The application of high reliability organisation theory in relation to high reliable organisational practice:
An air traffic case

By

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Foreword

This thesis has been a long journey, one that has played out over the course of weeks and months. Despite the mountains of papers and research I have read in preparation of this project, I cannot claim to know everything about the topic. I hope that this thesis will reflect the journey that I have made, and also that it reflects the tireless efforts of thousands within the aviation industry to make flying safe for everyone. Above all, I hope that it will serve as a satisfactory guide to this important subject.
The work presented in this thesis is based on many years of learning from mistakes. Although some of the pioneers of aviation safety are no longer with us, their work still resonates in the practices and attitudes of scores of experts. With that said, this thesis ultimately hopes to widen understanding of the vital field of high reliability and safety.

Signed,

Markus Biedermann

"Knowing that the world they face is complex, unstable, unknowable, and unpredictable, HROs position themselves to see as much as possible"
(Weick & Sutcliffe, 2007, p. 26)

Abstract

The High Reliability Organisations Theory (HROT) identifies five key principles for any high reliability organisation, pointing to air traffic control (ATC) and nuclear power plants as cogent examples. Nevertheless, relatively little is known about the current operational point of HROs. The literature surrounding this subject frequently highlights governance and economic regulation as significant factors in dictating HRO principles. These factors are influenced by both the economic pressures that result from shifts in operating points, as well as the intensely regulated world of global aviation. However, research into this topic has thus far failed to satisfactorily address the extent to which HROs are successful in operating in accordance with HROT principles. This gap in understanding leaves this study to pose the question: "*To what extent do highly reliable organisations apply HROT principles in daily organisational practice across the two essential business functions* Operations *and* Operational Support *against the influence of external influencing factors, especially regulation?*". The present dissertation used three different data collection methods: document searches; online surveys; and expert interviews. The purpose of these methods was threefold. First, to explore the extent to which the case organisation, Deutsche Flugsicherung GmbH (DFS), complies with high reliability principles. Second, to determine the degree of integration of the five dimensions of high reliability in the different business areas of the case company. Third, to explore factors that account for a difference between theory and practice. As a result, it can be stated the organisation complies to a very high degree with the principles of HROT across all business functions. There is a difference between operational and non-operational areas in the perception of the principles as well as in the application and level of integration. Whilst both areas provide deep understanding of HROT and show the dimensions in their day to day work, where the ideas originate from is less known throughout the organization, which leads to the conclusion of it being more in the DNA of the organisation rather than taught knowledge.

Whilst the knowledge and integration of the principles is high, many employees state that cost-pressure and regulatory burden apply. The organization acknowledges the influence factors, but also provide

evidence that it can`t disrupt an HRO’s reliability as its basic principle. The dimensions of HROT form a specific mindset that forms a culture within the organization lived and nurtured by the employees regardless of their area of business. This also results in the biggest difference between theory and practice. Although the awareness of HROT can only be explained and expressed by part of the organisations` members, the organizational practice, reflected also in its culture, shows a living HROT. This demonstrates the potential difference between theory and action, with a theoretical understanding of organizational concept unnecessary from a performance perspective. The present thesis could extend the theory by means of survey and expert interview results, since it could show that HROs such as ATC operates according to HRO principles independent from the area of business. The results from the expert interviews show that, in most peoples’ opinions, it is the employees’ attitude towards safety and resilience that makes ATC so safe.

Statement of Authenticity

I declare that the work in this thesis was carried out in accordance with the regulations of the University of Gloucestershire and is original except where indicated by specific reference in the text. No part of the thesis has been submitted as part of any other academic award. The thesis has not been presented to any other education institution in the United Kingdom or overseas. Any views expressed in the thesis are those of the author and in no way represent those of the University.

18/02/2022 Date [redacted]

Signed

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List of Abbreviations

A-CDM	Airport Collaborative Decision-Making
ACC	Area Control (Centre)
AIP	Aeronautical Information Publication
ANS	Air Navigation Services
ANSL	Air Navigation Services Limited
ANSP	Air Navigation Service Provider
APP	Approach Control
ASM	Air Space Management
ATC	Air Traffic Control
ATCEUC	Air Traffic Controllers European Unions Coordination
ATCO	Air Traffic Controller
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATS	Air Traffic Services
BAF	Bundesaufsichtsamt für Flugsicherung
BFU	Bundes Flugunfall Untersuchungsstelle
BMVI	Bundesministerium für Verkehr und digitale Infrastruktur
CAA	Civil Aviation Authority
CANSO	Civil Air Navigation Service Organisation
CAB	Civil Aeronautics Board
CAP	Civil Aviation Publication
CTOT	Calculated Take-Off Time
DAS	DFS Aviation Services
DFS	Deutsche Flugsicherung GmbH
DfT	Department for Transport
DIT	Disaster Incubation Theory
DUC	Determined Unit Cost
EASA	European Aviation Safety Agency
EC	European Commission
ENR	En-route
EOBT	Estimated Off-Block Time
ESARR2	Eurocontrol Regulation on Reporting and Assessment of Safety Occurrences

ETOT	Estimated Take-Off Time
EU	European Union
FAA	Federal Aviation Authority
FAB	Functional Airspace Block
FIS	Flight Information Service
Ft	feet (above mean sea level)
FOD	Foreign Object Damage
HRO	High Reliability Organisation
HROT	High Reliability Organisations Theory
ICAO	International Civil Aviation Organisation
KPA	Key Performance Area
KPI	Key Performance Indicator
MUAC	Maastricht Upper Area Control Centre
NAT	Normal Accidents Theory
NATS	National Air Traffic Services
NM	Nautical Mile
NPS	Net Promoter Score
NTSB	National Transport Safety Board
OPNOT	Operational Notice
PRC	Performance Review Commission
RAT	Risk Analysis Tool
RP	Reference Period
SA	Safety Assurance
SARP	Standards and recommended practices
SES	Single European Sky
SI	Supplementary Instruction
SMS	Safety Management System
SRM	Safety Risk Management
TDI	Temporary Desk Instruction
TOBT	Target Off-Block Time
TOI	Temporary Operating Instruction
TWR	Aerodrome Control/Tower Control
WW	World War

1 Introduction

1.1 Background

Civil and military aviation form an integral part of our global society. Ever since the first flight by Orville Wright in 1903, aviation has grown from the dream of a few individuals to a worldwide multi-billion-dollar industry. Despite pressure from various crises – economic, political, or even events like the COVID-19 pandemic – it has been and will always be part of our life. The world's appetite for travel has not been satiated by any other existing method of transportation.

Flights offer a unique advantage in range and speed over any other mode of transport. Aviation can rapidly traverse vast swathes of land and water and even reach remote areas without relying on pre-existing infrastructure, such as roads or train lines.

In military aviation, the same features allow strategists to reach far behind enemy lines, achieve long range reconnaissance missions, and provide air support for isolated areas. One of the most famous missions, which shows the possibilities of aviation in the military sector, is the Berlin Air Lift. Over the course of a ten month period in 1948 and 1949, allied forces provided the entirety of non-Soviet Berlin with all the supplies necessary to support a major city solely through the use of air transport (Tunnell, 2010).

Air transport has the potential to reach even further beyond these solutions. The Royal Flying Doctors of Australia, for example, provide health care and humanitarian aid to many remote communities. Their 68 aircraft cover the length and breadth of the Australian continent, helping to save lives for over 90 years since their foundation in 1928 (Hill & Harris, 2008). During the COVID-19 pandemic, cargo flights have represented an effective way to quickly distribute desperately needed goods such as masks and vaccines. Air transport, be it transporting people or goods, has proven to be a big step forward for mankind in every area of life.

The civil aviation industry claims to contribute 2.7 Trillion dollars to the world economy and provide 62.7 million jobs worldwide (IHLG, 2017).

Over the last 60 years, air transport has grown from a low volume luxury product for a few enthusiasts into a commodity product in highly industrialised countries, available to the majority of their people at competitive prices. More than 1,400 airlines and over 26,000 aircraft are in service around the globe, connecting more than 3,900 airports. This service is supported by 173 air navigation service providers (IHLG, 2017). It is not all plain sailing, however. Flying has been blighted by consistent accidents and tragic events ever since its early days. Catastrophes such as the Croydon mid-air collision in 1922, the first major accident in civil aviation (Croydon Airport Society, 2020), Air France flight 447, where an Airbus A330 crashed into the Atlantic ocean after a technical malfunction combined with pilot error (Bureau d'Enuqetes et d'Analyses, 2012), and the Überlingen accident, where miscommunication between Air Traffic Control (ATC) and the pilot caused two aircraft to collide in mid-air (BFU, 2004) have brought infamy to an industry that relies on safety to ensure passengers use its service. Air Transport has always had to face catastrophic accidents and, whilst they happen rarely, the consequences are often fatal.

The safety of air travel will form a critical part of its future success. Wilbur Wright is quoted to have said: *"if you are looking for perfect safety, you will do well to sit on a fence and watch the birds"* (Sternal, 2016). Whilst the true meaning of that statement is subjective, it acknowledges an important fact: safety is never a given and even the best system might fail at some point. Some anonymous members of the Federal Aviation Authority (FAA) in the United States once supposedly said that every aviation regulation is written in blood. Whilst this sounds rather harsh, it is hard to dispute that it is at least partly true. In the past, most approaches to safety were reactive, implemented as the result of particular accidents or mistakes. In an industry such as aviation, these accidents tend to result in casualties. Therefore, there is a consensus among all stakeholders in the industry that safety must be continually investigated and improved. Recent decades have shown just how much progress can be made when an emphasis is placed on safety, reducing risk, and managing crisis situations. Due to the nature of aviation, the factors that give impetus to improving safety are manifold. Regardless of whether these changes are motivated by financial considerations or otherwise, the collective aim of improving safety standards remains unshaken.

However, the economic pressures of a changing industry (one that has shifted from the pursuit of a privileged few to a cheap and widely accessible mode of transport for many) have led to concerns that safety in aviation is under threat (Papatheodorou & Platis, 2007). Governmental intervention through deregulation (Gillen, 2006; Moses & Savage, 1990; Tretheway & Waters, 1998) has increasingly introduced more market like environments into not only civil aviation, but also military aviation, yet still with a long way to go. Deregulation has introduced stakeholder theory into aviation, something that could pose a serious threat to safety standards (Papatheodorou & Platis, 2007). Work on this thesis began amidst record setting performances in aviation; it ended in the aftermath and rubble of COVID-19.

Aviation is a volatile world and as such, the COVID-19 crisis hit the industry hard. ‘High reliability’ has become a watchword in aviation, yet the pandemic threatened previous assumptions surrounding safety and resilience. It was truly a global crisis for a global world. The data collection had almost been concluded by the time the pandemic struck, but I decided to include a reflection on COVID-19 into the findings, as it provides relevant insights into reliability.

Safety and efficiency are often at odds with one another and within aviation, political influence and stakeholder interests are deemed to have a high risk of conflicting with safety (Hollnagel, 2013).

Any participant in the aviation industry must be stable and reliable in order to avoid catastrophes. If trust in the safety of air travel diminishes, the whole industry might be bound to collapse. One theory, namely the High Reliability Organisations Theory (HROT), provides an answer as to how the high standard in aviation organisations can be maintained. One sector of this industry stands out for its primary purpose of maintaining safety: Air Navigation Services (ANS).

The fundamental question this thesis will aim to answer is *to what extent do highly reliable organisations apply HROT principles in daily organisational practice across the two essential business functions* Operations *and* Operational Support *against the influence of external influencing factors, especially regulation?*

1.2 Thesis Design

This thesis is divided into the following different parts: literature review, research design and research findings, before a discussion and conclusion chapter brings all parts together.

1.2.1 Part 1: Literature Review

Part 1 deals with the relevant academic literature, which is essential as it provides a basic understanding of this thesis' topic. Four chapters will be used to create an understanding of high reliability organisations theory:

1. Air Traffic Management understanding, introducing ATC, the background and how it operates and interacts with the other actors in the aviation industry.
2. Safety understanding and management, outlining the wider concept of safety management, crisis management and risk management which are informed by and inform HROT.
3. High reliability understanding, providing the overview on which key theories have led to the emergence of HROT, while also exploring what principles this theory adheres to, as well as which key dimensions it covers within safety management.
4. Governance and deregulation of ATC, which is the most relevant influencing factor on HROs and will lead towards the focus of the research project.

1.2.2 Part 2: Research Design

Part 2 represents the present Research Design. In this context, the principle of triangulation should be mentioned. The research question will be answered using three different methods. These will be with a survey, expert interviews, and a document analysis:

1. Survey

A survey will be conducted to gain a broad basis of input from all members of the case organisation. The survey is open for all members of ANS organisations and will show the spread of knowledge within the industry of ATC. This will inform the expert interviews, which will serve as a different point of view on the subject.

2. Expert Interviews

Expert interviews will be conducted with select experts from the case organisation. These experts work in the management of the two essential business functions *Operations* and *Operational Support (also non-operations or business area)* in different hierarchical levels. Their level of knowledge about the case organisation and the area they work in allows them to provide relevant expert knowledge on the field of research, going beyond what participants in the survey would provide.

3. Document Analysis

All experts participating in an interview will be asked for specific documents, which have been created in the organisation in the context of safety and HROT. A document analysis will provide a third insight into the research subject through written evidence within the case organisation. All three methods will together form a triangular view on the subject matter and allow for a thorough analysis.

1.2.3 Part 3: Research Findings

Part 3 represents the data analysis and results chapter. In this part, Data gathered using the three data collection methods outline above will be analysed using:

- qualitative content analysis as explained by Mayring (2020) for the document analysis and the expert interviews.
- a statistical evaluation software for the survey.

1.2.4 Part 4: Discussion

In part 4 the findings are discussed and evaluated against the research questions and objectives. The results are provide in order of the chosen methods of this research and will form the basis for the final part of the thesis.

1.2.5 Part 5: Conclusions and Future Research

The present thesis concludes with part 5 as of chapter 6 with a summary of the results. The

contribution to theory and knowledge will be outlined into detail and in addition, recommendations for ATC practitioners, policy makers and regarding COVID-19 will be provided. With a closer look on the wider applicability of the thesis results, the final two chapters of part 5 will outline the limitations of the thesis and then leading into an outlook and scope for future research.

1.3 Importance and unique position of research

This study has been conducted in rather new territory of the theory. Very little research on Air Traffic Management against the HROT background is available and although there are examples of researchers, that have been able to look into an ANS organisation such as Perrow (1984), who mentions an area control centre, there may be few research if any, conducted by senior executives of such an organisation. On top of that, ANS organisations are in most countries classified as critical infrastructure organisations with specific access restrictions. This makes it extraordinarily difficult for researchers to get access to any relevant information apart from anyway openly available one outside these organisations. The position of the researcher within the organisation and the variety of posts held during the period of research allows a possibly unique insight and access to key members of the organisation.
As a result, this thesis contributes not only to theory but to research as a whole in three important ways.
For once, it opens the theory into the specific area of Air Traffic Control, which is in most cases very difficult to access for researchers of any field. Second, it provides an insight in the practice of Air Navigation Service Provider Organisations and how they translate theory into their day-to-day operations in a way that has likely never been conducted before and will be challenging to repeat in any future research. Third, the identified research gap was that relatively little is known about the current operational point of such an organisation and that even the organisation itself might not accurately know this but could only define it after an incident or an accident. Also, the literature provides no evidence as to whether an HRO as a whole is or is not operating according to the HRO principles, whilst HROT does not separate operations from the business area of an organisation as such.

This created a clear need for an empirical study examining this, and the present study falls within this category.
With the present research, data has been collected, presented and analysed, that will help many researchers, not only in the field of study, to further develop their theories and build new conclusions upon them.
Finally, it deepens the understanding of a member of the aviation industry, which is possibly underrepresented in todays` research and theories and calls for further research.
The author considers the results generalizable as to the worldwide set standards by ICAO, which every aviation nation is adhering, resulting in a comparable business environment for any air navigation service provider. Probably, the results are as well transferable to any other HRO or organisation outside the known HROs, which are required to operate relatively error free to avoid major impact on the organisation or customer.

2 Part 1: Literature Review

The present chapter provides general information regarding air traffic control, safety understanding and management, high reliability understanding and the governance and regulations of air traffic control.

2.1 Air Traffic Management understanding

The first chapter will provide an overview of air traffic management, its purpose, and which operating principles ATC - a part of air traffic management (ATM) - follows. To provide a contextual understanding of the field that this thesis is examining, the various parts of air traffic management will be described.

2.1.1 The origins of Air Traffic Management

To understand air traffic management, it is important to first understand its history. Civil aviation began with air traffic control, not air traffic management, with ATC having been introduced subsequently as safety net for aviation. Later, the scope was broadened to not only focus on safety, but also on efficiency and the support of all airspace users (e.g. Gliders, Hot Air Ballons, Drones, etc.). This went far beyond the initial remit of providing safety, yet safety remained the ultimate goal.

Planes were used on a large scale for the first time during the first world war (1914-1918). Back then their use was limited to surveillance and did not extend to the transportation of goods and passengers.

However, mankind learned that there was much more of a use to aviation than simply watching enemy lines.

Immediately after the war, in 1919, the International Convention for Air Navigation (also known as Paris Convention (United Nations, 1919)) laid down the basic rules for air navigation, such as each nation's sovereignty of airspace and the rules for overflying or flying to and from a country. The increasing speed and agility of aircraft made them appealing for civil purposes, and in 1921 James Herbert Knight made the first transcontinental mail delivery in the United States. At the same time and alongside these first steps into civil aviation, the foundations of future air traffic control were being laid.

Back then, pilots navigated along straight lines, following lookouts who acted as waypoints on the ground. Air traffic soon increased - although it was still very low compared to current levels even in Covid times - and the need to support the pilots as they flew became obvious. Air traffic control aimed to provide safety to the pilots flying their aircraft, giving them directions and information to navigate safely. All of this was based on the ground and used whatever technical means were available.

The first air traffic controllers were located at U.K. airfields. Their job was fairly straightforward. They informed pilots of other aircraft or vehicles in the area, using flags, flashing lights or soon also radio communications (introduced around 1930) (New World Encyclopedia writers, 2016). With increasing air traffic, the risks of flying soon became apparent. In 1920, an aircraft crash-landed near Burte Gardens, just south of London, close to Croydon airfield. Or in 1922, at Croydon airport, the first minor collision between an aircraft and a vehicle occurred. (Croydon Airport Society, 2020).

From its very inception, ATC has always played a major role in aiming to avoid such accidents from happening. From any accident the aviation industry learned and improved. In particular ATC always stayed on the forefront of accident-prevention and learning from these events.

Today, ATC uses modern surveillance equipment to build worldwide, interconnected systems that provide data on airborne, departing and/or landing aircraft. It also uses a host of other communication methods, ranging from radio telephony to datalink, allowing for the transfer of information between aircraft and the controller in almost real time (DFS GmbH, 2016). Since the first steps were taken in civil aviation, rapid development has taken place, and with it a rapid development of safety protocols. ATC, introduced to support safe flying, always lead the way in this regard.

After the second world war, Air Traffic Management was expanded in 1946 with the International Civil Aviation Organisation (ICAO). The Chicago Convention in 1944 (United Nations, 1944), signed by 52 countries, led to the foundation of ICAO as an international oversight and rulemaking authority as a subsection of the United Nations.

In 1946, ICAO published as one of its first documents *Doc. 4444 – Air Traffic Management*, which until today describes all the relevant elements for the provision of Air Traffic Management, but especially Air Traffic Control (ICAO, 2016b). The document details air traffic management as *"the dynamic, integrated management of air traffic and airspace including air traffic services, airspace management and air traffic flow management – safely, economically and efficiently – through the provision of facilities and seamless services in collaboration with all parties and involving airborne and ground-based functions"* (ICAO, 2016b, p. 25).

With this definition it becomes clear that the service provided to aircraft had evolved significantly over time. Gone were the days of lookouts on the ground, with focus shifting towards an integrated approach that would support the industry.

2.1.2 **Structure of air traffic management**

ATM is made up of various parts, including Air Traffic Services (ATS), Air Traffic Flow Management (ATFM) and Air Space Management (ASM) (ICAO, 2016b). It is important to note that an air navigation service provider (such as the case organisation in this thesis) normally provides all of these services.

ATS is further divided into the various tasks and services that an air traffic control unit performs or provides, which are (i) air traffic control service (ATC) (ii) Advisory service, (iii) Flight information service (FIS) and (iv) Alerting service (ICAO, 2002). Figure 1 shows a visual representation of the structure of ATM and the sub-parts of air traffic services.

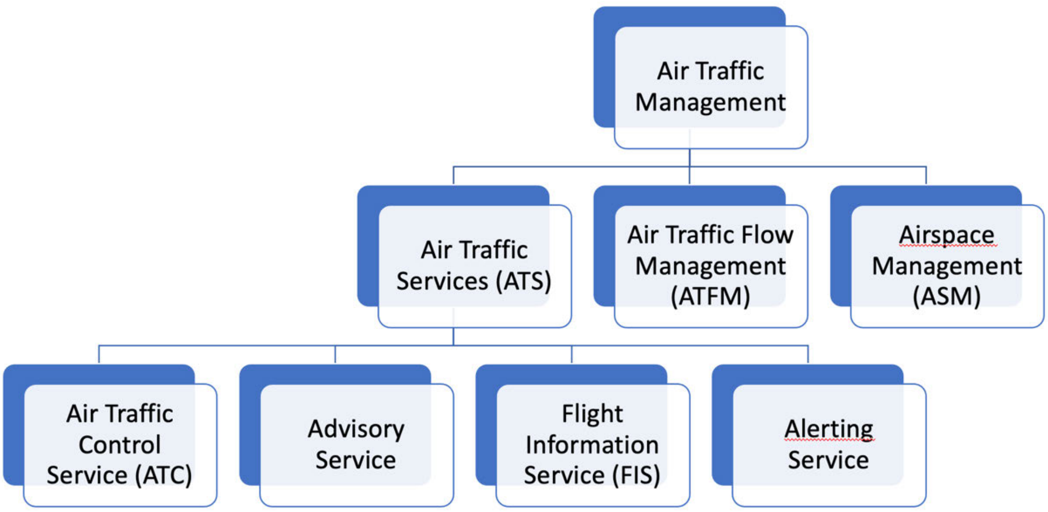

Figure 1: Air Traffic Management Structure, Source: own figure

2.1.3 Air Traffic Services

Air traffic services within an ANSP are the provision of services to an airspace user. Airspace users can be commercial or private aircraft, vehicles including hot air balloons, gliders, remotely piloted aircraft, and helicopters. The services are provided within the ATC unit's area of responsibility, which can be either on the ground, the taxiway system or the runway (= Aerodrome Control or TWR), within the terminal airspace of an aerodrome (=Approach Control or APP) or in the airspace outside these areas (=Area Control or ACC). Most of the time, area control is divided in lower airspace (up to 245000ft above mean sea level) and upper airspace (above 245000ft mean sea level up to 660000ft).

