraft Qualification and recurrent training for DSP instructors process issues CRM training with flight & cabin crew policy and process issues Training record retrieval by cabin crew member name process weaknesses
Training Other Personnel	CBT Classroom On site training other
Water and Waste System	Blue Ice Shed from Aircraft Evidence of Blue Ice other
Weather	Lightning Strike Microburst Rain Repellent Runway - Contamination St. Elmos Fire # Turbulence Fog Windshear Wake Turbulence - Encountered Wake Turbulence - Generated Weather Radar Unstable Atmosphere Volcanic Ash Thunderstorm Tailwind Sandstorm Severe Icing Severe Weather Heavy Rain Heavy Snow fall Hail other
Weight & Balance	C of G Control Loadsheet Compilation other
Windows	Window - Dirty/Obscured Window - Leak Window - Overheat Window - Seals Window - Unsecured Windscreen Heating Windscreen Wipers other Damaged / Shattered
Wing	Wings other

ANNEX 2 - #1117 Hard Landing

Kind of Report :	(Air) Safety Report
Area of Occurrence :	Safety Report
Type of Occurrence :	Flight Operations
Event Classification :	Suspected hard landing

General Information	
Please define your name	
Reporter :	Martins, Jorge
In case of an anonymous report please enter 'Anonymous'	
Please define a headline to your report	
Title :	Hard landing
General Flight Information:	
Aircraft Registration :	CS-TQU
Aircraft type :	737-800
Manufacturer :	BOEING
Flight Phase :	Landing
Departure :	LPPT
Destination :	LIMC
Airport of Occurrence :	Arrival airport
Location on aerodrome :	Other
Diversion :	
Date & Time of Event (UTC) :	2020-05-13 00:25
Flight Number :	JMM1305
Call Sign :	0
Inflight Return :	
Total number of persons on board :	
Did you declare the occurrence?	
Emergency declared :	
ATC advised :	
Dispatch advised :	

Operational Information	
Please fill, if speed and altitude were relevant regarding the event.	
Flight Altitude for VFR Density Altitude :	
Flight Level :	
Speed :	
Type of airspeed :	
Please fill, if flight rules and traffic type were relevant regarding the event.	
Current Flight Rules :	
Current traffic type :	
Please fill, if Approach Type was relevant regarding the event.	
Instrument approach type :	
Please define additional relevant information	
Training or Ferry Flight :	
RVSM :	
Techlog Reference :	
Coordinates of the event	
Latitude :	
Longitude :	

Weather Information	
Was the event weather relevant?	
Weather Relevant :	Yes
If yes, please fill all relevant fields below.	
Conditions and visibility	
Visibility (m) :	
Weather Conditions :	
Restriction to visibility :	
Light Conditions :	
Cloud Amount :	
Air temperature (°C) :	
Height of cloud base (ft) :	
Temp / Dew Point :	
Wind	
Wind speed :	
Wind direction :	
Speed measured at :	
Relative wind direction :	Tail wind
Wind gusts :	YES
Turbulence Intensity :	
Maximum gust :	
Precipitation and other weather phenomena	
Weather phenomena :	
Phenomena intensity :	
Weather Report	
Weather Report :	

Damage	
Damage Information (if applicable)	
Damage on aircraft :	Unknown
Damage on aerodrome :	None
Third party damage :	NO
Object damaged :	None
Damage caused by 3rd party :	No

Fatigue	
Fatigue Information	
Was Fatigue a contributing factor? :	
Important: Please also write a fatigue report if you think your fatigue levels had an impact on the reported occurrence.	

Report Text	
Please provide all relevant information to the event	
Report Text :	<p>Stabilized approach with tail wind until approaching the threshold. Then speed increased and also the RoD.</p> <p>PF removed power to correct for the speed, at the same time, didn't correct for the RoD high (never above 1000ft/min) I applied power, but was too late, as the aircraft impacted hard on the ground (even with power on).</p> <p>Event reported on TLB, for maintenance inspection. As no faults or damages were founded, we continued for the remaining flights that day.</p>
As a general instruction, please inform our Safety department what happened, give details why it happened and in case you have any safety recommendations, please provide	

ANNEX 3 - Hard Landing Bowtie Diagram