Note: above 660000ft marks the beginning of uncontrolled airspace, considered free airspace for everyone.

The primary function of ATCOs is to provide ATS within their area of responsibility, using radar and radio telephony to separate planes from other planes and/or objects in the sky and on the ground. Typically, a vertical distance of 1000ft and a horizontal distance of at least 5 nautical miles (NM) is required between two objects in the sky for them to be considered separated. The sky is delineated in a similar manner to the road system on the ground. There are airways for different purposes, and each follows a similar system as on the ground. Departure routes that are not dissimilar to motorway access roads, airways resemble motorways, and link airways function as trunk roads.

Although many airways can be used in both directions, there is a system that prevents two aircraft meeting same point on an airway. All aircraft moving west fly at even levels (in thousands of feet i.e. 20000ft, 22000ft, 24000ft, etc.) and all aircraft moving east maintain odd levels (i.e. 21000ft, 23000ft, 25000ft, etc.) (Mensen, 2014). The big difference between the road system on the ground and the airway system is that the airway system allows for three-dimensional movement. ATCOs give aircraft instructions about height, direction and speed, in order to maintain the minimum distance between aircraft and also to optimise the flight path of aircraft.

Figure 2 shows the flight paths of aircraft above Germany. Aircraft mainly follow the airways and as such, this figure shows quite nicely that the airway system aligns with major roads on the ground, which connect major cities. The blue lines relate to level flight, while the red ones to ascents and the green ones to descents.

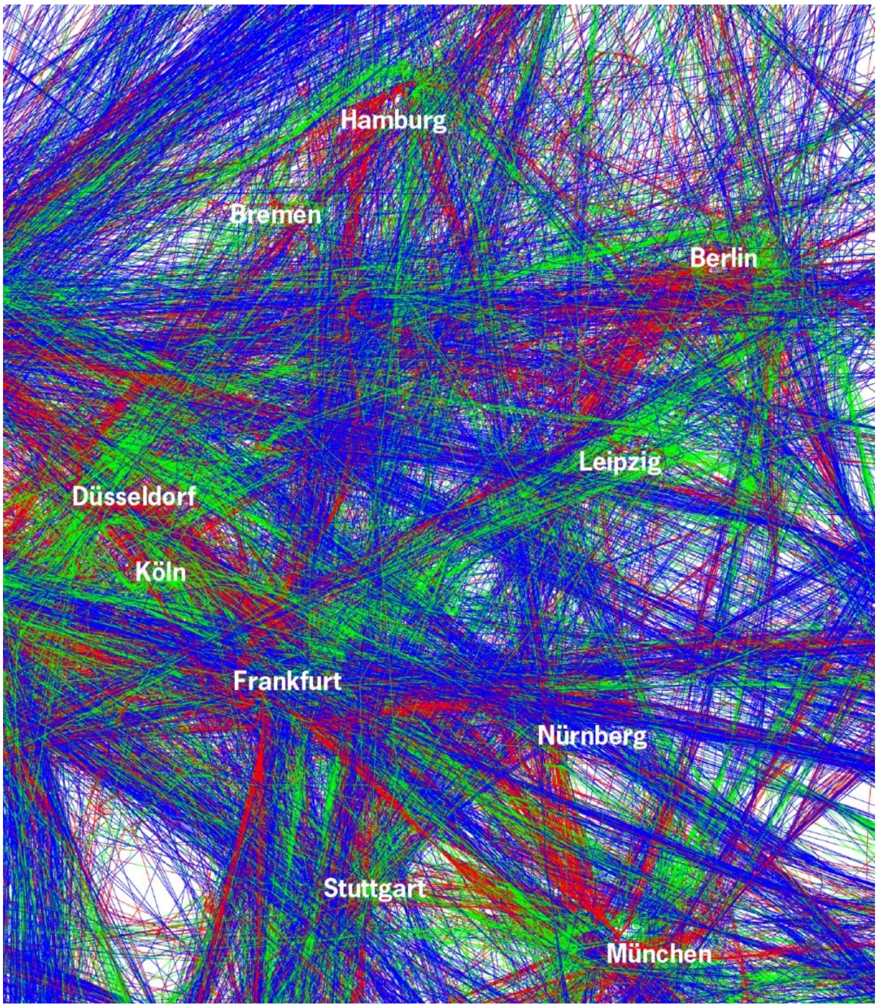

Figure 2: One day in January 2015, Source: DFS GmbH, 2020

ATCOs provide other services that support the provision of ATS. Advisory services inform pilots about any courses of action they may take, as well as offering basic information during the flight. FIS is a basic service for low level, mainly private aircraft that offers information about what lies ahead in the flight path. Finally, the alerting service is used to line with search and rescue. Should a flight be known to ATC and fail to arrive within a set timeframe, the responsible ANSP would start a search for that flight, as it might be the case that the aircraft requires assistance.

All tasks within ATS reflect the purpose of ATC, that of directly or indirectly contributing to a safe flight. A direct contribution constitutes the control of a

flight or an automatically initiated search and rescue for a potentially missing flight. An example of an indirect contribution would be, for example, the advisory service, which provides a pilot with relevant information about the flight and supports the pilot in making the best decision for a safe continuation of the flight.
Such a service requires certain characteristics that not all organisations will be able to provide.

2.1.4 Air Traffic Flow Management

This service is a rather recent concern within ATM, rising in importance when delays in air transport increased significantly in the late 90s (Baumgartner & Finger, 2014; Button & Neiva, 2013). As traffic numbers increased across the world – in particular across Europe – the current concept of ATC began to reach its limit. Traffic was worked 'as is', which meant that an ANSP had so much spare capacity in the system that an additional flight could show up at any time and would be handled without any noticeable delay. Once the capacity was maxed out by millions of flights within Europe and along the major airways, the old style of ad-hoc planning no longer allowed for an even flow of traffic. A new concept was required and with it more robust planning. As a result, ATFM became a vital part of the ATM concept.
The objective of ATFM is *"contributing to a safe, orderly and expeditious flow of air traffic by ensuring that ATC capacity is utilized to the maximum extent possible, and that the traffic volume is compatible with the capacities declared by the appropriate ATS authority"* (ICAO, 2016b, p. 25).
In simple terms, ATFM collects the planned route from any flight within or across Europe. It gathers information about speed and time over certain points, before calculating the number of aircraft within each hour in every piece of airspace (=sector). Because ATFM is aware of the hourly capacity in each sector, they can identify traffic levels that would be too high and assign slots to aircraft so that they will pass through that airspace at a later time. This system reaches its limits when so many aircraft want to fly that even later times would still have too much demand.

Although ATFM clearly states the contribution to safety in its definition, the main task as taken from the definition is maximizing the given capacity.

2.1.5 Airspace Management

The management of airspace is the third main service of ANSPs, which is only mentioned in the definition of ATM in Doc. 4444 (ICAO, 2016b). No other reference is given to this service in that publication of ICAO.
Airspace is a complex system of various sectors in the air where different types of air traffic are allowed. Figure 3 shows an example of how German airspace is classified (DFS GmbH, n.d.):

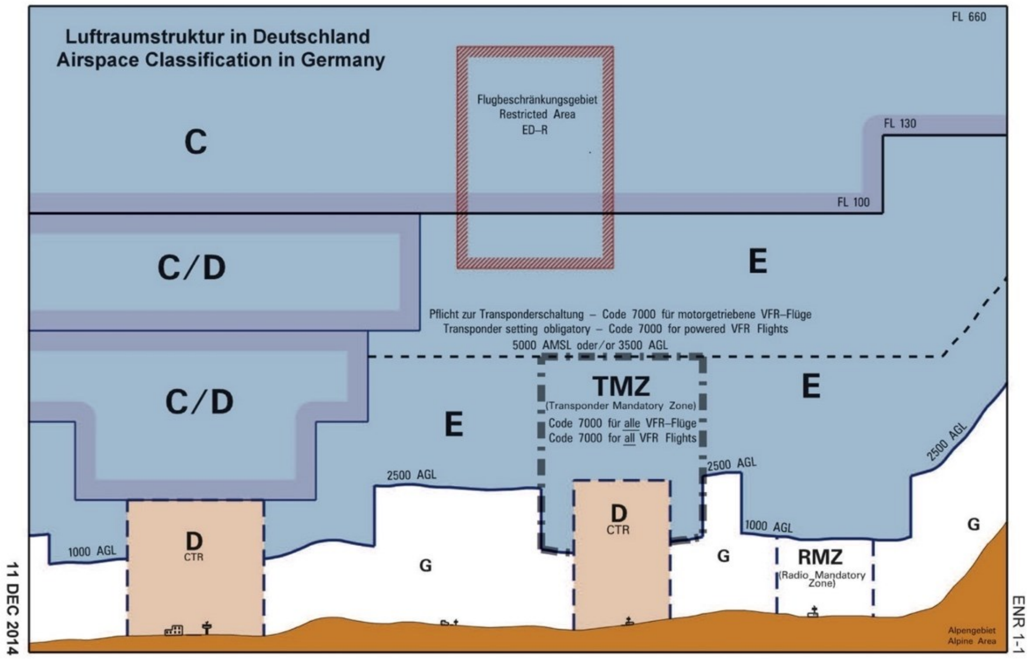

Figure 3: Airspace Classification Germany Source: AIP ENR 1-1, DFS GmbH, 2014

To use an example, Airspace class G is uncontrolled airspace. This means that ATC does not provide any service and each pilot must rely on their own skills in the area. This dearth of communication may be down to a lack of radar or radio coverage, but also as a means to simplify flying close to small airfields or over farms without requiring too much planning and coordination.
Airspace class D for example is reserved for arrivals and departures to controlled airports. Certain conditions apply when flying in and out, but as a minimum radio contact and adherence to ATC instructions are required.
Airspace class C is an airspace where fully instrumented and controlled

flight takes place. An aircraft has to adhere to any instruction given by ATC and have certain equipment for safety and control purpose.
The structure is used by not only civilian airline services, but also by military exercises or special missions such as search and rescue or the maintenance of navigational infrastructure. Hence why the management of this airspace as a part of capacity management is an important element of air traffic management (Mensen, 2014; Vaaben & Larsen, 2015). At an European level, regulation 551/2004 by the European Commission details Airspace Management (European Commission, 2010b). On the one hand, the use of airspace is supposed to remain as flexible as possible, but the airspace also needs to be managed in order to increase efficiency and maximize capacity (European Commission, 2010b).

2.1.6 **Summary of Air Traffic Management understanding**

In chapter 2.1. an understanding and overview of air traffic management was presented. Air Traffic Management first started in 1914 following the Paris convention as air traffic control, with the sole purpose of providing a service for the safe conduct of flights. After the second world war, ICAO was founded in 1946 and with it, ATC was expanded with additional elements such as ATFM and ASM. This was done in order to go beyond the sole provision of safety related services to also include capacity and efficiency management for the aviation industry. Any service provided by ANSPs under the umbrella of ATM has the aim to maintain or increase safety and requires the organisation to prioritise this fundamental objective.

2.2 Safety understanding and management

2.2.1 **Introduction to Safety Understanding**

The previous chapter introduced the air traffic background to this thesis. It showed how Air Traffic Management and Air Traffic Control are used as a support network for all aviation industry partners. It also highlighted the specific nature of an ANSP and how they differ from most organisations. This chapter will now further increase the understanding of safety and introduce a few key terms: high reliability organisations theory (HROT) and

highly reliable organisations (HRO). According to this theory, any ANSP is highly reliable. This topic will be discussed in depth at a later stage.
To create an understanding of what constitutes these organisations, this chapter serves the purpose of providing an overview of safety within aviation. HROT is perched within safety management and allows for a holistic approach to safety management through a combination of resilient operations, efficient handling of incidents and quick recovery from any failure. Furthermore, it shows how HROs are structured so that the organisation as a whole is able to provide that high level of resilience against various influence factors. HROT uses elements of risk management, safety management and crisis management to form a key part of its principles. This chapter will also introduce the relevant elements of these areas to further a thorough understanding of HROT from various viewpoints. The chapter starts with an introduction to risk, safety and crisis management. Thereafter the aviation industry and its reputation as the safest mode of (civil) transport is placed into its context, which shines a spotlight on the most important element to HROT of all three introduced models: Incident Management.
The key to remaining safe is knowing as much as possible about the situation your organisation is in at any point in time. Incident management is a fundamental element in achieving this, as the traditional approach of focusing on investigating and learning from failures is based on the flawed assumption that highly reliable organisations like aviation should have accidents to learn from. As HROs are normally related to critical infrastructure, it is also not desirable or acceptable that such organisations encounter accidents if they are avoidable. This first chapter will begin to build an understanding of not only how HROs operate and how HROT was developed over time, but also the factors that this seemingly stable relationship relies upon to avoid the very disasters that they set out to avoid.

2.2.2 Risk Management

The risk of facing a dangerous situation is naturally of paramount importance to safety understanding and management. One needs to know when to face it in order to understand how to face it, which ultimately defines the requirement for preparation. Since its early days, risk management provides an organisation with the required process to assess, identify and mitigate risks (Mehr & Hedges, 1963).The origins of risk management derive from insurance strategies. In its early days, the term safety management itself was not commonly known or used. All of the concepts which were later introduced as safety management were found within risk management.

One of the oldest risk management related documents is the *Code of Hammurabi*, which is a law book from the Babylonian empire dated around 1950 B.C. (Duncan, 1904).

With the development of probability theory by Blaise Pascal in the mid-16th century, modern risk management first came to the fore, which describes risk as the probability of occurrence of an event multiplied with the consequence, should the event occur (Norrman & Jansson, 2004). This was further refined by Pierre Simon la Place and his work about probability and both mathematical models together facilitated quantitative approaches to risk management (Molak, 1996).

Modern risk management arose from a concerted safety push, one that coincided with the emergence of safety management as a separate stream. The industrial revolution in the late 18th century revealed some new risks which had not considered before (i.e., health and safety at work). In large factories with shift work and intense working environments, the monotony of work affected the performance of workers in various ways. One of its implications was a significant increase of injuries at the workplace as a result of false operating of machines (Pollard, 1963). Since then, risk management has had to change significantly, despite there having been no change to the key tenets of safety.

The risk management cycle consists of several steps, laid out in the figure 4 as described by Elkhweldi and Elmabrouk (2015). Initially, risks need to be identified and subsequently assessed and quantified to identify appropriate countermeasures. These countermeasures then need to be implemented and continuously controlled. Hence, risk management does not represent a final product, but rather an ongoing process.

Regardless of whether probability calculations or qualitative measures or a

Figure 4: Risk Management Cycle, Source: Elkhweldi & Elmabrouk, 2014, p. 2

combination of both is applied, the standard risk management cycle remains similar across literature and can be described as:

1. *Risk identification*

Any potential risk that might have an impact is identified.

2. *Risk Assessment*

Any identified risk is assessed against its likelihood of occurrence and severity of impact.

3. *Selection of risk management strategy*

Potential strategies are acceptance (no action) and mitigation (reduce or eliminate risk).

4. *Implementation*

The selected strategy is implemented into the organisation.

5. *Risk monitoring*

Any implemented strategy is monitored against its desired outcome and re-assessed as and if required. This approach is in line with common literature in this field, for example Zsidisin and Ritchie (Zsidisin & Ritchie, 2008) or Khan and Burnes (Khan & Burnes, 2007).

To differentiate between high-risk and low-risk, the U.S. Federal Transit Administration (2019) suggests the use of the risk management matrix shown in the figure 5.

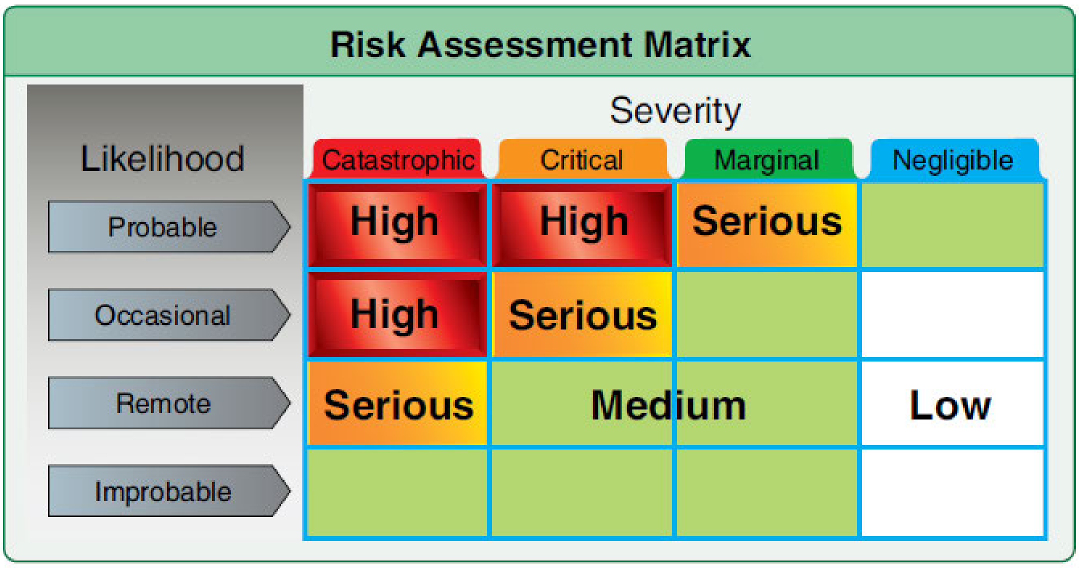

Figure 5: Risk Management Matrix, Source: U.S. Federal Transit Administration, 2019

Offshoots of risk management apply the same principles, for example Olson (2010) in his work on Enterprise Risk Management Models. A similar approach can also be found in the work of Kleindorfer and Saad (2005) who focus on disruption mitigation strategies in supply chains. These principles similarly apply to safety management in aviation (Müller, Wittmer, & Drax, 2014). The risk assessment methods, developed within aviation and commonly known across the industry as Risk Analysis Tool (RAT) are of similar nature as for example the Eurocontrol regulation on *Reporting and Assessment of Safety Occurrences in ATM* (2006). One further example of a risk matrix for aviation can be taken from the U.K. CAA guidance documents as shown in figure 6.

SEVERITY	SEVERE A	A1	A2	A3
	HIGH B	B1	B2	B3
	MEDIUM C	C1	C2	C3
	LOW D	D1	D2	D3
		HIGH 1	MEDIUM 2	LOW 3
		PROBABILITY		

Figure 6: U.K. CAA Occurrence Grading, Source: Eurocontrol, 2015

It also applies the principle of categorising any occurrence subject to severity vs. probability in order to identify the risk.

2.2.3 Safety Management

As mentioned previously, the changes to health and safety at the workplace brought about by the industrial revolution saw the emergence of safety management as a standalone subsection. Taken in isolation, risk management sometimes accepts risks if the overall (monetary) benefit is higher than the expected (financial) loss of the occurrence. Safety management, although largely similar in its views and processes, aims to simultaneously understand how occurrences happen while also focussing on the prevention of harmful outcomes against humans (Vogt & Leonhardt, 2006).

Preventing injury or loss of life has played a major role in dictating the direction of aviation ever since its inception. Almost any recorded loss of an aircraft in an accident resulted in severe injuries and often the loss of human life, in many cases resulting in the deaths of all people on board. The insurance approach to accepting a risk in aviation normally results in putting a number next to human life. While it is a relevant factor within the insurance industry, aviation requires the trust of its passengers and employees in the safety of the mode of transport.

It must be noted that aviation safety management did not start with aviation. An early example for the increasing importance of safety is the industrial revolution and with it the introduction of heavy machinery into work and daily life. Mass transport vehicles such as trains had a radical effect on day-to-day life in the 1800s alongside the first acccidents involving this mode of transport (Hollnagel, 2014).

It is also important to note that these early accidents informed a discussion on what is defined as casualty with regards to an accident. Some industries over the years came up with a definition and the aviation accident investigation according to ICAO defines after an aircraft accident that "*an injury resulting in death within thirty days of the date of the accident is classified as a fatal injury*" (ICAO, 2000, p. 10). These definitions are highly important for insurance companies and their risk management departments but also to better understand statistics on aviation accidents or fatalities. Also discussions surrounding the liability of operators for passenger welfare and safety began to gather momentum already with the first mass transport vehicles such as trains (Nokes, 2002). This is also still relevant today, in particular in the aviation industry.

In his book about the emergence and development of aviation safety, Hollnagel (2014) describes the events during industrialisation as *The First Age* of safety, which is also in line with the work of Hale and Hovden (2004), who describe the age of industrialisation in a similar way. Three ages of safety (development) have been identified in their work, namely *Age of Technology, Age of Human Factors and Age of Safety Management*.

For the purpose of this thesis, it is important to note that all ages are claimed to be various stages in the development of safety management, yet only the latter resulted in the emergence of dedicated safety management systems amongst all industries, which were separate from risk management. In the context of aviation, Roelen and Klompstra (2012) explain that safety management corresponds to a managerial process with two responsibility levels:

- State level

States need to establish safety programs that correspond to a set of activities and regulations with the aim to improve safety.

- Service providers level

Aircraft operators, airport operators, maintenance organisations and air traffic service providers are individual actors who are part of the safety program. These actors need to implement safety management systems (SMS), which are acceptable to the respective state as per regulation from ICAO and EASA (ICAO, 2013; Müller et al., 2014; Performance Review Commission, 2010). In practice, this means to identify safety hazards, to ensure the remedial action implementation that is necessary to maintain the agreed safety performance, to provide continuous monitoring of this safety performance and to guarantee a continuous improvement of the SMS (DFS GmbH, 2016). Table 1 shows an organisation's minimum requirements with regard to the implementation and maintenance of an SMS. These requirements include four different components with twelve elements.

SMS framework components	SMS framework elements
1. Safety policy and objectives	1.1 Management commitment and responsibility 1.2 Safety accountabilities 1.3 Appointment of key safety personnel 1.4 Coordination of emergency response planning 1.5 SMS documentation
2. Safety risk management (SRM)	2.1 Hazard identification 2.2 Risk assessment and mitigation
3. Safety assurance (SA)	3.1 Safety performance monitoring and measurement 3.2 The management of change 3.3 Continuous improvement of the SMS
4. Safety promotion	4.1 Training and education 4.2 Safety communication

Table 1: Safety Management System with Components and Elements, Source: Roelen & Klompstra, 2012, p. 2.

2.2.4 **Crisis Management**

While safety understanding affords an insight into what is done and where it generally comes from, crisis management forms a critical part of refocusing the observer's attention on what would happen if safety regulations were absent. First, it needs to be understood why crisis management exists as a research area and why the area in itself is of such high relevance.

Risk and Safety Management - introduced in the previous chapters - are primarily focussed on identifying risks to mitigate them and preventing disasters or accidents. In the real world, preparation sometimes has no bearing on whether an accident will happen or not. This is when crisis management becomes important. It also forms a key element addressed in HROT, in particular why some organisations are able to recover from them so quick such as airlines (e.g. the Germanwings accident (Bureau d'Enuqetes et d'Analyses, 2016)) or ANSPs (e.g. the Überlingen accident (BFU, 2004)). These organisations are able to deal with a crisis in a way that does not risk the business with total failure.

According to Pauchant and Deville (1993), the concept of crisis is first found in Ancient Greece, where the word *krisis,* which meant *decision,* was used in Greek literature in reference to war and forced undesired decisions (Cawkwell, 2005). Modern philosophers such as Hegel, Nietzsche and Kant have used the concept of crisis to describe significant political and sociological challenges (Kant, 2016). Since then, crisis has been picked up in various areas of research. As noted by Pauchant and Deville (1993), who did a study across the variety of available crisis management literature in the 80s and early 90s, the concept of a crisis differs depending on which area it is applied to. This is of importance as the different definition of the same terms across various areas of scholarly debate is a common pattern in crisis literature.

In economics, the term is largely used for recessions, governmental deficits or very high unemployment (Brewer & O'Connor, 1988). In management theory, crisis is largely related to a potential or actual significant financial loss to a company (Blome & Schoenherr, 2011), whereas in safety management, where HRO is a large contributor, it is referred to as the situation appearing after an accident (Martorell, Soares, & Barnett, 2014; Sagan, 1995).

One of the key findings of Pauchant and Deville´s research is that across all crisis management literature

"crisis are disruptive situations affecting an organization or a given system as a whole and challenging previously held basic assumptions; they often require urgent and novel decisions and actions, leading potentially to a later restructuring of both the affected system and the basic assumptions made by the system's members" (Pauchant & Douville, 1993, pp. 45-46).

It is important for the purpose of this study to note that *High Reliability Organisations* is one of the identified key terms used in conjunction with crisis management literature, which might be used as evidence that HRO literature is part of crisis management literature. A highly reliable organisation is not only able to better prevent facing a crisis but also better able to recover from it (Weick & Sutcliffe, 2007).

In the area of crisis literature, HRO researchers such as Weick, Sutcliffe and Obstfeld (Weick, Sutcliffe, & Obstfeld, 1999) recognize HRO as a strategy for crisis intervention, which addresses the challenges of uncertainty and incomplete knowledge. This concept of preventing, addressing and recovering from a crisis is a common pattern in all crisis management literature. When Hermann (1963) discusses organisational behaviour in an organisation as a result of crisis, his concept of *viability* already demonstrates a method of preventing crisis. Furthermore, he identifies that a

"*crisis will be formulated along three dimensions. An organizational crisis*

(1) threatens high-priority values of the organization,

(2) presents a restricted amount of time in which a response can be made, and

(3) is unexpected and unanticipated by the organization" (Hermann, 1963, p. 64).

This is of particular significance within high reliability theory, as the same approach is picked up and addressed, which becomes increasingly obvious over the course of this literature review. A complementary view of crisis is found in political science, for example in addressing public sector crisis such a debt crisis or the refugee crisis, which Europe has experienced before the political systems attempted to recover from the crisis (Andeßner, Greiling, & Vogel, 2016).

Whilst it is true that the understanding of crisis varies across disciplines, some common threads remain apparent. Definitions of crisis all share the view that the disruption factors as a result of complex interactions within a given phenomenon that lead to an unwanted yet significantly negative outcome (Pauchant & Douville, 1993; Boin et al, 2005; Mikes, 2005). It is fair to state that the term crisis normally would relate to a situation of critical failure.

Another concept of crisis management is risk management (often referred to as safety management in high reliability environments) which complements crisis research in dealing with the likelihood (risk) of moving into a crisis. All approaches to crisis management have one key element

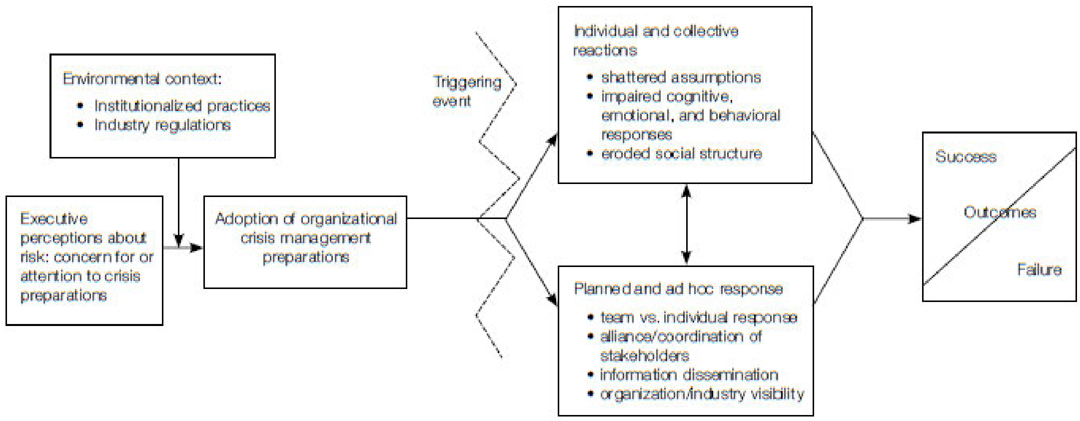

Figure 7: Crisis Management Process, Source: Boin, 2008, p. 11.

in common: crisis management is about dealing with a crisis and the return to normal operations.

According to Boin (2008) as shown in figure 7 above, crisis management must be understood as a process. Initially, an organisation needs to be prepared for eventual crises. Once a crisis occurs, the organisation must react to it, which then results in an outcome.

Risk as well as safety management look to the future and aim to prevent an adverse event from materialising or accepting that it would materialise as the organisation would be protected through alternate means i.e. insurance. Crisis management addresses the actual crisis and as such is a very reactive approach.

One of the most widely known crisis management concepts is the Lufthansa approach last deployed in 2015, when Germanwings flight 9525 was deliberately crashed into terrain by the captain flying at that time. The accident itself will be introduced in detail later in support of HRO understanding.

The Lufthansa crisis management showed an excellent performance in managing a major crisis of an organisation where the most important

aspect of its service - safety of operations - was at question and crisis management had to make sure that Lufthansa could recover from this accident without losing the trust and faith of its customer base.
Lufthansa deployed immediate, short term and medium term measures within less than two hours from the accident and managed to stay ahead of the game in maintaining control over most of the media coverage. They engaged with relatives and other affected people, while also gaining most of the air time on any broadcast on the matter (Schreiber, 2016). This event shows the importance of crisis management alongside risk and safety management, and highlights that regardless of how well prepared an entity might be, an accident can happen.
In summary, it can be convincingly stated that crisis management forms part of safety management. In the aviation industry, absence of safety can more easily lead to a catastrophic event, resulting in a crisis. An organisation within the aviation industry such as airlines or ANSPs require thorough crisis management processes as part of their standard operating principles more than other organisations.

2.2.5 The Importance of Incidents

With a solid understanding of risk, safety and crisis in a broader sense, this chapter will introduce the term *incident* and *accident* in the way that the aviation industry refers to them. It is of high importance to understand these terms against the backdrop of this industry, as it will increase understanding of why some principles within HROT are a certain way, and why the adoption of some principles may be more challenging in aviation than other industries.
The aviation system has the lowest accident rate of any transport system. Based on the 2017 European Aviation Safety Agency (EASA) report on aviation safety over the past ten years, there were only two recorded accidents within Europe (EASA, 2017). The annual safety report of the International Air Transport Association (IATA) states an average of 1.76 accidents per one million sectors of flight on a global scale between 2013 and 2017. This translates to roughly one accident per million flights with about 200 million flights in total in that period. The number of fatal aircraft accidents is even lower at 0.23 fatal accidents per million flights (IATA,

2018). Figure 8 below shows the number of air traffic fatalities worldwide from the years 2015 to 2019 (ICAO, 2020).

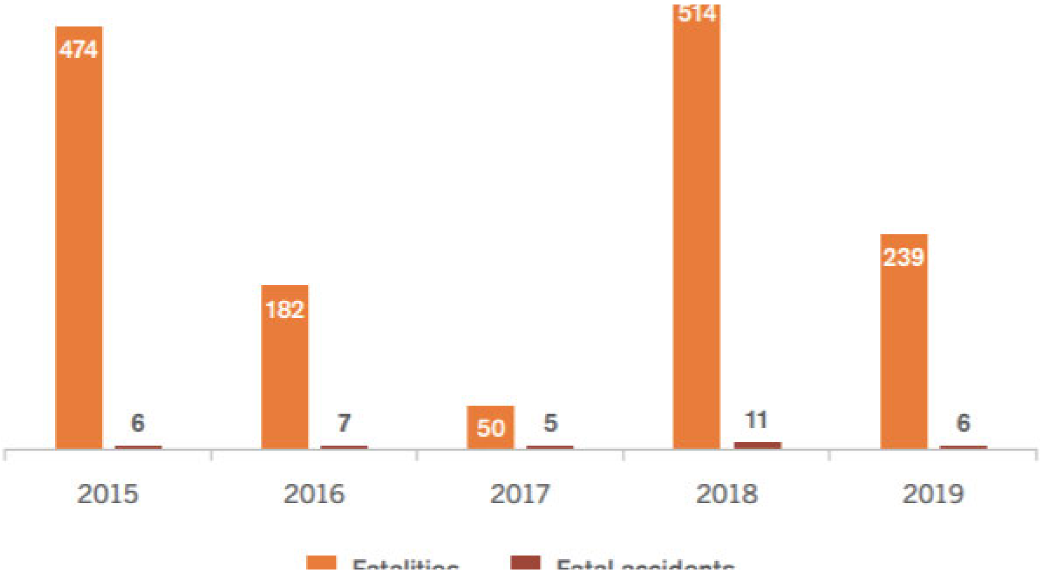

Figure 8: Number of Air Traffic Fatalities Worldwide, Source: ICAO, 2020

To set these numbers into context with road accidents, the total number of fatalities worldwide from aviation accidents was 287 in the year 2019, whereas the total number of fatalities from road accidents only in Europe was more than 25,000 (European Commission, 2018). It has not been possible to identify a specific definition on what accounts for a fatal injury as a result of an accident in the literature.

Risk management models define risk as the likelihood of occurrence and the consequence of it actually happening (Norrman & Jansson, 2004). But they place further emphasis on learning from failures of the system (Hampton, 2009), as do safety management approaches (Müller et al., 2014).

With such a low number of occurrences (accidents) across the whole aviation industry, the status of the system's safety could be questioned due to the lack of data available. Risk management is a largely statistical science and requires a relevant sample size in order to deliver relevant data (Anca, 2017). Normally, accidents would be the main object of investigation (Leveson, 2004). However, in industries with low accident rates, a different approach is required (Hollnagel, 2014).

To overcome that shortfall, safety science started to look at occurrences that didn't necessarily lead up to an accident but could have potentially done so: the so-called *incidents*. Incidents can be understood as "*an unexpected or unwanted change from the normal system behaviour, which causes or has the potential to cause a loss*" (Cooke & Rohleder, 2006, p. 214).

This concept allows for the investigation of occurrences, which have the potential to create a problem alongside the ones that actually led to an accident. The underlying assumption in this approach is that there must be many incidents or 'near misses', as they are referred to in some of the literature (Hollnagel, 2014) before any of the identified risks would occur. Within high reliability organisations theory, incidents are of particular importance as a part of what constitutes high reliability. But they are also key for these organisations as a whole, as they are identified to operate relatively error free in a demanding environment and recover quickly from failure (Weick & Sutcliffe, 2007). A relatively error-free organisation may have many risks and even risks with severe consequences, but a low likelihood of occurrence.

Combining the concept of risk (likelihood and consequence) with the concept of incidents (unexpected change from the normal status) leads to safety management systems. In order to avoid unlikely yet severe events from occurring, incidents need to be investigated as if they were to be accidents. In particular, high reliability relies on learning from incidents (S. Jordan, 2010; Müller et al., 2014; Ali, et al., 2015). In order to avoid or to mitigate low probability but severe risks, the incident investigation is the most critical part of the risk assessment process. The following chapter gives some information on how to differentiate between incidents and accidents.

2.2.6 **Incidents versus Accidents**

Whilst the distinction between incidents and accidents seems to be clear, there is some debate in the literature as to how these teams ought to be applied.

Going back to Cooke et al. (2006), their definition of incidents shows that an accident can be seen as a specific type of incident. Cooke and Rohleder state that

"*the commonly used term accident is an incident in which a non-trivial loss occurs*" (Cooke & Rohleder, 2006, p. 214).

Some literature shows the lack of a clear differentiation between these two terms. For example, when the Space shuttle Challenger exploded and seven crew members died on January 28th, 1986, it was mostly referred to as the *Challenger Accident* (Committee on Science and Technology, 1986; President's Commission, 1986). This would follow the accident definition provided by Cooke et al. (2006).

A casualty or the loss of a multi-million-dollar asset can be identified as a non-trivial loss. But the same event is also referred to as the *Challenger Incident* (Werhane, 1991). Hence, the terms *Accident* and *Incident* were used synonymously.

Perrow (1994) developed the Normal Accidents Theory (NAT) in the early 80s, where he investigated the Three Mile Island event. On March 28th, 1979, one of the reactors of the Three Mile Island Nuclear Power Plant near Harrisburg in the United States experienced a partial meltdown. It was the biggest nuclear accident ever at the time. According to Perrow, this event is classified as an *accident,* whereas researchers in the field of safety science refer to the same event also as an *incident*. When Le Coze discusses hazard prevention, he refers to the *Three Mile Island Incident* (Le Coze, 2015, p. 7). But also when Hoffman and Woods discuss macro-cognitive work systems, they use the same example in referring to it as an incident (Hoffman & Woods, 2011).

This study, as well as its surrounding academic current, defines an incident being a change from the norm and an accident being a change with a loss. This becomes obvious whenever the Three Mile Island event is referred to in HROT literature, as it is declared an *accident* (Shrivastava, Sonpar, & Pazzaglia, 2009; Werner, 2012).

As incidents and accidents form an important part of research into high reliability, the specifics of the aviation industry on these terms have to be taken into account.

The most influential organisation in terms of defining safety standards across the globe is the International Civil Aviation Organization (ICAO). ICAO provides standards and recommended practices (SARP) to its 192 Member States (as of September 2021) across the globe. These SARPs are used by the Member States to ensure their local regulations follow an international norm. Each member state has a Civil Aviation Authority (CAA), which has, amongst other tasks, the oversight on the governance and ensures the implementation of international standards in the member state. In the ICAO Annex 19, the requirements for safety management systems (SMS) are detailed, providing a list of definitions which apply to all Member States in the aviation industry. Of particular relevance is the definition of an incident, that is

"an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation." (ICAO, 2016a, p. 16).

Two points stand out from this definition. The ICAO as governor of aviation focuses safety on the operation of an aircraft. This is in itself ambiguous as the aviation industry has more participants than just aircraft, such as airports, airlines and air traffic control. An incident that may not affect the safe operation of an aircraft is not covered by the governance or not considered a (relevant) incident by the ICAO. Even within an airline that usually operates aircraft, relevant and irrelevant incidents may occur according to this definition.

This approach can be found in various regulations regarding the flight of an aircraft. For example, an urgent medical condition of a passenger is not considered an incident, nor would it result in any form of priority handling for the aircraft in flight.

The Civil Aviation Publication (CAP) 745 of the U.K. CAA states a medical emergency has

"no status in the U.K. and controllers are not required to give priority to aircraft" (CAA, 2003, p. 11).

A seriously sick passenger potentially suffering from a heart attack would not necessarily result in any form of priority handling of the flight. This is in line with the ICAO definition, as a sick passenger does not have an effect on the safe handling of an aircraft. Only if the nature of the medical emergency could affect the safe operation of an aircraft, which would be the case if one of the pilots would suffer from a medical condition, would this constitute a relevant incident. This would then be covered by the status 'emergency' of an aircraft, which is always declared, whenever there is *"a condition of being threatened by serious and/or imminent danger and of requiring immediate assistance"* (CAA, 2003, p. 11). A pilot no longer capable to operate an aircraft would result in imminent danger to the safe operation of an aircraft and therefore also be considered an incident or accident, depending on the outcome of the situation.

The second point, which stands out from the ICAO definition of an incident, is the term *safety*. Not only does an incident become irrelevant if it does not affect the operations of an aircraft, it only becomes relevant if it affects the safe operation of an aircraft. Annex 19 provides a definition of safety, which 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"* (ICAO, 2016a, p. 16).

This definition allows for further interpretation, which will be addressed later in the thesis in more detail. What is important at this stage is the clear link between incidents, safety as well as risk management with these two definitions. Safety management is a form of risk management and, particularly within the aviation industry, it is focussed on the operation of an aircraft.

ICAO also provides a definition of an accident. It has already been noted that an accident is a specific form of incident (Cooke & Rohleder, 2006; Khattak, Wang, & Zhang, 2012). The ICAO acknowledges this approach within the definition of an incident (ICAO, 2016a) and furthermore defines an accident as

"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 or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down, 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, except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; 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, except for engine failure or damage, when the damage is limited to a single engine, (including its cowlings or accessories), to propellers, wing tips, antennas, probes, vanes, tires, brakes, wheels, fairings, panels, landing gear doors, windscreens, the aircraft skin (such as small dents or puncture holes), or for minor damages to main rotor blades, tail rotor blades, landing gear, and those resulting from hail or bird strike (including holes in the radome); or*
- *the aircraft is missing or is completely inaccessible."* (ICAO, 2016 p. 15).

Another point stands out from this definition. An accident is usually related to a significant loss. Examples of this include the Three Mile Island Accident (Rogovin, 1979), the Challenger Accident (President's Commission, 1986) and the Air France Concorde accident, where on July 25th in 2000 the left engine of Air France Flight 4590 caught fire due to an object on the runway, resulting in the aircraft crashing only a few minutes later. All 109 people on board and four on the ground were killed in that accident (Ministere de L'Equipement des Transports, 2003). However, the ICAO definition only considers those on board an aircraft with the intention to fly as relevant. Only the last of the three examples would be considered an accident.

Following this definition, the event on June 11th of 2018 at Frankfurt airport, where a pushback vehicle caught fire whilst towing a Lufthansa Airbus A340 from one stand to another without resulting in an unrecoverable loss of the aircraft, is no more than an incident. Figure 9 below shows the emergency forces responding to the incident as photographed by the author of this thesis.

Figure 9: Incident at Frankfurt Airport, Source: Own Photography, 2018

To summarise the findings around incidents, it is important to state that an incident is the result of any unexpected and unwanted change from the normal system behaviour. Accidents are incidents which result in a loss. Incidents are of high relevance in the aviation industry as the number of accidents is too low to provide enough statistical data for aviation risk management. The ICAO mandates specific safety management requirements within the aviation industry, which focus on the operation of an aircraft rather than an organisation as a whole. Incidents are only relevant if they affect or may potentially affect the safe operation of an aircraft, whilst accidents are only relevant when they include people on board of the aircraft with the intention to fly. For the purpose of this research the definition of incident and accident according to ICAO will be used unless otherwise stated.

2.2.7 Summary of safety understanding and management

The previous chapter introduced a basic overview to safety and safety management including insights into crisis management and the importance of incidents in the aviation industry. It provided an outline of risk management principles, which are the foundations of safety management. The chapter also showed how safety management in the aviation industry is regulated by the highest authorities such as ICAO and EASA (within Europe). It introduced the concept of crisis management as the management of a situation, which occurs when attempts to avoid an unwanted event through risk and safety management fails and to recover back to normal operations. Finally it showed the importance of incidents in a safety environment with little data on accidents and the difficulty even in aviation related research to differentiate between the terms incident and accident. The next chapter will now further build on this knowledge and introduce high reliability organisations theory.

2.3 High Reliability understanding

This chapter will create an understanding of high reliability in the context of risk, safety and crisis management. It will show how this differs from previously discussed concepts, whilst at the same time complementing them.

There will be a discussion of two different streams in risk, safety and crisis management, which contributed to the development of high reliability theory, namely Disaster Incubation Theory (DIT) and Normal Accident theory (NAT).

The foundations of this area of research date back to Turner (1976), who was among the first to investigate the causes of disasters and how the terms incident and accident have been used across all risk and safety management related literature over time. This will also provide an overview on the understanding of disruptive events, alongside prevention methods and the concept of resilience. As this thesis is placed within *High Reliability Organisations Theory*, it is important to provide an overview of contributing literature. It will support the understanding of how risk, safety and resilience are incorporated in HROT, as well as the role of incidents and accidents.

With the information in this chapter, it will become clear that by following HROT, an organisation can create an environment that allows for operations with a very low accident rate. It will also show that incidents are a relevant part of the operation of business that help to maintain stability.

The issue is not so much an incident, as it is an example of how to deal with it so that it does not lead to an accident or make the organisation unable to continue to operate. HROs are able to provide this high level of resilience. It furthermore will show that HROT identified has certain elements that are critical in the external relationships of any HRO.

2.3.1 Disaster Incubation and Man-Made Disaster Theory

In his work on understanding causal chains resulting in disasters Turner (1976) supported risk and crisis management research at that time. The early stages of his Disaster Incubation Theory focus on a failure of foresight of or within an organisation. They contribute to their own failure through a number of factors, whilst *"rigidities in institutional beliefs, distracting decoy phenomena, neglect of outside complaints, multiple information-handling difficulties, exacerbation of the hazards by strangers, failure to comply with regulations, and a tendency to minimize emergent danger"* (Turner, 1976, p. 378) are the most common causes of failure. The name of the theory derives from the six-stage model of failure of foresight, which has been developed as the key concept of DIT. This model outlines several stages through which a crisis, a disaster or a catastrophic event evolves unnoticed over time and what happens during and after the inevitable event. Table 2 shows the stages as a brief summary.

The sequence of Events Associated with a Failure of Foresight	
Stage I	**Notionally normal starting point:** (a) Initial culturally accepted beliefs about the world and its hazards (b) Associated precautionary norms set out in laws, codes of practice, mores, and folkways.
Stage II	**Incubation period:** The accumulation of an unnoticed set of events which are at odds with the accepted beliefs about hazards and the norms for their avoidance.
Stage III	**Precipitating event:** Forces itself to the attention and transforms general perceptions of Stage II

Stage IV	**Onset**: The immediate consequences of the collapse of cultural precautions become apparent
Stage V	**Rescue and salvage - first stage adjustment:** The immediate post collapse situation is recognized in ad hoc adjustments which permit the work of rescue and salvage to be started.
Stage VI	**Full cultural readjustment:** An inquiry or assessment is carried out, and beliefs and precautionary norms are adjusted to fit the newly gained understanding of the world.

Table 2: The Six Stages of DIT, Source: Turner, 1976, p. 381.

In this model, Stage II is called the *incubation period,* where *"the accumulation of an unnoticed set of events which are at odds with the accepted beliefs about hazards and the norms of their avoidance"* (Turner, 1976, p. 379) takes place. In this crucial stage of an evolving disastrous event, the organisation faces occurrences which go against what would be accepted. However, they are either unnoticed due to lack of knowledge or a lack of understanding.

Ultimately, this leads to a critical event. Just as any adverse event ultimately changes the collective mindset, it also changes the view of the organisation. New rules and a cultural change take place, which reduce the risk of the same scenario happening again. Turner recognises that the pattern would then start over again and potentially repeat itself as the new culture and rules will face the same issues in a different way (Turner, 1976).

The DIT was the first theory to describe the pattern of escalation and de-escalation of a disruptive event over time and would prove to have a significant impact on crisis and risk management. The work laid the foundation for several other streams of academia, in particular the Normal Accidents Theory as well as High Reliability Theory, which have a close relationship to the DIT and also take on many elements of it. Later work by Turner (1994) further refined the concept and addressed the need for rigid management during the incubation period to avoid disasters. He also outlined the role and importance of management in all aspects of disasters and its role in high reliability. Turner states that any system failure and/or disaster would have a sociological and a technical side. Neither negative event would have solely one or the other aspect as a causal factor.

In order to address the issue and to avoid the incubation stage (stage 2) that would result in an unwanted event, Turner promotes a move towards a more open communication within the organisation as well as a high awareness of consequences or potential consequences of actions, with a particular view on management decisions (Turner, 1994). Pidgeon and O'Leary (2000) refer to DIT in order to support their work on failures in organisations and technology. They state that *"despite the best intentions of all involved, the objective of safely operating technological systems could be subverted by some very familiar and `normal' processes of organizational life"* (Pidgeon & O'Leary, 2000, p. 16),

which they refer to as the key message from man-made disaster theory (a theory synonymous with DIT). They conclude that DIT highlights the implication for any system of complex interactions between contributing parts or conditions. This will be of importance later in this literature review, when Perrow (2011) and his Normal Accident Theory is discussed in line with this particular strand of thought.

Furthermore, DIT also discusses a potential discrepancy between what occurs after an event and what should have been done, the importance of cultural understanding of the events leading up to the crisis or critical failure and required cultural learning. Tuner, along with other researchers who use DIT concepts in their work, provide an overview on how much influence the cultural beliefs have in what we say we do and what we actually do (Turner, 1994; Pidgeon, 1997; Pidgeon & O'Leary, 2000). Culture is a key area of understanding high reliability, as it shows the importance of governance and the actions of all members of an organisation under the guidance of management. The core concepts of the DIT model incubation, escalation and the cultural aspect were further developed by other researchers within safety and resilience literature. Park (2011) uses the DIT to investigate the influence of culture on society's safety performance, as well as Sagan (2004), who discusses normal accident theory in reference to the importance of the findings from DIT. This is manifested in cultural aspects and management involvement. DIT's chief contribution to crisis and high reliability understanding is that although there are strategies in place to constantly assess the operational performance, whenever there are highly complex structures or interactions part of an organisation, the likelihood of unintentionally harmful events is high. Scenarios in which events do not result in a catastrophe but in a near miss can be used as a learning experience for the organisation in the same way as an actual crisis. Any such event should serve the purpose of changing the crisis management for the better. Another of DIT's contributions to crisis and high reliability understanding studies is the fact that, regardless of the technology used in any socio-technical system, the human factor and ultimately the culture of any organisation will be the key element in reliability and resilience (Pidgeon & O'Leary, 2000).

2.3.2 Normal Accident Theory

The correlation of risk and complexity is a common theme in DIT. The more complex and coupled any socio-technical system is, the higher the risk of unwanted and unseen events becomes, which can end in catastrophe. This concept forms a core part of another element in the understanding of high reliability and is found in the literature on Normal Accidents Theory (Perrow, 2011). Perrow investigated the Three Miles Island accident and the Bhopal disaster in detail before publishing his Normal Accidents Theory, where he states that any organisation operating in a high-risk environment that requires complex technology is unable to reach accident-free operations.

The Three Miles Island Accident occurred on March 28th in 1979 at Three Mile Island Nuclear power plant near Harrisburg in the United States. One of the reactor units partially melted as a result of a cooling system failure. The catastrophe could have been prevented as it has the cooling system had been reinstated before the full meltdown of the reactor unit. Although the technology was not all new at that time (the first Nuclear Power Plant having been built in 1954 in Obninsk, Russia), Perrow argues that *"many processes are still not well understood, and the tolerances are frightfully small for some components"* (Perrow, 2011, p. 16).

The investigation report on the Accident by the President´s Commission concluded that two closed valves on the two pipes for the emergency cooling system blocked the water from circulating, leading to a failure of the emergency cooling system and the overheating and subsequent meltdown of the reactor (Rogovin, 1979). It had not been possible for the investigators to identify the cause for why the valves were closed in the first place. All that was revealed was that *"the Three Mile Island operators finally had to concede reluctantly that large valves do not close themselves, so someone must have goofed."* (Perrow, 2011, p. 19) and on the other hand “*three operators testified that is was a mystery to them how the valves had gotten closed, because they distinctly remembered opening them"* (Perrow, 2011, p. 19).
Perrow concludes that there is always a likelihood of failure. His research identified two major conditions, which make any complex, high risk organisation susceptible to failures. If an organisation is characterised by interactive complexity (unpredictable and invisible interactions inside the system) and tight couplings (interdependencies between the system´s components e.g. people, equipment or processes) while at the same time having a catastrophic potential, an unexpected event is a likely outcome, which leads to an uncontrollable and therefore unavoidable failure of the system (Perrow, 2011).
This is why he defines the two dimensions:

- Linearity-complexity and
- Coupling.

Whereas linear systems only lead to one single step, complex systems in fact lead to many steps and sometimes even circle back on themselves. Additionally, complex systems are somehow unpredictable regarding the occurrence of accidents. Systems also can be loosely coupled or tightly coupled. Whereas loosely coupled systems are generally ambiguous regarding their reaction to events, tightly coupled systems do not have this degree of slack. Figure 10 below shows the two dimensions according to Perrow (Perrow, 2011) with some examples.

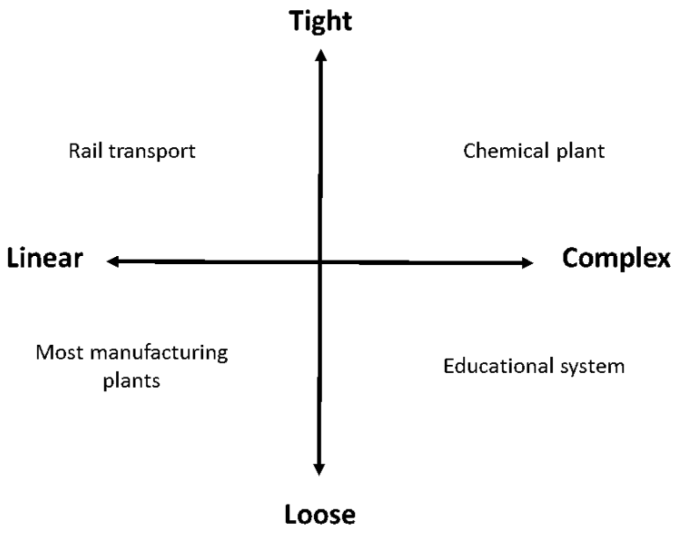

Figure 10: Perrow's Two Dimensions in Normal Accident Theory, Source: Innovation Garden, 2020

Both dimensions become very clear in the Three Mile Island Accident. The tight coupling on the technical side of the nuclear power plant comes into play when a closed valve results in a blocked pipe. Under normal operating conditions this is not required and would be inconsequential, but in the specific nature of an emergency situation it becomes vital. In that specific event, both valves were closed for unknown reasons, whereas only one closed valve would have had a significantly lower impact. As the main cooling system had failed due to a minor fault, the emergency cooling system was the only failsafe insurance left. Yet this had also failed (Rogovin, 1979; Ford, Mutic, & Bergendahl, 2012).

These two valves were not remotely monitored, hence why the maintenance record sheets showed them (wrongly) as open. This information was available to the operators in the control room, but they were not aware that it was false, hence why the decisions that could have made to avoid a disaster (which as this stage was avoidable) were not taken. In short, the wrong decisions were made because they were based on the wrong information. It could be argued that the wrong entry on the maintenance sheet was the root cause for the ensuing accident (Perrow, 2011).

The interactive complexity as the second main element in NAT can also be shown when using this example. The various interactive elements, which create a complexity that goes beyond what the human element of the system is able to confront, result in wrong decisions becoming the cause for an inevitable failure. This again goes back to the complex nature of the technology itself. No operator will be able to fully understand the system or technology they are using. A good example of this is modern mobile phones. Everyone knows how to operate a mobile phone, but only few know what technology is necessary for someone to move from A to B whilst making an uninterrupted phone call. In this example, Perrow states this as the

"*old war between operators and the equipment others have designed and built"* (Perrow, 2011, p. 19).

If something were to go wrong, both sides (operators as well as designers) would argue that it was not their fault. Yet the fact is something went wrong.

In summary, tight coupling in the sense of NAT is the level of mutual dependency of each component in a system, and the potential impact that one component's failure in a system can have on others (F. Wolf & Sampson, 2007). The system shows a complex interaction with the human ability to fully understand the system, and also their ability to predict interactions within the system. If both elements come together, it gives the operators fewer options or opportunities to take corrective actions, as most logical actions would have wider, unintended or sometimes undesirable consequences (F. Wolf & Sampson, 2007).

With the examples Perrow investigated, it is obvious that within catastrophic events, many different elements come into play. Of particular interest for this study is the point he makes about the involvement of interactions beyond the obvious system - namely contractors or governments and their policies - which contribute greatly to the complexity of systems. The NAT includes large parts of the DIT, in particular the difficulty in identifying the interactions in the incubation period. Contrary to DIT, the NAT no longer sees a risk mitigation potential in sound management decisions and operational learnings, but concludes that failures are inevitable in any tightly coupled and highly complex system (Perrow, 1994). This results in the NAT's approach to mitigating risks as reduction of complexity and to 'untighten' couplings.

It is described as transforming an organisation from complex to linear interactions and from tight to lose couplings. The key differences are shown in the following two tables 3 and 4.

Complex Systems	**Linear Systems**
Tight spacing of equipment	Equipment spread out
Proximate production steps	Segregated production steps
Many common-mode connections of components not in production sequence	Common-mode connections limited to power supply and environment
Limited isolation of failed components	Easy isolation of failed components
Personnel specialization limits awareness of interdependencies	Less personnel specialization
Limited substitution of supplies and materials	Extensive substitution of supplies and materials
Unfamiliar or unintended feedback loops	Few unfamiliar or unintended feedback loops
Many control parameters with potential interactions	Control parameters few, direct, and segregated
Indirect or inferential information sources	Direct, on-line information sources
Limited understanding of some processes (associated with transformation processes)	Extensive understanding of all processes (typically fabrication or assembly processes)

Table 3: Complex and Linear Systems, Source: Perrow, 1984, p. 88.

Tight coupling	**Loose coupling**
Delays in processing not possible	Processing delays possible
Invariant sequences	Order of sequences can be changed
Only one method to achieve goal	Alternative methods available
Little slack possible in supplies, equipment, personnel	Slack in resources possible
Buffers and redundancies are designed-in, deliberate	Buffers and redundancies fortuitously available
Substitutions of supplies, equipment, personnel limited and designed-in	Substitutions fortuitously available

Table 4: Tight and Lose Systems, Source: Perrow, 1984, p. 96.

The linear system Perrow describes is not a simple production line, as for example one might find at a car manufacturing plant. A Linear system has easy to follow dependencies and control mechanisms. A key element for linear systems is to have basic knowledge about the system available to the large scale and that all (human) elements of the system can handle most of the components within it.

The loose coupling according to Perrow require many ways to achieve the goal. To get an understanding of what this would mean, Perrow provides a more detailed insight into this and states four important elements of loosely coupled systems.

1. In such systems, *"delays are possible; processes can remain in a standby mode; partially finished products (tail assemblies or students) will not change much while waiting"* (Perrow, 2011, p. 93).

2. Loosely coupled systems allow more variance. For example, in a university study program, the order in which various grades are achieved is of less relevance, as long as all are achieved before the degree.

3. Loosely coupled systems can achieve the goal in many different ways. Perrow describes this as *"equifinality - many ways to skin the cat"* (Perrow, 2011, p. 94).
4. In such systems, slack is possible. It is acceptable to have a lower quality result at the end and it may even be wasted, but the overall process or system is not damaged by doing so.

In summary, NAT acknowledges the interdependencies between the human element and the technology, which have been introduced in DIT. Furthermore, it challenges the DIT view of proper management and handling as being able to mitigate risks in socio-technical systems, when it comes to tightly coupled and highly complex organisations such as nuclear power plants, petrochemical plants or air traffic control. NAT concludes that within any highly coupled system with complex interactions, a failure is inevitable regardless of the mitigation strategies. The only way to address these problems is to transform any such system into one with loosely coupled components of low complexity.

Other scientists within high reliability share this view and support it with further examples. Sagan (1995) in his research on close calls in the nuclear wing of the U.S. Military stresses the fact that complex interactions and tight coupling are even more critical in organisations where official safety goals are hampered by production pressures. In less tightly coupled and low complexity systems, this approach can ultimately lead to a catastrophic event. With this, Sagan introduces the economic pressure and external influence onto a system into the NAT. Clarke (1999) states that in the context of NAT with economic pressure introduced into the concept, confidence in disaster management should be scarce and planning will become more of a symbolic nature.

The main contribution of NAT to understanding of high reliability is the identification of the main problem areas in the quest for high reliability: tight coupling and interactive complexity. The more these two elements come into play, the more difficult is it to understand and subsequently mitigate potential risks. Building on the DIT, Perrow achieved a significant shake up in the literature around disaster management and a shift towards high reliability. While his research draws a rather one-sided picture on disasters and the way to avoid them, many scholars have picked up on his conclusions and quickly developed them further.

2.3.3 High Reliability Organisations Theory

One of the most important streams for this thesis and any understanding of high reliability is the key work that led to the High Reliability Organisation Theory. In the preceding chapters, discussion centred around building an understanding of the main underlying theories that ultimately led to the emergence of HROT. DIT noted that systems have a certain vulnerability and tendency to fail due to unnoticed, previously unconsidered events, which could create a significant disturbance. But also, even after an event, learning (although theoretically necessary) will not prevent future events from taking place. In particular, the management of any system takes a key role in this. Moreover, this thesis portrays the wider picture with NAT expanding this initial view; in particular against the background of highly complex and tightly coupled organisations with catastrophic potential. Within these, the particular nature of such organisations is bound to fail unless complexity and coupling is addressed to introduce a higher resilience.

Perrow´s NAT approach was challenged by several academics (Roberts K. H. & Bea, 2001; Rochlin, 1986) as being too narrow in its point of view. The critics around NAT centred on providing examples of organisations that operate in critical infrastructure or similar environments with a catastrophic potential, yet relatively error free over longer periods of time (Rochlin, 1986). Examples of such organisations are air traffic control, airlines, chemical industry or nuclear power plants and as such the same (or similar) as used by DIT or NAT.

Cummings (1984) argued that NAT is over-simplified so that *"humans are the victims of high-risk technologies and potentially catastrophic organizations, while systems (complexity and tight coupling) are the villains."* (Cummings, 1984, p. 1).

He challenges the theory as being shallow and not giving any guidance, which would on the one hand understand the nature of the problem that could or should be resolved or the suggestive nature of conclusions, which leave little room to grasp its essence. The Berkeley group, consisting of

Todd LaPorte, Gene Rochlin, and Karlene Roberts, raised the question of how some companies, although highly hazardous, are able to operate error free for a very long time and are still able to provide productive capacities (LaPorte & Consolini, 1991). Going to the beginning of this chapter, this is the major challenge to NAT. They were reluctant to existing approaches, for example the one described by Wildavsky (1988), who promotes a trial and error approach. Learning from mistakes as the only way to increase safety was not in line with what the Berkeley researchers thought.

As a result, this group investigated organisations with large-scale operating systems that perform at extraordinary levels of safety and productivity (Roberts K. H., 1990a) and world normally be bound to fail according to NAT. They published the results of their work in the book *Managing the Unexpected* (Weick & Sutcliffe, 2007). The title alone reads like a gentle nudge towards DIT and NAT, when at the same time it seems to answer the overarching question of the earlier two theories: *how will it be managed?* The book laid the foundation for high reliability organisation theory.

The Berkeley group focussed on similar organisations as Perrow did before, which allows for easy comparison to NAT. Of high relevance to this thesis is that NAT, as well as the Berkeley group, looked at air traffic control as a system but did not provide any further details on what the findings were.

The research of the Berkeley group concludes that, in opposition to NAT, accidents are not inevitable (Weick & Sutcliffe, 2007; Bea, 2008; Werner, 2012). As proof of this, examples of organisations that according to NAT should have failed or must fail are provided. A host of organisations are examined, ranging from air traffic control and aircraft carrier operations to nuclear or petrochemical plants. For a long time, none of these organisations showed any tendency to come close to a failure of their complex systems.

HROT does acknowledge the fact that there are some thriving organisations that seem to contradict NAT or DIT. Furthermore, HROT raises the question of what makes these organisations resistant to failure, or to use a term introduced earlier: *so resilient?* Weick and Sutcliffe (2007) state in the very first sentence in their book that *"unexpected events often audit our resilience"* (Weick & Sutcliffe, 2007, p. 1). With this initial statement, the key terms - also highly relevant for this project - are introduced: *unexpected events* and *resilience*. At the same time, throughout all the literature around HROT, organisational resilience against unexpected events is the nature of avoiding any failure. This key theme is also the one element that stands against DIT and NAT. To develop an understanding of resilience and high reliability, HROT investigates characteristics of such high reliable organisations in order to provide a deep understanding of how to avoid the likely failure (Roberts K. H. & Bea, 2001).

2.3.3.1 Principles of HROT

Having introduced the background and evolvement of HROT, the key principle within this theory must now be outlined, as it builds the basic theory against which the intended research will be tested. According to Roberts and Bea (2001), any organisation that can be classed a HRO shares three key principles. Those principles all together are not found in other organisations and therefore qualify to be an indicator when searching for HRO namely:

1. HROs aggressively seek to know what they do not know: any HRO has processes and people in place to conduct training, assessment of training outcomes and re-training of staff with the purpose of improving and maintaining the competence of any member of staff. A special focus is taken on special occurrence handling, for example how to deal with unexpected events. As part of it, incidents and near misses are continuously recorded and analysed to find potential errors in the system (Roberts & Bea, 2001).

2. HROs balance efficiency with reliability: Although HROs in the modern´ world are subject to economic pressures, the trade-off between reliability (in other words, safety) and efficiency is very

carefully assessed. The focus is to focus on quick wins for safety and aim for profit in long-term planning (Roberts & Bea, 2001).

3. HROs communicate the big picture to everyone: The last key factor for HROs is an internal communication, which allows everybody to report and to access results of reports at any time. At the same time, it is clearly communicated on how to behave during normal and abnormal situations. As an example, the hierarchy in HROs is different in normal operations than in emergency situations. In the latter, everybody is encouraged and allowed to intervene at any time, if the safety of operations might be affected (Roberts & Bea, 2001).

2.3.3.2 The Five Dimensions of HROT

The Berkeley Group further revealed five characteristics in organisations responsible for the high reliability of operations, namely

(1) *preoccupation with failure,*

(2) reluctance to simplification,

(3) sensitivity to operations,

(4) commitment to resilience and

(5) deference to expertise (Weick & Sutcliffe, 2011)

These characteristics are also referred to as the five dimensions of high reliability (Shrivastava et al., 2009). With every champion of crisis management planning, the problem of unexpected events is the biggest one, i.e., the problem of not being able to prepare for any kind of interference. Going back to the earlier introduced concept of incidents, it is fair to state that addressing incidents is the biggest challenge. Lee Clarke (1999), in his work *Mission Improbable,* quite clearly points out the difficulty in anticipating what would happen next. He goes as far as raising the question of whether any crisis management plans -in particular in complex organisations- are more than just serving the purpose of putting the employees minds at rest, as any plan will likely fall apart once it is tested (audited, to use the HROT phrase) (L. Clarke, 1999).

This stream of crisis management literature introduces the term *fantasy documents* (Birkland, 2009; L. Clarke, 1999; Rijpma, 2003) which is used for all documents, processes or procedures, which *"are generated to prove that some authoritative actor has 'done something' about a disaster"* (Birkland, 2009, p. 146). HROT takes this into account and acknowledges the challenges of investigating events such as the Cerro Grande wildland fire in the year 2000. A huge national forest area is located around the city of Los Alamos, near Santa Fe in New Mexico. Cerro Grande is a high plateau, where a controlled burn of woodland took place in order to reduce the risk of a great fire. The supposedly controlled burn got out of control within 24 hrs, due to unexpectedly high winds and dry conditions, turning into one of the biggest disasters in firefighting. It resulted in a 190 square km woodland fire that destroyed family homes and part of the Los Alamos National Laboratory (which at that time contained nuclear material). The estimated total economic damage was calculated at around one billion U.S. dollar (Johnson, 2001). When the event was reviewed against the principles of HROT, many traits of HROs were only partially followed or were entirely missing.

In order to further develop the understanding of high reliability, the five principles will be described in more details as these form the foundation of this area of research and is of high relevance to the project.

The five dimensions can be divided in two concept areas: anticipation and containment. Anticipation is the ability to predict an unexpected event based on small precursors. In DIT or NAT, it has been recognised that such events always precede a major incident or even accident. Within HROT, anticipation is used to identify and interpret such events and at the same time to imagine others that might happen (Weick & Sutcliffe, 2007). HROT concludes that in doing so, escalation is slowed down, which gives the organisation more time to apply the second concept: containment.

In these two main concepts, the relationship to DIT is clearly shown, with Stage II and III in the failure of foresight providing a similar approach. However, it is fair to say that whilst DIT states that these patterns do occur, HROT concludes that there are organisations who are mindful about these patterns and pro-actively address them rather than follow them up on a reactive basis. The second concept of HROT is to *"prevent unwanted outcomes after an unexpected event has occurred rather than to prevent the unexpected event itself"* (Weick & Sutcliffe, 2007, p. 65). The five characteristics are divided into the two chapters: anticipation and containment. The following table 5 shows how the five characteristics are split up in the two chapters:

Anticipation	**Containment**
Preoccupation with failure	Commitment to resilience
Reluctance to simplification	Deference to expertise
Sensitivity to operations	

Table 5: The Five Principles of HROT, Source: Weick & Sutcliffe, 2007, p. 65.

HROT argues that all successful HROs share these five characteristics, and knowledge about their importance forms part of their culture and processes.

When Weick and Sutcliffe (2007) investigated the Cerro Grande fire, they compared the HRO principles with the way this fire exercise was handled. Due to the catastrophic nature of the event, HRO was supposed to have failed.

As a result of their investigation, they found the main failure to be in the reaction to the early warning signs. Signs that something might go wrong were discernible at the very early stages of the Cerro Grande Fire but were either ignored or rejected by the responsible managers. It highlights the importance of incidents and the understanding of their potential, which is highly relevant for this study. In the following chapter, the five principles of HROT will be explained in detail.

1. Preoccupation with Failure

A HRO is careful in investigating failures. The assumption is that any mistake or failure is a potential crack in the system rather than an individual failure. It is in line with this approach to be mindful of any incidents. On March 25th, 2016, when Germanwings 9525 was deliberately crashed and all 150 people on board were killed, the event sent shockwaves through modern society. The pilot was dealing with significant psychological disorders and subsequently caused a catastrophe while committing suicide (Bureau d'Enuqetes et d'Analyses, 2016). The investigation report of the event shows early warning signs that highlighted the potential issue. The pilot in question had paused his training for 10 months due to medical reasons and during this period, his certificate of medical fitness for pilots (Class 1 Medical) has not been renewed due to depression and the medication taken to treat it. This was refused some months later, and only later was the medical certificate reinstated (with restrictions) a year later. The restrictions amounted to an annual check for medical fitness and a statement that the medical would be suspended immediately if his depression returned (Barreveld, 2016). The pilot in question had several short periods of sickness related absence in the time before he committed suicide.

All of these events happened over a longer period and could have potentially been known. The early warning signs by itself should have been dealt with by the HRO strongly but were not interpreted accordingly. The restriction in the medical to be re-assessed result in economic pressure for the person subject to it. A pilot is normally insured by a loss-of-license cover, which supports the pilot in case of a permanent loss of his certificate of medical fitness. In this instance, the restriction in the medical disqualifies a pilot from this insurance as the risk of losing the medical is too high. As pilots normally have to contribute a large amount of money to their training, the pilot in question was still in debt to the amount of 40.000 € (Bureau d'Enuqetes et d'Analyses, 2016). These different factors, taken together, help build up a picture of the root cause of the event.

According to HRO principles, early warning signs need to be treated as a potentially significant event and a likely systemic failure. The response to the signals in the Germanwings crash was weak (an annual medical check being the only significant response) but should have been strong (i.e. no medical, withdrawal from duties).

Hopkins (2007) describes the preoccupation with failures as a constant search for possible lapses in the system with the view they might be a precursor for larger unwanted events. He further stresses that in HRO this is primarily achieved through reporting systems for incidents and the investigation of even minor events against this principle. Young (2011) supports this approach in his investigation on failure in banks and bank systems. In particular, missing or ignoring weak early warning signs is the cause of failures. Reason (1997), with his Swiss-Cheese Model of accident-causation, as well as Rasmussen (1997), in his analysis of human error, follow the same approach and highlight the importance of understanding the impact of accumulating weak signals and their correlation to larger incidents or accidents.

2. **Reluctance to simplify**

"Knowing that the world they face is complex, unstable, unknowable, and unpredictable, HROs position themselves to see as much as possible" (Weick & Sutcliffe, 2007, p. 26). In accepting the importance to understand the wider implication of weak signals, the interpretation of this in HROs starts with the view that there is always a more to the story than at first glance. It also means that events, which have already been analysed and understood, are treated seriously to ensure they will never happen again. A HRO would question whether the past event was fully understood or if the new event only appears to be similar but is something more important. According to HRO theorists, it is of particular importance to treat every event as if it was a first instance and be reluctant to quickly put it to bed (Weick, 1987; Youngberg, 2004; Sutcliffe, 2010).

A burst of debris from the left stabiliser wing of the Challenger Shuttle only 80 seconds after lift-off was recognised by the ground team as a normal event without larger implications, as it has happened before and did not cause any problems (McDonald & Hansen, 2009). This time, it was the starting point of a catastrophe.

Reducing the complexity of a problem to increase manageability is a common method of addressing complicated and complex phenomena. Various approaches exist such as dimension reduction, which includes filtering and statistical methods (Spears, 1999), or pattern detection, which reduce unstructured data down to identifiable patterns (Holzinger, Popova, Peischl, & Ziefle, 2012; Valdeza & Braunera, 2015). All of them share the principle of reducing complexity by excluding various (supposedly) irrelevant factors for the problem-solving task. Within HRO, such an approach increases the risk of missing small incidents or ignoring early warning signs.

On April 10th, 2010, the Deep Water Horizon oil drilling plant exploded in the Gulf of Mexico and released 4.9 million barrels of oil (Graham et al., 2011). HRO researchers found evidence that one of the contributing factors was the misinterpretation of causal events (R. Roberts, Flin, & Cleland, 2015). It was further acknowledged by other investigators that the lack in understanding of individual events that led up to the event ultimately led to mismanagement and allowed the disaster to happen (HSE, 2009; Tang, Dawal, & Olugu, 2018).

Aven and Krohn (2014) describe the reluctance to simplify from HROT as one of the four important pillars of risk management. Aven (2016) further argues that it is fundamental for resilience in any system, even beyond HRO.

3. Sensitivity to operations

The third element of HROs deals with the management of the organisation. With this principle, Weick and Sutcliffe (2007) highlight the importance for any member of the organisation to understand how the system operates, even beyond their own area of responsibility. The front-line operators have a clear picture of other elements within their organisation and how they interact. With this, the likelihood of identifying an anomaly is hugely increased and the risk of missing an important small event becomes low.

HRO strive to provide important information to the whole organisation rather to keep it within silos (Hopkins, 1999). The background is that a *big picture* is barely achievable if the individual elements are withheld from the organisation as a whole. Young (2011) identified the silo-based approach, which is common in banks as a key element of the failure of such systems, acknowledging the HRO approach to strive to overcome silo-thinking in their organisations. Hoppes et al. (2014) describe the sensitivity to operations and the resulting reduction or removal of silo-based risk management as key success criteria for managing uncertainty in enterprise risk management processes. The particular benefit, which is identified in this work, is the potential to find risk families, which are risks that exist across different departments of an organisation, which can be mitigated more effectively if all information is shared across the organisation.

The U.S. Navy Seals operate so that every member of a team knows the full extent of not only the mission but also the roles, responsibilities and limits of the team members. Vogus et al. (2017) investigated a Navy Seals team and how they operate in order to compare their way of creating mindfulness against the HROT principles. With regards to sensitivity to operations, they were able to provide evidence about how important it is to share information amongst all members of the team. Only front-line operators (soldiers in the field or workers on site) have first-hand knowledge. This information needs to be placed in the organisation as it creates a better understanding of the overall situation, allowing every member of the system to contribute in order to increase resilience.

Going back once again to the Cerro Grande wildfire and putting this into the context of the third principle of HRO, this shows that if information, which had been available to the firemen site at the time, had been made available to the whole firefighting organisation, the likelihood of an earlier and better response would have increased. When the burn boss at Cerro Grande called his dispatcher for a fresh crew, the actual nature of the situation was not made clear enough and got lost in translation, allowing for a crucial delay in releasing more and fresh firefighters to the site (Johnson, 2001; Weick & Sutcliffe, 2007).

This concept has been supported by Hopkins (2007) with his investigation into highly reliable organisations. Front-line operators must be sensitive to the operations, but the same is true for the managers, who usually don’t have any first-hand knowledge and must rely upon the information that they are provided with. When a front-line operator speaks up, he needs to be confident that, regardless of what he might have to share, it does not fall back on him. Weick and Sutcliffe relate to this in stating that "*people who refuse to speak up out of fear enact a system that knows less than it needs to know to remain effective. People in HROs know that you can't develop a big picture of operations if the symptoms of those operations are withheld*" (Weick & Sutcliffe, 2007, p. 29).

Research in safety management, and particularly in aviation safety, refers to this as the *Just Culture.* It is a principle first mentioned by James Reason in his work on Human Errors (Reason, 2000) and subsequently adopted in aviation by Eurocontrol as a guiding principle for safety management and safety culture (European Organisation for the Safety of Air Navigation, 2006). Just Culture in aviation is defined as "*a safety culture as including: just reporting, learning, informed and flexible cultures*" (European Organisation for the Safety of Air Navigation, 2006, p. 11).

In his book on Just Culture, Sidney Dekker refers to it as finding a balance between accountability and safety (Dekker, 2007). It highlights the importance of learning from mistakes rather than blaming an individual who might have made one. A good example is an aircraft carrier operation at the USS Enterprise, as investigated by HRO researchers Roberts and Rousseau (1989). Anyone on board the carrier can stop all flight operations within seconds if it is deemed necessary for safety purposes. In their investigation, a stray bolt left on the airfield is used as a prime example for sensitivity to the operations. Such a small metal object by itself does no harm to an aircraft carrier. But it could cause a significant problem if it were sucked into a jet engine. During take-off, it might lead to a main engine stall, loss of thrust, and subsequently a hull loss. In order to mitigate this, not only can each member of the team stop deck operations if such an object is found, but so called foreign-object damage (FOD) walk downs are carried out several times a day (Weick & Sutcliffe, 2007).

When the Concorde accident in 2000 happened, the root cause was a metal object on the runway, which caused significant and unrecoverable damage to the airframe (Ministere de L'Equipement des Transports, 2003). A FOD walk down would have prevented this accident from happening. The object would have been found and removed from the runway before it could cause an accident. These walk downs are an important safety (and therefore risk management) process and a mandatory procedure several times a day at airports.

4. **Commitment to resilience**

The fourth principle of HROs occupies a larger area of contemporary research. Resilience is the ability to recover from failure or being able to continue operating after major incidents or when under continuous organisational stress. Weick and Sutcliffe define resilience as a "*combination of keeping errors small and of improvising workarounds that allow the system to keep functioning*" (Weick & Sutcliffe, 2007, p. 14). Steen and Aven (Steen & Aven, 2011) refer to resilience as the ability of a system to accept variability in performance, whilst at the same time reducing the negative variances to avoid unwanted outcomes.

A key point within HRO research, which acknowledges the findings of NAT as well as DIT, comes down to accepting the error as part of the organisation. HRO is not error-free. The difference between normal organisations and HRO is that an error, regardless of its magnitude, will not disable the organisation as a whole. In particular during a crisis or in the time shortly before a major incident, a system is stressed to its limits and beyond. A power grid is an example of a resilient system. Irrespective of where a failure in the system occurs, the key is to keep the breakdown isolated and prevent knock-on effects to the rest of the grid, as for example in overload scenarios. The system needs to be able to react on instantaneous events that affect performance (Lundberg & Johansson, 2015). A more common example occurs over Christmas, where electricity consumption peaks. Although this is a known event, situations like these may occur unforeseen and put stress onto the whole system.

Air traffic control is another example. The unpredictable factors in directing flights are primarily prevailing weather conditions and the variability of aircraft performance, which is again dependent to some extent on the weather conditions. The system in air traffic control is set up in a way that mitigates this variability and keeps the system stable during high demand and workload over extended periods (Lundberg & Johansson, 2015).

HROs plan for this, as they are aware of their systemic limits and allow for processes and procedures, which provide enough variability within themselves to maintain stable even under stress.
When Germanwings pilot Lubitz crashed his aircraft, there would have been time to enter the cockpit and address the situation. The cockpit entry system, which has been focussed around protecting the pilots from intruders from the cabin, prevented this. All possible ways to get into the cockpit did not take into account someone inside being unwilling to open the door. Either this or it has been considered, but nobody imagined that someone would prevent the door from opening (Barreveld, 2016). A resilient system aircraft-crew at this point could have had an alternative way to recover from this situation. This shows that any system or parts of it can have a failure. A resilient system will maintain stability and recover and HROs are not only aware of this fact, but focus on building their structure and culture in a way that guarantees this (Le Coze & Dupre, 2006).

5. Deference to Expertise

The fifth and final element that make up HROs is their deference to expertise. All organisational structures follow a certain hierarchy. A typical pyramid setup ranges from front-line workers - via lower and middle managers - up to a board of directors or similar body that makes the decisions. Considering the sensitivity to operations in HROs and the importance of sharing knowledge, it becomes apparent that also the decision-making needs to be placed with the element in the organisation that is able to make the right decision when required. Respect of a front-line worker’s expertise and knowledge by higher management will increase the resilience of an organisation (Weick, 1987; Weick & Roberts, 1993; Youngberg, 2004). A good example lies in the U.S. Navy SEAL operations. Each member of a SEAL team needs to have full understanding of the mission, as well as the various strengths and weaknesses of each team member. They need to rely on the contribution of every member of the team during a mission and to be considered of equal value, regardless of the organisational hierarchy (Vogus & Sutcliffe, 2017).

A less extreme example might be again the Cerro Grande wildfire case. The early warning signs which were observed by front-line fire fighters in the development of the disaster, for example in the unusually strong winds, were not taken into account by the designated decision makers (Weick & Sutcliffe, 2007). Some organisations have deference to expertise built into their organisational processes, like air traffic control, where the ultimate decision making that ensures the safety of air traffic is placed with the front-line air traffic controller. This is reflected in German law, which states that air traffic control is responsible for the separation of aircraft within the area of responsibility (BMVI, 2015). The regulation of ANSPs state that only someone holding an air traffic control license is allowed to perform air traffic control, which includes giving instructions to aircraft in the area of responsibility (DFS GmbH, 2018). In doing so, the German Air Navigation Service Provider prohibits direct influence by a manager without required expertise in operations, but at the same time it respects the expertise of the Air Traffic Control Officer, who is regarded by HROT as a front-line worker. Perrow (1994) describes it as *"at air traffic control centres supervisors and controllers may switch responsibilities when necessary and informal teams are often formed to trade advice and manage dangerous operations"* (Perrow, 1994, p. 214).

Apart from deferring decision making to ostensibly more experienced ranks, this element is also about changing the person that would lead the decision making based on the requirements of the situation. This is reflected in Praetorius and Hollnagel´s (2014) work on maritime traffic management with a focus on resilience and safety barriers. They identified a lack of longer-term planning in the system, which requires the controllers to be reactive. In identifying this as a downside of the system, they unintentionally highlight the importance of relying on the expertise of various input sources and the ability to trust one another depending on the situation, when they describe the modus operandi as *"the system's ability to monitor its own state and lay the groundwork to be able to anticipate* *and respond in good time"* (Praetorius & Hollnagel, 2014, p. 12). This describes the controller’s interaction and joint decision-making process.

2.3.3.3 Boundary of HROs

Adopting the five dimensions of HROT as part of an organisation’s structure will enable high reliability, but such a structure has limitations, or so called ‘boundaries’, that could result in a breakdown of the system. It is important to understand that eliminating errors and mistakes within HRO can only take place within certain limits, as outlined in this chapter. Organisational theorists such as Rasmussen (Rasmussen & Vicente, 1989), David D. Woods (Wears & Woods, 2007) or Richard Cook (Cook, 1998) view HROs as systems exposed to external influence factors. They identified the boundary of highly reliable organisations. Certain external influence factors are believed to be critical for HROs to retain their highly reliable nature.

Cooke and Rohleder (2006) describe how difficult it is to maintain the steady application HROT in an environment exposed to economic pressure. In a system, which has to balance safety versus productivity demands, economic pressure might lead to a higher pressure on the productivity demand. As a result, the pressure on the safety demand to lower the hurdles for certain activities becomes even higher. This could result in a vicious cycle, as there is a feedback loop between the two. An incident or accident, even if recovered, requires resources that would normally be available for production. The lower the standard, the higher the chance of a loss of productivity due to an incident.

Cooke (Cooke, 2003) uses the example of the Westray mine disaster, where an underground Methane explosion killed all 26 miners of a Nova Scotia coal mine in 1992. The accident investigation revealed that employees had been filing safety concerns. These were ignored not only by management, but also by government institutions. The main driver is described as productivity pressures and business requirements. The mining company could not recover from that accident and went bankrupt less than a year after the incident.

Although coal mines are not normally considered as high reliability organisations by nature, the safety nets of coal mines are set up in the same way as the HRO principles. This example is only one in literature that shows that HROT is relevant even far beyond the area of research of the theory itself. In order to create a highly resilient environment, the workforce is required to recover from any failure without external support in certain circumstances.

Important work has been presented by Nemeth et al. (2011), when they investigated patient safety against economic pressures and when such a system would be bound to fail. They identified three boundaries of such high reliable systems:

i) economic failure boundary,
ii) unacceptable workload boundary and
iii) acceptable performance boundary.

All these boundaries create a counter-gradient that leads to a current operating point. If this point were to cross any of these boundaries, the likelihood of a breakdown in the highly reliable system is significantly increased. Management normally puts pressure on the system to bring the operations as far as possible away from the economic failure boundary. At the same time, the workforce will try to find a way to sustainably deliver the required performance. These two forces will push the operating point over time towards the acceptable performance boundary. Figure 11 below shows a schematic overview of the principle. Between the acceptable performance boundary and the operating point, there is marginal boundary, which accounts for the error margin that an organisation allows itself. Crossing the marginal boundary would bring warning flags.

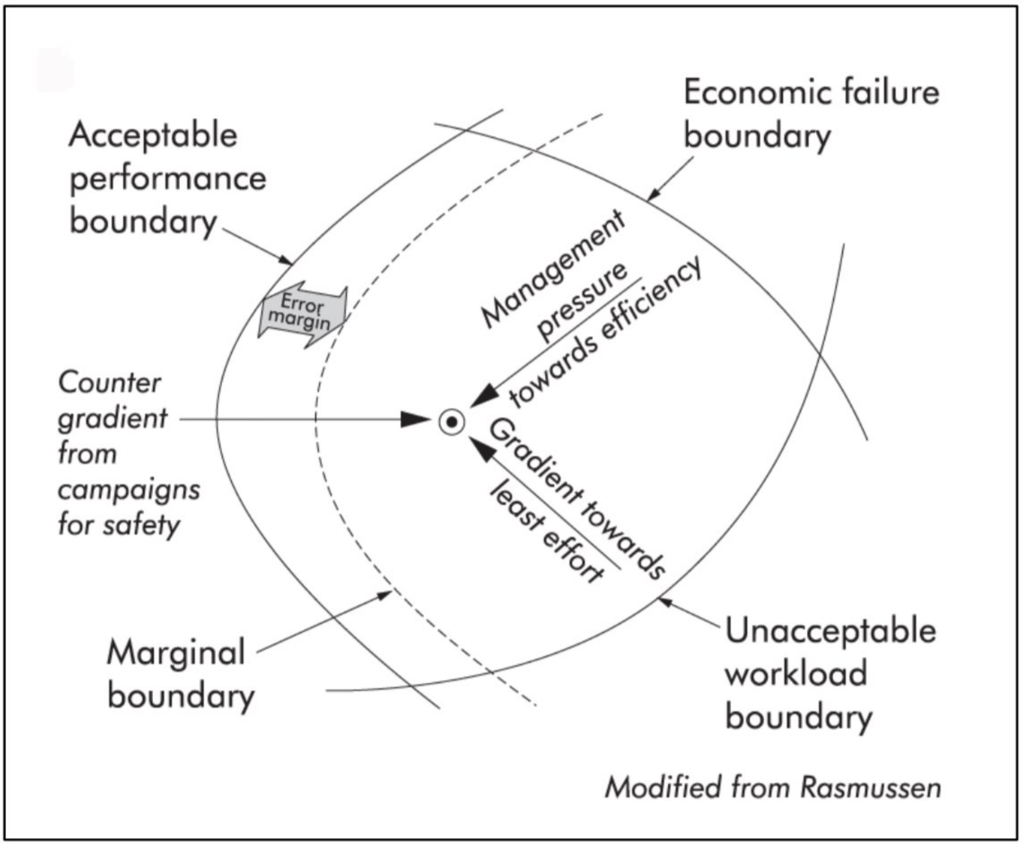

Figure 11: Boundaries of HROs, Source: Nemeth et al., 2011, p. 3.

In the context of HROT, the acceptable performance boundary is the point at which the principles of HROs can still be maintained and a recovery from failure is possible. Whilst HROs will constantly try to understand where their current point of operations is (principle 1), they will aim to allow enough flexibility in the system to deal with unwanted scenarios, which means that they would want to stay away from any boundary at a similar distance (principle 2). To achieve this, they would need to communicate and share relevant information from each of the boundaries within the organisation to inform a shared view of the system (principle 3). The risk in such a system is that the current point of operations is normally not known, even though HRO theorists like Cook argue that these organisations strive to understand where they might be. It is yet fair to state that the literature agrees that economic pressure on a system such as HRO, could result in the failure of it (Hollnagel, 2007; Morrow, 2016).

2.3.3.4 Limits of HROT

HROT is not free from criticism. Charles Perrow, even though his work is reflected, included and respected in HROT is at the same time one of its harshest critics. He points out the focus on the organisational structure as being too narrow. He further argues that an increased awareness within a system will not overcome technical shortfalls, although he acknowledges the importance of the structure itself (Perrow, 1994).

He also challenges the view of HROs as being able to tackle technological complexities though organisational learning and implementation. Perrow disagrees with this view and places emphasis on the complexity of modern technology. He also posits that a deep understanding of operations, which are privy to HROs in the sense of the theory, cannot be achieved (Perrow, 1994).

The initial work on high reliability - including one of the first publications on HROT in 1990 by Karleen Roberts - somewhat support Perrow's view. However, it also challenges it (Roberts K. H., 1990b). In this research, the findings from an investigation of elements of reliability on an aircraft carrier are presented. The difficulty in overcoming potential issues in complex and complicated systems is acknowledged by Roberts when she describes the various systems and their inability to communicate with each other. However, Roberts provides an overview of the strategies applied at her case that address this issue: *continuous training* and *redundancy within the system* (Roberts K. H., Stout, & Halpern, 1994).

Another challenge that HRO theorists have had to confront to is the question of how one can clearly identify an HRO. The discussion was initially started by the landmark work of Sagan (1995), in which he investigates the safety of nuclear weapons. In the book, Sagan refers to NAT as a negative theory that concludes accidents are inevitable, whereas HROT is a positive one that concludes that accidents are avoidable if the organisation is set up in the way HRO theorists identified. Roberts further states that one can identify HROs *"by answering the question, "how many times could this organization have failed resulting in catastrophic consequences that it did not?" If the answer is on the order of tens of thousands of times the organization is "high reliability""*(Roberts K. H., 1990b, p. 160).

This initial definition of high reliability is rather vague and underscores into a common problem in all areas of safety and high reliability topics, the lack of clear-cut definitions. It further provides evidence for the criticism of it being one-sided in its view. Hopkins (2007), who challenges NAT as well as HROT in his publications, highlights the problem with this method of describing HROs. It is impossible to know how many times something could have failed if it never has failed.

Marais et al. (2004a) also highlight the shortcomings in the definitions of HRO as well as accidents and accident rates. In particular, Roberts' definition is taken as an example that it could either result in almost any organisation having to shut down or any organisation being highly reliable. Many critics argue that HRO did use inappropriate examples in trying to define the elements of high reliability. Tightly coupled and complex interactions are difficult to delineate from normal operations as there is no definition of a normal operation (Sagan, 1995; Hopkins, 2007). Aircraft carriers, which are used as the prime example of high reliable operations, along with ATC can be seen as highly de-coupled systems. In air traffic control, the activities in one sector have little to no influence on the activity in another, hence why the argument of interactive complexity cannot be applied in such a system(Marais, Dulac, & Leveson, 2004). Aircraft carriers are more siloed operations as they are mostly independent from their environment (Sagan, 1995).

This would also be in line with the view of Marx (2017), who claims that there cannot be any organisation that is completely reliable. Marx states *"organizations will be reliable only around those things they value by putting in the time and resources to achieve an extraordinary level of reliability"* (Marx, 2017, p. 1). He supports his narrative with the example of baggage handling versus the maintenance of aircraft. Whilst mishandling luggage is widely accepted, losing a critical function of an aircraft isn't. He concludes that a fully highly reliable organisation cannot exist and that there are many such examples. Despite his disagreement, Marx concludes that every company can achieve high reliability in creating a system that supports this achievement (Marx, 2017).

Hopkins (2007) takes a similar line in his research about the problem of definitions in HROT. Roberts notes the extraordinary safety performance and resilience on nuclear aircraft carriers, which experience 1.93

accidents involving fatalities or significant damage per 100.000 flights (Roberts K. H., 1989). Hopkins states that these numbers do not serve as evidence as there is no definition of the term accident available in the aviation industry. Moreover, he argues that this results in a lack of comparative evidence. Hopkins concludes that "*these differing interpretations indicate just of difficult it is to use statistics to support any claim of "near accident free performance*"*"* (Hopkins, 2007, p. 4).
One problem with HROT seems to be the lack of definitions or comparable evidence across various organisations, which are meant to be highly reliable. Whilst it is fair to state that part of this seems to be in line with an issue across the aviation industry as a whole, the evidence provided by researchers like Hopkins (2007) and Marais et al. (2004) point out the same difficulties in other areas such as nuclear power plants. La Porte (1996) underscores the problem, a problem which remain unsolved to this day, stating *"no one knows what the population of HROs might be"* (La Porte, 1996, p. 69). He bases his statement on the limited number of cases investigated and at the same time (or as a result) only a limited number of types of organisations.
Although HRO principles have been noted by researchers of various fields over the past decade, such as Sidney Dekker (2013) who investigated the driving forces behind disasters, and Erik Hollnagel (2014), who confronted the issue of defining safety, a great deal more research is required to understand real life HROs. Researchers such as Richard Cook (1998), who investigated the failures in complex systems as a challenge to NAT, or David D. Woods and Richard Cook (1999) in their work on human errors within aviation, try to provide a better understanding of why HROs function as opposed to failing to do so. They also provide diverse evidence to support the presence of HRO principles in the known types of organisations, anomaly airlines, air traffic control, nuclear power plants and also to some extent in emergency care units at hospitals.
Bourrier (2011) has made an important contribution to this topic in her work *The Legacy of the Theory of High Reliability Organizations: An Ethnographic Endeavor.* She concludes that HROT has significantly contributed to the understanding of organisational design and a new focus

on complex organisations and what they do different compared to less complex ones. She stresses the point that little is known about the function of these organisations and that more needs to be done to reach an understanding of these organisations (Bourrier, 2011). This research project will significantly increase the understanding of these organisations, using a case that is recognised by all theorists in the field as HRO by its very nature: ATC.

2.3.4 Summary of HRO understanding

High reliability organisations theory is located in safety management and provides an approach to operating a company with a very low accident rate - also referred to as relatively error-free – in the application of certain principles throughout the organisation. These principles, also known as the five dimensions of high reliability, are found in certain industries or organisations, such as nuclear power plants, aircraft carriers or air traffic control. All of these organisations share extremely low accident rates and have proven over many years of service that they are able to prevent unwanted events in the main or are able to recover from an error in a very short time. This provides further input to risk and safety research, whilst the latter supports a better understanding of crisis management.
HROT primarily builds on disaster incubation theory and normal accident theory, which have emerged after accidents in modern technological systems, such when the Three Mile Islands (Hopkins, 2001) or the Challenger Accident (Vaughan & Rochlin, 1997) took place. Whilst the DIT and NAT primarily are of the view that a disaster is inevitable, HROT adopted some key principles of the two theories and further identified specific patterns in modern technology systems that can prevent disaster, provided the organisation is mindful of its own limitations. This led to the five dimensions of HROT

i) *preoccupation with failure,*
ii) *Reluctance to simplify,*
iii) *sensitive to operations,*
iv) *commitment to resilience and*
v) *deference to expertise* (Weick & Sutcliffe, 2007).

Although not free from limitations - such as potentially small samples or also the unwillingness of certain organisations to allow independent oversight - it has been adopted by the aviation industry and forms the basis of most recent views on aviation safety, as well as regulation and legal requirements (ICAO, 2000; 2016a).
These organisations are described as systems (Cook, 1998; Cooke & Rohleder, 2006) which have three main boundaries:

i) economic boundary,
ii) unacceptable workload boundary and
iii) acceptable performance boundary (safety).

Should any of these boundaries be crossed, the organisation would ultimately collapse. As the three boundaries create counter gradients, an operating point can be assumed, which HRO aims to understand and identify. Yet little is known about how to determine this point. However, it is agreed amongst HRO theorists that whilst HRO provides a better understanding of where the point might be, economic pressure can result in an HRO to collapse, which could be a catastrophe. More research is recommended to further understand the operation of such organisations (Bourrier, 2011) and their boundaries (Cooke, 2003).

2.4 Governance and Regulation of ATC in Europe

In the present chapter, the air traffic control sector and its governance will be outlined. Taking into account HROT and its definition regarding HRO within organisations, the air traffic services sector can also be defined as an HRO industry sector. At the same time, the European air navigation service providers are either state agencies (i.e. Greece and France), government owned organisations (i.e. Germany, Portugal) or as in the example of the U.K. a public/private partnership (Elias, 2017). There is no ANSP within Europe that would account for a fully privatised organisation. These two things together provide a sector within the aviation industry that is on the one hand under state control and on the other subject to regulation either through ICAO or within Europe as an example additionally through the economic regulation by the European Commission. Even in this age of proliferated air transport, there are still natural state protected monopolies within air traffic control.

Whilst the airlines industry is liberalised for many years and the service provision at an airport level, such as in the U.K. or Spain (Comendador, Valdes, & Perez-Sanz, 2011), is becoming more and more liberalised across Europe it does not hold true for ANSPs.
In Germany, the state owned ANSP must provide the air traffic services at any airport, which is recognised by the ministry for transport as being of public interest subject to §27 of the German Air Law (LuftVG, n.d.).
Such state protected monopolies affect the aviation industry as a whole, as political interests supersede economic requirements. The organisations (ANSPs) themselves are also highly restricted in their business decisions. Looking at the interactions between the partners within the aviation industry, vertical relationships between open market players like airlines and airports have been common since the opening of the market alongside deregulation started (Meyer & Menzies, 1999; Fu, Homsombat, & Oum, 2011; Noruzoliaee, Zou, & Zhang, 2015). However, a critical part of the industry, the management of the skies, is not made part of this approach so far. As such one could argue that due to the reluctance to open up ATC to an open market, the liberalised part of the industry is restricted in their freedom to operate in a sustainable manner.
Following a few unsuccessful privatisation attempts in Germany and the U.K., the European Commission, introduced economic regulation to improve the efficiency of the European ATM network (Elias, 2017).

2.4.1 Governance of ANSPs in Europe

Governance in aviation is still predominantly influenced by the events of 1919, when the Paris Convention set the scene for civil aviation (United Nations, 1919). As the airspace has been defined as a sovereign to a nation resulting in the requirements to implement rules and legislation around aviation by the undersigned states, it was natural that vertical governance structures have been adopted over the years. Vertical governance is a common governance structure particular on a governmental level (Kuronen & Caillaud, 2015). Since then, a lot has changed and has been further developed. The view of air transport as a state's sovereign right shifted towards it being a key driver for commercial success in an increasingly globalised world. Between the public and the private sector, the need for opening up air transport to the globe has been identified.

The aviation industry has been a victim of its own success. Air transport of goods and people has always been an sector of public and military interest (Dempsey & Gesell, 2004). Roughly ten years after the flight of the Wright brothers, the First World War broke out. This was also the year of the first ever commercial passenger flight from St. Petersburg, Florida to Tampa. World War I would prove to be a boost for the aviation technology. Aerial dominance was identified to be of significant importance in military conflict. Whoever dominated the sky was able to make a massive difference on the ground and as such, aviation was seen as a key element of a nation's military power.

This also fuelled the nature of aviation policy, which is still in place today. Shortly after WW I, the *Paris Convention on Aviation* in 1919 took place. It laid out the foundation of the structure of aviation in defining that every country *"has complete and exclusive sovereignty over the air space above its territory"* (United Nations, 1919, p. 1). With this brief statement, air transport was locked in behind the invisible barrier of borders on the ground. The second World War undermined this view with the dominance of the Nazi fighters, the first rocket attacks, the bomber squads of the Allied Forces and the newly developed jet engine. In WWII, a significant number of soldiers were carried over long distances in a short period, which was an entirely novel approach to passenger transport.

After WW II, airlines were seen as important national strategic devices that should be state-owned. Starting with the airlines, airports and aviation infrastructure, such as air traffic control came to be considered in a similar manner, which opposes the idea of a market and even free trade (Walulik, 2016). The view that boundaries on the ground would extend up in the air did not take into account the global nature of flying. It also shows the view back then of air travel being a domestic market industry rather than an international one. With that in mind, it is understandable that each state sets up all supporting infrastructure such as air traffic control in the same way but within its own area of responsibility. It became apparent in the post WWII era that air transport was a major driver of the world's economy and required a more globalised approach. From the moment a passenger arrived the airport until they had left security at their destination, the aviation value chain was under the control and vertical governance of a certain nation (Bailey, 2002; Moses & Savage, 1990).

Today's governance of the aviation industry has its origins at the end of WWII. On the 7th of December 1944, 52 countries signed the Convention for Civil Aviation. This created the International Civil Aviation Organization as supranational governance organisation (United Nations, 1944). This important event paved the way for bilateralism in air transport for over 100 countries at that time. In particular, article 6 introduced freedoms of the air, which regulated the way civil air traffic was allowed to fly over, through and within countries. However, the freedoms of the air seem to be a contradictory approach to any market environment. Article 6 stipulated that access to a consumer market (by the passengers) of a given state is owned by the government, who decides which non-national companies (airlines) are allowed to have access to the market. This, however, was in return for specific bilateral agreements that describe how much airlines from the own country were allowed to access the foreign passenger market. Lumbroso describes it quite accurately as

"*Air carriers became capacity and price takers within a market structure pre- determined by their respective governments. This would ensure carriers were financially viable, subject to occasional capital infusions from the national government and would create a duopoly with little competition"* (Lumbroso, 2019, p. 23).

Governance structures such as the ICAO have been described as multi-level governance. The European Union is the most prominent example of such a structure. Researchers in the systems theory in the 1970s, such as Fuchs (1973) and Mesarovic et al. (1972) were the first to describe complex horizontal and vertical relationships within a system. With the European Union, research on multi-level governance structures gathered momentum and such structures were more thoroughly investigated compared to before. A supranational entity takes over some power from sovereign countries (Huinink, 1989; Hooghe & Marks, 2001; Jordan, 2003).

Such a governance structure contains four main levels (Jordan, 2003), which will be explained in the following:

- ***Supranational level:***

This level sits within an overarching body. Such a body has been given the authority by the members to take binding decisions agreed by national legislation, which will apply to all members.
In an aviation context, there is an even higher authority, which is the ICAO as a supranational organisation for 52 European states (including the European Union Member States). ICAO has published various regulatory documents, which have been brought into national legislation. To date, 19 annexes have been published, of which the most important to the purposes of this thesis are

- Annex 11 *Air Traffic Services* (ICAO, 2002),
- Annex 13 *Accident Investigation* (ICAO, 2000) and
- Annex 19 *Safety Management* (ICAO, 2016a) notwithstanding the fact that all Annex`s have an effect on air traffic control.

Although ICAO sits on an almost supra-supranational level, it is important to highlight that, its publications do not apply to the European Union as a single entity, but to the members of ICAO. To date, all European Union Member States are at the same time ICAO members. This means there is no conflict of interest, but once the European Union would accept a member from outside the ICAO states, this might be a potential issue. The risk however is close to zero as to date any nation worldwide, which is participating in air transport is a member of ICAO. In this context is must also be mentioned that the European Commission is a supranational entity for all European Union Member States.

- ***National level:***

The government of an individual state resides at this level. Some of its sovereignty has been transferred to the supranational level, but the rest remains within the remit of the nation level. National interests have to be taken into account and brought in balance with the supranational level. In the context of aviation, the Minister of Transport of each state reflects the

national level. In the example of Germany, it would sit within the Federal Ministry of Transport and Digital Infrastructure (BMVI). But also national bodies, acting on behalf of the government of a sovereign state, are on this level.
In the aviation context, the National Aviation Authorities act on this level. In Germany, the Bundesaufsichtsamt für Flugsicherung (BAF) has been implemented for this purpose. The Aviation Accident investigation Board (AAiB) also sits at this level. In Germany, the Bundesstelle für Flugunfalluntersuchung (BFU) has the role of the AAiB and has been implemented alongside and independent to the BAF for the purpose of investigating accidents and serious incidents in an independent manner. The BFU is also a result of the Chicago Convention (United Nations, 1944). ICAO published Annex 19 on Safety Management, which prescribes the set-up of a national independent investigation board (ICAO, 2016a).

- ***Regional level:***

The third element are subnational governance bodies, which are empowered to act on behalf of the overarching body within a sovereign state (Hooghe & Marks, 1996; 2001). This level does not hold sovereign authority but advises the national level in policy making. In the aviation context there are few examples such as the regional representations of the CAA in the U.K..

- ***Transnational level:***

Various NGOs, institutions and bodies on a transnational level have been recognised as advisers and oversight agencies to support transparency and increase legitimacy across the multi-level governance structure. In the context of aviation safety, the European Aviation Safety Agency (EASA) is the most important entity, given the appropriate authority to harmonise regulatory processes across Europe, as well as to drive safety standards. For governance and policy making, EUROCONROL has been implemented as transnational entity and is at the same time the most important organisation on a European level for any air traffic control related regulation such as Single European Sky, which will be described into more details later in this chapter (Cogen, 2016). Table 6 provides an overview of the multi-level governance structure in aviation to show the vertical, top-down governance approach with specific examples for Air Traffic Control.

Governance Level	**Air Traffic Control**
Supranational	ICAO/European Commission
National	BMVI, BAF, AAiB, BFU, CAA
Regional	Regional representation of the CAA
Transnational	EASA

Table 6: Overview on multi-level governance in Europe and Air Traffic Control, Source: own table

Although there are many similarities and most entities apply for all players in the same way, air traffic control is still not privatised, nor does it act in an open market environment. Airlines and airports have developed vertical relationships in an open market and are exposed to economic pressure (Fuhr & Beckers, 2006; Fu et al., 2011; Burghouwt, 2013). However, the air traffic control industry or sector lacks market forces and governance structures remain the same as they have been since the early days of aviation. The multi-level governance structure of air traffic control within the European Union may appear to be beneficial, but it does come with some challenges. The economic aspect is subject to many research projects, such as Goodliffe (2002), who describes the economic benefits of public/private partnership structures in the U.K., and the U.S. Government Accountability Office (2005) that describes the potential benefits of privatisation in air traffic control for the U.S.

European legislation, adopted into state law in the European Union, is an example that highlights the difficulties of European legislation. One of the most important current European laws is EU 2015/340 (European Commission, 2015), which fundamentally changed the way air traffic control staff is licensed, trained and remains competent. In this document, which has been adopted by the European Union from ICAO, the language proficiency requirements for aviation personnel such as ATCOs is defined.

The background is an ICAO regulation to maintain a common standard for aviation language across the globe. In the aviation world, English and French are the two recognised languages (Note: French only used in France alongside English). EU 2015/340 defines that a language proficiency structure must be implemented by each member alongside a description of which levels will exist. Six ICAO language levels have been defined (1=lowest; 6=highest standard) and a minimum of level 4 has to be maintained for all personnel licensed to transmit on radio.
As a result, each nation was required to adopt this regulation into state law. Germany initially tested all aviation personnel to determine the baseline and developed guidelines and principles from that. France granted level 6 to all aviation personnel to start with and the U.K. only granted level 6 to U.K. passport holders (regardless of their background) while testing others. All of these approaches are in line with the legislation but still don't align. Multi-level governance structures in a system of sovereign states doe present some challenges. Legislation works differently in each country and reaching commonality is driven by political decision making rather than economic considerations or necessity. Also, the difference in legal interpretation of the wording is a challenge to achieve commonality.

2.4.2 **Deregulation and liberalisation in ATC**

The terms deregulation and liberalisation are not clearly defined in literature on aviation. Normally, deregulation as well as liberalisation would allow for competition on products and pricing. Although it has to be noted that even liberalised markets are often still subject to regulations such as for example the telecommunications market in Germany, which is liberalised yet still subject to major governmental regulation (Dewenter & Haucap, 2004).
In the aviation context these terms are often used synonymously as for example the three packages of (de-)regulation acts published by the EU between 1988 and 1993 to allow airline market liberalisation (Button, 2001).
Research sometimes uses the term liberalisation and sometimes deregulation when investigating the opening of markets and introducing

competition (Dewenter & Haucap, 2004). Considering the nature of the many regulations in place, which mostly restrict competition, it is understandable that the terms are not clearly delineated from each other within aviation. This might also be a possible cause for literature in the aviation environment to use these terms synonymously.

For the purpose of this study, the terms liberalisation and deregulation need to be seen synonymously as this is the most common approach within regulatory documents, which is mostly relevant to the ANSPs. It is also in line with the concept that within aviation in particular the ANSP environment is a highly regulated environment where the reduction of the restrictions would ultimately lead to more competition.

On a global level, the United States were one of the first countries to address the nation-bound governance culture in the aviation industry with a focus on airlines. Although airlines themselves have never been state owned in the United States (whereas in European countries the idea of a flag or national carrier was common), the regulatory framework around airlines has still been subject to regulation such as in ticket pricing or route assignments (Walulik, 2016).

Prior to the liberalisation in the U.S., the Civil Aeronautics Board (CAB) had the authority regulate the entire American airline market. New entrants, tariffs, mergers and agreements between existing airlines, to the extent of subsidising individual airlines, was within the power of this body. The underlying assumption was that adequate air transport coverage cannot be achieved by an open market as airlines would only fly to/from high revenue areas (Walulik, 2016).

The deregulation started with the Federal Aviation Act in 1958 (*Federal Aviation Act*, 1953), the Federal Aviation Agency (FAA) and nine years later, the National Transport Safety Board (NTSB) was introduced. Both agencies took over major parts of the CABs authorities. With the Airline Deregulation Act in 1978 (95th Congress of the United States of America, 1978), the U.S. government opened a new chapter in the aviation industry, which was soon picked up by other states across the globe. It also stated that the CAB would be dissolved in the short term, which happened in 1985.

Within the United States the new deregulation act handed over control of large parts of the value chain to the industry. Starting with airlines first, other parts of the value chain such as airports, airport security or ground handling followed suit over the ensuing years, with the view to increase performance and efficiency for the benefit of the passenger.

A key tenet of the idea was that safety would never be compromised. Regardless of whether it was for example owned by a government or a private enterprise, safety was of the highest interest to all stakeholders of the aviation value chain. It was challenged over the years by many researchers from various fields, with examples of compromised safety due to efficiency trade-off revealed (Moses & Savage, 1990; Gillen, 2006; Papatheodorou & Platis, 2007). Whenever decisions are made solely for the benefit of efficiency, the likelihood of mistakes potentially leading to an incident increases (Hollnagel, 2009).

Other countries followed this principle and the European Union deregulated the airline market in 1992 (Sichelschmidt & Wolf, 1993). Over time, several HROs underwent a change from being state owned towards being privately owned. Air traffic control still not transformed into a privatised organisations in almost every country in the world (one example for privatisation would be NavCanada, the Canadian ANSP) and the discussions around this topic have become quiet for some years. Mainly the difficulty from a legal and governance perspective that comes with deregulating the air traffic control market has thus far prevented large-scale success in that area.

2.4.3 **ANSP privatisation attempt in Germany**

The German ATC provider, DFS, was transformed from a state agency into a government-owned private entity in 1993. Since then, the company has been set up as an organisation 100% owned by the Federal Republic of Germany. There is little difference between a state agency and this form of ownership with regards to regulatory oversight or flexibility of the board of directors, as it still reports directly to the Ministry for Transport and Digital Infrastructure in Germany. This has been seen as inadequate for a long time but was prevented to be further developed by legal restrictions within Germany. In 2006, the German parliament sanctioned a new law, which would pave the way for a full privatisation of air traffic control in Germany. At the same time, it would have set a precedent for Europe at large.

As any law in Germany must pass several steps in the government and must be sanctioned by the parliament and the president, Horst Köhler, back then president of Germany, ultimately refused to sign the new law and set an end to this process. His decision was made public on 24th October 2006. He based his decision on concerns that this law would be against the German constitution which at that time prescribed any ATC provider to be a public entity. A public entity in Germany at that time was only allowed to be owned by the German Government (Köhler, 2006).

The situation today is somewhat different, as the German constitution has been amended to address the concerns raised at that time. The political magnitude of a German President refusing to sign a law has had a big impact in Germany, and up until today, there has not been any further attempt to push the privatisation in the government. This might also be due to the introduction of the economic regulation of air traffic control across Europe, which reduced the pressure to privatise.

To put the president´s decision into context, it is important to understand one potential major factor that might have influenced his decision: the accident over Überlingen, which happened on 1st July 2002. The final court decision was made public on the 27th of July 2006 so just about three months before he refused to sanction the new law. The court of Konstanz/Switzerland concluded that Germany was to be solely liable for the accident's compensation. The narrative given by the Swiss court was that the provision of air navigation services over German sovereign territory by a foreign country's ANSP was against the German constitution and air law. The law in Germany was based on the Paris Convention of 1919 (United Nations, 1919).

As an additional background it is important to understand what happened on that day, as it amounts to the most serious accident in European aviation history.

On the night of July 1st, 2002, a Bashkirian Tupolew passenger flight and a DHL Boeing 757 Cargo aircraft were cruising at the same height on collision course. The area was within German airspace whilst the provision of air traffic control was subcontracted to Sykguide in Switzerland. When the Swiss air traffic controller spotted the critical situation, he instructed avoiding action to the two aircraft, which were contradictory to the onboard anti-collision system advice. As one aircraft followed the instruction of the controller and the other aircraft followed the instructions of the on-board system, the two planes collided at 23:35:32 hrs, about 10,630 m above the area of Überlingen. The tail of the DHL plane cut the Tupolew in half and both aircraft disintegrated in the air (BFU, 2004). All 71 people on board of both aircraft died as a result of this crash. On the 24th of February, the responsible controller of the night, Peter Nielsen, was even murdered by Osseten Witali Kalojew, who lost his wife and his two children in the accident (Reuters, 2007). Various changes to the air traffic control system with regards to procedures and safety have been made after the accident. The political dimension of this accident was significant and still influences decision making today. The courts concluded that the legal environment in Germany does not allow for subcontracting of air traffic control to other ANSPs within the sovereign airspace of the Federal Republic of Germany in its format at the time. The provision of air traffic control services by Skyguide over German territory was concluded to breach existing law and as a result, the Federal Republic of Germany was solely responsible for any compensation (Bezirksgericht Bülach, 2008).

This case also brought an important element of air traffic control to the surface, which over the previous years has not been discussed: air traffic control as the sovereign task of the state. It is fair to question whether a sovereign task of a state can be subcontracted to a privately run organisation. During this literature review, no publication to has been found to clearly answer this question.

With this event and the decision of the German president, the privatisation within Germany that would have had the potential to be a landmark within Europe had come to a sudden stop and has not been picked up again to date. As identified, one possible cause might be the introduction of the economic regulation which -amongst other things- aims at reducing the cost of service of ANSPs and allow for some competition.

2.4.4 **Economic Regulation of ATC**

As highlighted in the previous chapters, the deregulation or full privatisation of air traffic control has to date failed to be successful in the European Union. Ultimately, governments were unwilling to agree to a full privatisation, whilst the ANSPs themselves were also not in line with the idea. In addition, more regulatory requirements above and beyond the economic regulation have been introduced such as the new EU regulation 2020/1234, which introduces a regulatory framework around Apron management services (European Commission, 2020).

It is also difficult to conclude whether air traffic control can still be considered a sovereign task of the government or not, which would be important for another discussion on liberalisation of air transport beyond the boundary of air traffic control. For example, the Department for Transport in the U.K. (DfT) consulted on the future of air transport in the EU, as well as in the U.K. itself. The report also discusses the ownership of NATS as an example of a public private partnership. It concludes that the structure of air traffic control will not change and that governance will remain with the government (Great Britain Department for Transport, 2003). On a European level, economic regulation of air traffic control has attempted to address the prevailing issues. It has been developed as an alternative governance approach to a full liberalisation as it avoids the difficult topic around sovereignty of airspace.

The concept of economic regulation in the European Union has been mentioned in the early stages of the foundation of Eurocontrol, with the SES program being initiated to increase efficiency of the air traffic management network across Europe. Subsequently is has been implemented on a European level. In 2004, the European Union published the commission regulation number 2096/2005 (European Commission, 2005). This has led to a so-called *performance management package*, introduced in 2009 as the SES Package II. Amongst other things, this regulation prescribed the introduction of a performance scheme for air navigation services and a five-year preparation and consultation period. In 2009, the concept was published within the SES II package, and as a

formal act the European Union published the commission regulation number 691/2010 (European Commission, 2010a).
This regulation mandated several measures to be implemented by each member state and to
provide an overview on the implementation of the performance scheme including continuous reporting of the key performance indicators (KPIs), the Performance Review Commission (PRC) has been tasked.
Four key features have been imposed to all European States by the European Commission, which will be outlined in more detail in the following chapters.

2.4.4.1 Implementation of a performance scheme

The implementation of the performance scheme aimed to set binding targets for the EU Member States. The targets were set to increase the efficiency of the European ATM network. For this purpose, key performance areas (KPAs) namely a) Safety, b) Capacity, c) Cost-Efficiency and d) Environment have been implemented (European Commission, 2019). The performance scheme is set up in different periods, which are called Reference Periods (RPs). The first RP was covering 2012-2014, the second one started 2015 and finished in 2019. The third one is currently in application and started 2020 to cover the years until 2024.
Due to the Covid-19 pandemic, the European Commission decided on a revised RP III. In November 2020 exceptional measures due to the Covid-19 pandemic (European Commission, 2020) that allowed the EU Member States to adapt to the challenges of the pandemic to alleviate the pandemic impact were published. They include (i) revised performance targets, (ii) work on a revised performance plan for the remainder of the RP III, to which the EU Member States were due to submit their recommendations by October, 1st 2021, (iii) revised KPI for the Cost-Efficiency KPA, (iv) revised unit rates and (v) implementation of additional monitoring and reporting on the measures to address the pandemic impact. Details on the RP III revisions have not yet been available at the time, the thesis has been finalised.

Each KPA of the performance scheme contains specific KPIs to be met by the Member States as outlined in table 7 below:

KPA	KPI (examples)
Safety	Effectiveness of safety management Risk severity classification following Risk Analysis Tool
Capacity	En-Route ATFM delay (Minutes per flight) Local targets for terminal
Cost-Efficiency	Unit rate (Average determined en-route unit cost) Local targets for terminal charges
Environment	Horizontal en-route flight-efficiency (% additional distance)

Table 7: SES Performance Scheme KPAs; own table

A more detailed view on the four KPAs will allow a better understanding of the specific targets.

a) Safety

With ATC´s most important target to maintain an optimum level of safety and to provide their service to all airspace users, this KPA is set out to focus on uniform safety standards and risk and safety management practices. The KPIs focus on the level of implementation of various measures rather than specific figures:

i) Safety policy and objectives;
ii) Safety risk management;
iii) Safety assurance;
iv) Safety promotion;
v) Safety culture (European Commission, 2019, p. 32).

b) Capacity

The capacity KPIs are setting targets on the average minutes of delay per flight attributable to air navigation services. In terms of which delay is caused by (=attributable to) ANSPs, the KPI definition states that *"all ATFM delay causes, excluding exceptional events"* (European Commission, 2019, p.33) shall be taken into account. (Note: examples for exceptional events are weather phenomena such as heavy thunderstorms or fog).

The calculation is made by the Network Manager and is the difference between the estimated take-off time (ETOT) and the calculated take-off time (CTOT) allocated by the Network Manager.

In this context it is important to indicate that the ETOT is a forecasted time upon which the aircraft will become airborne based on estimated off-block times (EOBT) or target off-block time for specific airports participating in the collaborative decision-making procedures (A-CDM) plus an estimated taxi-out time. This shows that the passenger experience in terms of a delay might be different as actual taxi times might vary or during congested hours at airports, the waiting time at the runway holding point before departure might be longer.

Figure 12 shows the average en-route ATFM delay (0.33 min in 2020) per flight covering the years 2015-2020 as per the report of the PRC:

Figure 12: Average en-route ATFM deay per flight; Source: PRR 2020

c) Cost-Efficiency

This KPI is based on the year-on-year change of the average Union-wide so-called determined unit cost (DUC) for en-route air navigation services. It is expressed in a percentage to reflect the annual variations, starting from a baseline value, calculated as laid down in the regulation.

Figure 13 below shows a comparison of unit costs between 2018 and 2019 as well as the actual unit costs in 2019:

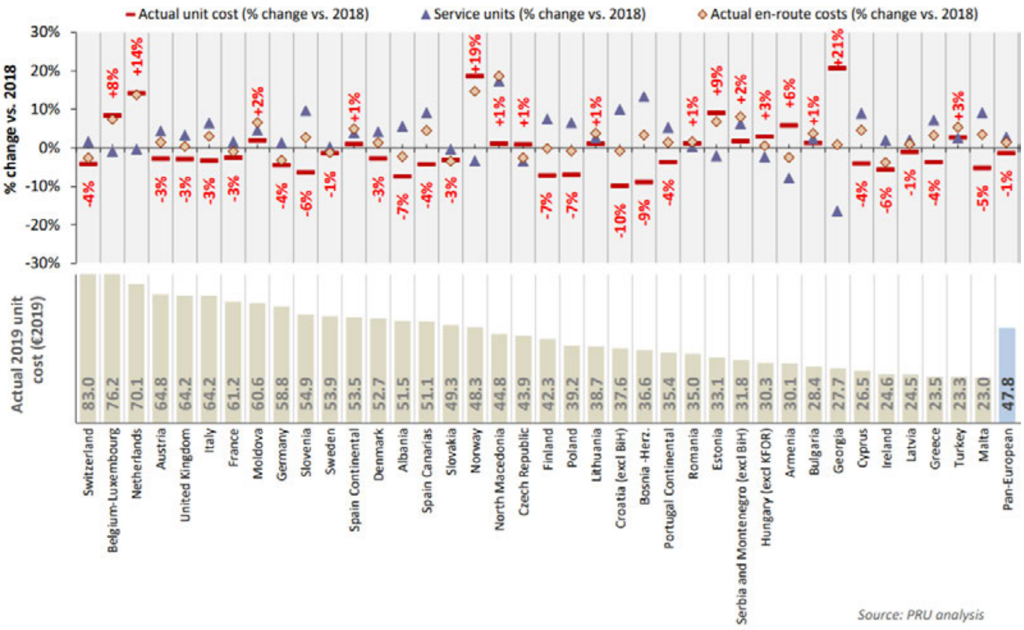

Figure 13: Actual Unit Costs en-route; Source: PRR 2020

It shows for example that the U.K. sits at 64.2€ which is fifth highest in Europe compared to 83.0€ in Switzerland, which is the highest value. The European average is reported to be at 47.8€.

d) Environment

The environment KPI refers to *"the average horizontal en-route flight efficiency of the actual trajectory"* (European Commission, 2019, p.32). The calculation is based on a comparison between the en-route part of a flight based on actual trajectory derived from surveillance data and the so-called achieved distance. The definition of the achieved distance reads that it *"is a function of the position of the entry and exit points of the flight into and out of each portion of airspace for all parts of the trajectory. Achieved distance represents the contribution that those points make to the great circle distance between origin and destination of the flight"* (European Commission, 2019, p. 32).
In simpler terms it can be understood as the difference between the shortest possible route through the various portions of airspace and the actual flown distance based on real surveillance data.
Figure 14 shows the 2020 en-route flight efficiency:

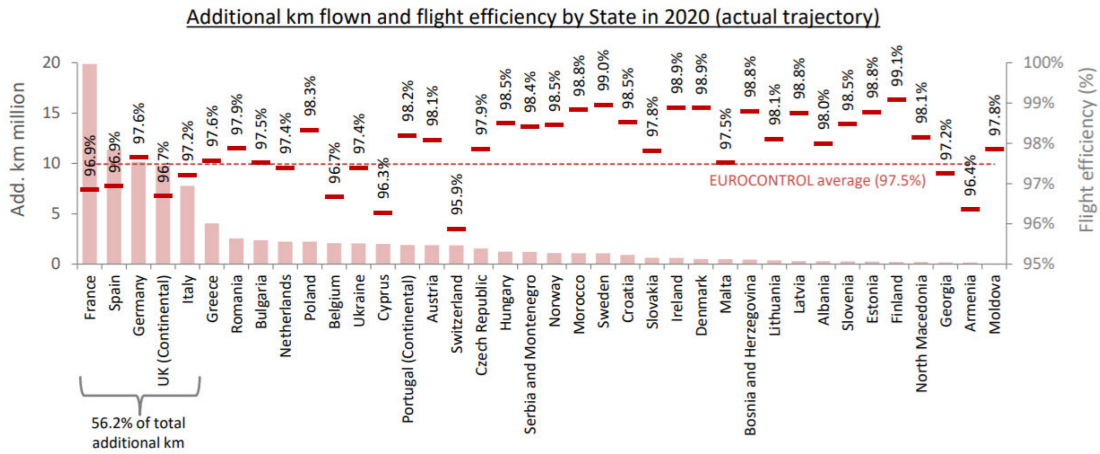

Figure 14: En-route flight efficency by State; Source: PRR 2020

2.4.4.2 Revised charging scheme

A new formula to calculate en-route and terminal charges for air navigation services has been implemented (European Commission, 2013b). The charging scheme aimed to support and complement the implementation of the performance scheme. It was set to contribute to an increased cost efficiency of air navigation services whilst maintaining an optimum level of safety (European Commission, 2019).

The charges are calculated based on the maximum takeoff weight (MTOW) of an aircraft, always assuming, it would be fully loaded at the time of departure. The so called en-route weight factor is calculated as $\sqrt{\frac{MTOW}{50}}$, which is then set to the power of 0,7. The formula results in a decreasing charge per ton with increasing MTOW of an aircraft (degressive tariff).

As larger aircraft normally carry more passengers than smaller ones, an aircraft that would be able to carry more passengers could be more beneficial for an airline than one with less seats in terms of costs per passenger (Castelli & Ranieri, 2007).

The revised charging scheme also aimed to bring it more in line with the ICAO principles and to reach commonality across Europe (U.S. Government Accountability Office, 2005).

2.4.4.3 Implementation of a European Network Manager

A central unit to manage the capacity and ATFM slots across Europe has been implemented. The network manager has the task to increase the efficiency of the of capacity provision. One major challenge of this body is again the nation-bound character of the market, as it still lacks all relevant information. Many countries have incompatible air traffic control systems, and it is still a work in progress to get all data into a central management system. Therefore, in 2017 Eurocontrol published the guidelines for data exchange in the European ANSP network (Eurocontrol, 2017) laying the foundation for more interoperability across all ANSPs within Europe.

2.4.4.4 Functional airspace blocks

To address the difficulty of sovereignty of the airspace, the European Commissions imposed Functional Airspace Blocks (FAB). Countries were required to combine their airspace to create cross-border airspace structures, where air traffic control is provided in a joint manner, allowing higher capacities and efficiencies.
An identified weakness of the European Airspace is its fragmentation into small blocks (sectors) and a structure, based on national boundaries rather than operational requirements. The FAB concept aims to overcome these restrictions in cooperative relationships between ANSPs to provide a more efficient service provision.
The categorization of FABs was developed, taking into account geographical criteria according to the European Commission (2011) resulting in nine FAB initiatives:

1. NEFAB (North European FAB): Estonia, Finland, Latvia, Norway.
2. Denmark-Sweden: Denmark, Sweden.
3. BALTIC FAB Poland, Lithuania.
4. FABEC (FAB Europe Central): France, Germany, Belgium, Netherlands, Luxembourg, and Switzerland.
5. FABCE (FAB Central Europe): Czech Republic, Slovak Republic, Austria, Hungary, Croatia, Slovenia, Bosnia and Herzegovina.
6. DANUBE Bulgaria, Romania.

7. BLUE MED Italy, Malta, Greece, Cyprus, (and Egypt, Tunisia, Albania, Jordan as observers).
8. U.K.-IRELAND FAB United Kingdom, Ireland.
9. SW FAB (South West FAB) Portugal, Spain.

To date, the FAB idea has not been entirely successful due to issues, primarily down to legal and governance problems (European Commission, 2011).
Denmark-Sweden as well as U.K.-IRELAND however, have been implemented in 2014 and also the Maastricht Upper Area Control Center (MUAC) is a showcase for a harmonised airspace within Europe showing progress in the implementation of the FAB concept. MUAC is a non-profit ANSP operated by Eurocontrol on behalf of Belgium, Germany, Luxembourg and the Netherlands and is the largest European cooperation in FAB level to date.
Whilst an even further extended coverage of upper European airspace could provide further benefits, it has some limits due to lacking political willingness to transfer the control of their airspace to another ANSP. A recent study by Deloitte for Eurocontrol (2021) also highlights issues in the concept of including an ANSP in a multi-state international organisation such as Eurocontrol. The requirements of an ANSP are according to this study contrary to the wider mission of the (Eurocontrol) Agency (Eurocontrol, 2021).
The Report Of The Wise Persons Group On The Future Of The Single European Sky (2019) even states that *"the FABs should no longer be mandatory"* (Wise Persons Group, 2019, p.16) as the evolvement of partnerships between ANSPs and digitalisation would allow for a different approach achieving the same goal, which the group refers to as *Digital European Sky*.

2.4.5 **Summary of Governance and Regulation**

Chapter 2.4. introduced the governance of ANSPs in Europe. It highlighted the difficulty in distinguishing between the terms deregulation and liberalisation within the aviation context as they are often used synonymously and need to be applied in this way within the context of this research. The chapter further provided insight on the problem of deregulation in an environment of sovereign governmental tasks and showed the example of the German attempt to privatise its national ANSP, which has come to a sudden halt, when the president refused to sanction the required legal change. Finally, it outlined the economic regulation in Europe, which has been introduced by the European Commission to set a framework with set targets in various KPAs to be achieved by the ANSPs of each EU Member State ultimately leading to improved service provision and cost reduction, whilst maintaining an optimum level of safety.

2.5 Summary of Part 1

Part 1 provided an overview on the literature in this area of research. It outlined the various elements relevant for conducting the study. The first part introduced ATM and ATC. It provided an overview and understanding of this thesis' academic context. The ANSP sector requires a specific approach to safety. Incidents and accidents are only one mistake away from happening. A careful focus on managing the operations is required for an organisation that has been created to support the aviation industry in maintaining safe operations.

The second part, chapter 2.2., introduced risk and safety management in general and specifically in the aviation industry. It has been shown that the aviation industry as a whole is one of an exceptional safety record with a very low accident rate compared to any other industries. Furthermore, it explained that in order to improve and develop the highest safety standards, such an industry can not only rely on learning from accidents but has to look for additional sources of data for the purpose of investigations. As such, the aviation industry focusses on indents that could have led up to an accident just as much as on the accidents themselves. Understanding why something almost went wrong will support risk mitigation strategies to maintain the accident rate at the lowest possible level.

In chapter 2.3., the theory supported by this research has been introduced. High reliability organisations theory -HROT- provides an understanding of how organisations are set up in an environment with extraordinary safety records, whilst at the same time delivering high performance in daily operations. Against the background of the aviation industry, Air Traffic Control has been (re-)introduced as a prime example for highly reliable operations and with the purpose of achieving, maintaining and improving safety as paramount goal. HROT literature describes three principles and five dimensions of high reliability, which are found in any HRO. Setting up the organisation with respect to these parameters will allow to contain errors within the system and maintain stable operations even with undesirable situations occurring. However, the chapter also introduced the limitations of such systems, which are primarily found in external sources that put pressure onto the organisation. The operating point of an HRO, which should always allow enough buffer to cope with economic and workload issues to avoid safety critical events, can be affected by significant economic pressure.

The final chapter 2.4. then introduced governance and governance changes in the aviation industry. Starting with an overview, it explained why the structures have been set up in such a way. It then outlined the deregulation and liberalisation and the difficulties in even delineating the terms.

The most recent development in air traffic control governance is the introduction of a European-wide performance regulation, which set out specific targets to be met by the ANSPs of each EU Member State. This approach is similar to what has already been applied to airlines and airports. Within the aviation industry, this represents a logical next step. The difference, however, is that in comparison to air traffic control, airlines and airports are not considered a state service provision to the extent ATC is.

Across the four chapters, the main areas that are subject to further investigation have been revealed. One is the problem of defining HROs, which has been raised in the HRO literature at various points. Second, the plea from HRO theorists to do further research regarding the understanding of HROs and how they operate. Third, the influence of market economic exposure on an HRO is incompletely understood and existing literature does not yet fill this gap. All of it against the initial understanding of ATM and its main purpose of providing safety above all.

The presented research project will support closing this gap. The research subject, a state-owned ANSP, is a HRO as per definition in literature. The industry sector of air traffic control is a perfect research area as it is at the beginning of liberalisation and the first steps have only recently been made. Any changes can now be identified in their early stages. The results will create new knowledge on how HROs operate and how their way of operations might change when liberalisation is introduced. It will help understand the question in literature of whether market economics will ultimately bring an HRO into imbalance, or whether the concept of a highly reliable organisation will also contain such forces.

Aviation has learned from accidents. It has learned from crisis to crisis and developed and pushed an unparalleled framework second to none when it comes to managing safety.

3 Part 2: Research Design

3.1 Introduction

Part 2 will now introduce the research design and theoretical framework whilst outlining the research questions and objectives that have been identified during the literature review.

3.2 Research Paradigm

A research paradigm is a set of assumptions about how the world interacts, shared amongst a group of scientists that do research on the world (Kuhn, 1996). With his definition of a paradigm, Kuhn (1996) provided a widely accepted view across all areas of research. Furthermore, a paradigm or the set of assumptions within a paradigm provide a framework for research or in other words the organised study of the world (Deshpande, 1983). Paradigms are, according to Kuhn, a crucial toolbox for any work of a scientist.
In social science, the field in which this research is located, Healy and Perry (2000) identify four paradigms, namely

1. positivism,
2. realism (post-positivism),
3. constructivism (interpretivism) and
4. critical theory.

One could view the paradigm as a distinct path of research whereas each path takes its own view on the ontology (*the reality that the researcher is about to investigate*), the epistemology (*the relationship between the reality and what is supposed to be investigated)* and the methodology (*the approach or tools used to investigate)* (Healy & Perry, 2000). The following table 8 provides an overview of the four different paths of research and their corresponding ontology, epistemology and methodology based on a comparison developed by Guba and Lincoln (1994):

Paradigm	Positivism	Post-Positivism	Interpretivism	Critical Theory
Ontology	**Naive Realism** Clear Cause/Effect relationships exist in the real world	**Critical Realism** Reality is imperfect by its nature. The focus in on exploring probabilistic tendencies	**Relativism** Reality of the world is independent from our cognition and does exist relative to context and time. Reality may change with knowledge	**Historical Realism** Reality is a construct of historical structures, which are perceived as reality in the absence of insight
Epistemology	**Objectivism** Objectivist assumptions exist that allow determination of how things work	**Subjective** Reality can be approximated but never 100% determined	**Subjectivism** Subjective view on knowledge that is created in the interaction between investigator and investigated	**Subjective** Knowledge is value mediated and value dependent. Many approaches lead to the same result
Methodology	**Quantitative** Experimental approach to verify hypothesis	**Mixed Methods** Modified experimental approach to falsify hypothesis	**Qualitative** Case Study, dialectic/hermeneutic approaches	**Qualitative** Reconstruction of previously held assumptions. Dialectic nature.

Table 8: Overview on the four different parts of Research, Source: own table based on Guba & Lincoln, 1994

The present study will be conducted within the interpretivist paradigm.

Nothing in the world exists without its relationship and dependence on other objects in the world (Crotty, 1998). There is always more than one truth in all and every aspect of the world. This research project adopts the position that reality is a construct, created through the interaction of individuals, where meaning is gained through a common understanding of knowledge, which is in line with the interpretivist position (Guba & Lincoln, 1994).

Given that, this study adopts the position of a relativist ontology, a subjectivist epistemology and a qualitative methodology to explore the difference between theory and practice in a case HRO. Interpretivism has its foundation in a work by Berger and Luckmann (1966), who described how reality is created amongst individuals in a social world. They state that *"knowledge is socially distributed and the mechanism of this distribution can be made the subject matter of a sociological discipline"* (Berger & Luckmann, 1966, p. 28).

In saying so, they adopt the position that knowledge is of subjective nature. Furthermore, they looked at various elements of social interaction such as assumptions or values that contribute to an individual's perception of reality.

Another key component of interpretivism is to understand that there are as many realities as participants in the world (Robson & McCartan, 2016) and furthermore

"that the task of the researcher is to understand the multiple social constructions of meaning and knowledge" (Robson & McCartan, 2016, p. 25).

In HROT, operational as well as cultural aspects within an HRO are interdependent and therefore cannot be investigated in isolation. Robson´s work is of value for the research as it supports the approach to investigate the application of HRO principles on various levels within the car organisation, but also on the same level across the two main organisational areas to fully understand the wider picture.

HROT research has shown evidence for an interpretivist approach as in the Challenger accident investigation (Vaughan & Rochlin, 1997) or in organisational research, which has been based upon HROT principles (Roberts K. H. & Libuser, 1993), but also more recently in the investigation of high reliability of highway maintenance (Busby & Iszatt-White, 2014). The foundations of HROT by the Berkeley group have been based upon the interpretivist approach, but as it was important to further gain a deeper understanding of existing knowledge, empirical investigation through observation was primarily applied in the field (Babbie, 2009).

With regards to the research problem, applying the interpretivist approach allows for the exploration and development of an understanding based on the experience of the individuals that are actually part of the organisation subject to research. Applying interpretivist principles allows us to investigate how the shared social understanding of individuals and groups within an organisation is developed and influenced. It allows us to gain specific knowledge, as well as which elements and factors are important to the various members of the organisation and how they influence their behaviour against the HRO principles. In particular, the difference in understanding between the business and the operational area will show the distinct ways in which individuals in their social environment interact with their environment and how they are affected in different ways by the same factor.

Investigating the phenomenon will also facilitate conclusions on how the organisation feels that high reliability functions or does not function within the organisation they are part of. This is another aspect that interpretivist research will allow to be revealed (Guba & Lincoln, 1994). Therefore, the next step is to choose an appropriate data collection method, which is described in the following chapter.

3.3 Research Question and Objectives

The High Reliability Organisations Theory identifies five key principles for any high reliability organisation. Furthermore, HROT provides examples of such organisations, which have been defined during the work of the HRO researchers, namely air traffic control or nuclear power plants. So far, little is known on the current operational point of such an organisation. Even the organisation itself might not accurately know the distinction between an incident or accident but could only define this in hindsight. It has been possible to identify some of the most significant external influence factors on the HRO principles from literature. These mostly lead to economic pressure that might move the operating point into the undesirable areas. Within the highly regulated framework of aviation, governance and economic regulation was identified as significant factor.

Alongside this, when highly reliable organisations were investigated, the research took place in the operations such as investigating how a nuclear power plant operates or how an air traffic control centre provides the air traffic control service.

There has been no evidence from literature as to how a (highly reliable) organisation as a whole is or isn't operating according to the HRO principles. HROT does not differentiate between the operational and operational areas of the organisations as such. This leaves the question for this research to answer as:

"To what extent do highly reliable organisations apply HROT principles in daily organisational practice across the two essential business functions Operations *and* Operational Support *against the influence of external influencing factors, especially regulation?"*

Given that these principles should in theory be followed, it can be hypothesised that they are applied to a high degree. This question is particularly pertinent given that Bourrier (2011) identified a dearth of knowledge about HROs and stated that more needs to be done to understand them. Given that the theory explored in the literature review indicates that HROT came about for the specific purpose of avoiding failure (Roberts K. H. & Bea, 2001), addressing this research question could also potentially reveal insights that directly relate to the extent to which HROs are able to harness a set of principles that could contribute to their resilience. As previously stated, such resilience is fostered via learning from incidents (S. Jordan, 2010; Müller et al., 2014; Ali et al., 2015), which HROT emphasises (Weick & Sutcliffe, 2007). In order to address the research question, the research project will focus on three main objectives that will build the narrative to close the gap in the literature:

1. Determine the extent to which the case company complies with high reliability principles
2. Determine the level of integration of the five dimensions of high reliability in the different business areas of the case company
3. Explore the factors that account for any identified difference between theory and practice

A specific methodology is needed to answer the research questions. The following chapter provides information on how to achieve the research objectives.

3.4 Selection of Data Collection Method

Because data can be seen as the basis for scientific work, this data must initially be collected in a scientific manner. The aim of the following chapter is to provide an overview on the method that is expected to be best for the present research project. For this reason, the advantages and disadvantages as well as the main applications of quantitative and qualitative methods will be explained shortly. At the end of this chapter, the suitable method for the present project will be selected based on theoretical explanations.

For example, the aim of quantitative survey methods is to represent matters numerically. Reality is seen as objective and can be comprehended by the help of controlled methods. A specific behaviour can be explained as precise as possible and can be predicted by identification of relationships and by models. For this purpose, numerical data is being used (Burzan, 2008). The deductive approach used in quantitative methods collects data in a theory-driven manner, with this data required to meet the quality criteria of validity, objectivity and reliability. Generated data thus serves to check theories and/or hypothesis, which have been defined in advance (Döring & Bortz, 2015). In general, one uses statistical key figures such as correlation coefficients and average values (Rasch, Friese, Hofmann, & Naumann, 2014). Generated data can also be evaluated by variances and likelihood of occurrence, by stochastic procedures such as significance tests or by the help of multivariate statistics like for instance factor and cluster analysis

(Burzan, 2008). Quantitative survey methods offer a huge variety of different possibilities, for instance questionnaires, experiments, content analysis, observations and quantitative interviews. Surveys can be conducted in person, via phone, writing, or by the help of the internet (Kühl, Strodtholz, & Taffertshofer, 2009).

The use of quantitative methods will provide the necessary numerical foundations for answering the study's research question, given that it asks about the extent of compliance and that the research looks at the level of integration of these principles within the case company's various business areas, and these are quantifiable characteristics. Without quantitative data, these goals would rely solely on expert opinions and qualitative methods, which would arguably be insufficient at answering the research question to a satisfactory degree.

Advantages of quantitative methods can be seen in the possibility to identify statistical correlations due to the use of precisely quantified results. In addition to that, the above listed methods allow for the analysis of very large and thus representative samples. Generated results are of high comparability and high objectivity (Berger-Grabner, 2016). The disadvantages of quantitative methods are a relatively low flexibility and the fact that these kinds of investigations cannot determine the causes of specific attitudes or findings – at least, the focus is on testing whether the generated results match the theory or not. For this reason, quantitative methods do not lead to improvements (Berger-Grabner, 2016). In addition to this, quantitative methods often are criticised due to their high degree of standardisation. In many cases, these methods cannot focus in on each attendee. All participants receive the same questions, but no one can guarantee that all participants interpret these questions identically. Of course, this point of criticism does not count for all of the above listed quantitative methods. Experiments, content analysis or behavioural observations can thus be better tailored to the participants.

Having gone through quantitative methods, the qualitative methods will be explained presently. In contrast to quantitative methods, qualitative methods try to explain reality by subjective views. The goal is to understand the causes of specific behaviours. The main object of qualitative research is people; for this reason, qualitative research can be seen as strongly related to subjects. Potential distortions through rigid assumptions and standardised instruments can be avoided by the direct access to people. The personal interview is a good example for such a direct access to people (Berger-Grabner, 2016).

The holistic approach is one of the main characteristics of qualitative survey methods. It includes all surveys, which are conducted in familiar environment to the participants. As a result, distortions can be minimised (Lauth, 2010). Qualitative methods are of high flexibility and great openness. Due this high flexibility, they can respond accordingly to unpredictable and unknown aspects (Lauth et al., 2008). The evaluation of generated data typically is done through interpretative means, due to the high subjectivity. In contrast to quantitative methods, qualitative ones are designed to be explorative and hypothesis-generating. Similar to quantitative methods, there is a huge variety of different types, for instance the qualitative interview, which is controlled and designed by the interviewing person (Döring & Bortz, 2015). In this way, deep insights into specific topics can be gained.

According to Denzin and Lincoln, qualitative research is an "*interpretive, naturalistic approach to the world*" (Denzin & Lincoln, 2005, p. 3). It is a scientific approach to make sense way individuals view their world.

From this view, qualitative research can be seen as a design that incorporates various interpretive methods that aim to get a better understanding of a specific subject matter. However, it is always understood and acknowledged that every individual has a different view on how to make sense of the world (Denzin & Lincoln, 2005).

In comparison to quantitative research, qualitative research does not seek to produce numbers or test theory from objective facts. In fact, in the interpretivist paradigm that this research is located in, the term *fact* is a controversial one, as the key element is that there is no single truth and no single fact. 1+1 does not always equals 2 but can be 3, depending on the mathematical theory applied (Bell, 2001). Quantitative research relies on the assumption that anything can be clearly defined. Any object, any truth is singular and finite. Hence, the qualitative research does allow multiple truths and perspectives, which all are of equal relevance in building reality. Another notable difference between quantitative and qualitative research is the sample size. Diving into the qualitative sphere requires large samples for relevance. Qualitative research aims for depth rather than breadth in research and aims for smaller samples that are investigated into more details (Gerring, 2007). Denzin and Lincoln (Denzin & Lincoln, 2005) describe the qualitative researcher as a *Bricoleur*. With that term they refer to someone who combines various methods that are suitable to make sense of the world and would even invent new tools and methods, should it become necessary.

Qualitative data collection methods are of vital importance in answering this project's research questions. Primarily, they will provide an insight into the differences in how HROT principles are applied in the real world versus in theory. This requires description as opposed to simply numerical values, and as such would not be possible via purely quantitative methods. Qualitative approaches will allow for a greater freedom among respondents to communicate the nuances of the case company's behaviour, nuances which are harder to express through the use of quantitative methods alone. As a result, the combination of both quantitative and qualitative methods is vital in answering this study's research questions.

Due to the flexibility of the qualitative approach as opposed to a quantitative, it is well suited to circumstances that require a deep understanding of specific phenomenon, such as the one in this research. Zikmund (2009) describes qualitative methods as the tools of a mechanic. It requires specific tools that deepen nature of the problem. The less specific the objectives are, the less descriptive they are, and the more likely it is qualitative research methods will be appropriate (Zikmund & Babin, 2009).

To summarise, qualitative research is more suitable to describe a complex phenomenon (Denzin & Lincoln, 2005) with complex and dynamic interactions (Guba & Lincoln, 1994), such as the one encountered by HRO researchers in the early stages of NAT (Perrow, 2011) or when HRO phenomena are investigated, such as Medeiros et. al. (2009) who investigated risk management in banks through the lens of HROT. Roberts and Bea (2001) specifically state that in HRO, interviews and surveys are applied for organisational use, which leads to the conclusion that investigating HRO will apply the same methods.

In more general terms, the main advantage of qualitative methods is their flexibility. Due to the high degree of openness, completely new matters can be discovered. Backgrounds can be investigated better, whereas uncertainties can be eliminated quickly. The content-related validity is thus very high, because the open interviewing allows generating of deep information contents.

On the other hand, qualitative methods often are more cost - and time - consuming than quantitative ones. In addition, the requirements regarding the qualifications of the researcher as for example when conducting interviews are very high due to the increased interactions with participants. Even with regards to data evaluation, the provided instruments and methods are designed relatively elaborately. Furthermore, critics point out the lack of objectivity in qualitative data. The interpretation of qualitative data is far from controllable, with the sample generally not representative and the whole approach far too time-consuming. In this context, Saldern (2007) states that qualitative approaches are nothing more than an excessive burden for practitioners. In addition to this, they lack theoretical underpinning to a great extent. With regards to the present research project, the user must face the challenge of choosing the right application of quantitative and qualitative methods. The focus is on the question of which method can be seen as most suitable for the present research project.

Due to the previously explained characteristics of the quantitative and qualitative data collection methods, as well as the present paper’s objectives, the present paper uses both the qualitative as well as the quantitative approaches. The quantitative method can answer the research questions, whilst descriptive statistics can be used. The present research project analyses a relatively large sample, which is only possible through a quantitative method. Additionally, the deep knowledge and experience of some experts can only be gathered by the qualitative method.

This research applies documentary analysis, surveys and semi-structured interviews to explore the understanding and level of integration of HROT principles into the case company with a focus on how external factors such as economic regulation influences the level of integration. The decision to use both quantitative and qualitative approaches for this study provides a solid foundation to the research. This mixed methods process aims to build on the strengths of each approach while minimising their respective weaknesses. The use of the quantitative method will balance potentially subjective data with a numerical analysis in order to uncover any relationships and general patterns in the research. Because this method is driven by objectivity, its use in this study will facilitate a mathematical line of inquiry that greatly reduces the danger of researcher bias.

The qualitative research element will add a rich layer of context to the quantitative research process. Without this complimentary method, it would be impossible to adequately answer the research questions posed at the beginning of this study. The mixed method not only facilitates this study’s ability to answer the foundational questions, but it also provides a viable method of achieving these aims by constraining costs with the smaller qualitative research sample required.

3.5 Case Design

High reliability organisations are complex systems that incorporate a wide range of technology. ANSPs are HROs operate in a challenging environment due to the high reliability aspect but also due to the political and economic framework. As highlighted in the literature review, HROs and the influence from their environment on the core principles has had limited academic research to date. Much of the developments in this area were instigated by the industry itself (in particular the ANSP landscape) and on a political level. It has followed the approaches that have been applied to other organisations in the same business sector, such as airlines or airports. Although some researchers such as Papatheodorou and Platis (2007) raise specific concerns in their research about the importance of influences on HROs from external influence factors, there is a lot more to investigate. Research in this area needs to carefully reflect the importance of the topic and choose a research design that is able to capture the details of a phenomenon over which the researcher has no direct control (Yin, 2003).

In the context of this research, the specifics in air traffic control are of relevance. An ANSP provides an interesting context to investigate such a phenomenon as it is one of the few industries, which to date is still primarily operating as a monopoly. Therefore, the variables that can have an economic influence on a single organisation are limited to mainly governmental bodies. In addition, ANSPs are required to own all aspects of their complex infrastructure, which is considered to be a state's critical infrastructure.

The vast majority of the day-to-day business of ANSPs is handled through operational staff, which is subject to a wide range of complex regulations on a local, governmental and international level, applicable to all other ANSPs in the same way. This regulation framework does not take into account any economic aspects and supports the HRO nature of the organisation. In contrast, any European ANSP is also subject to economic regulation, which is independent from HROT and has a direct influence on all aspects of an ANSP, not just the operational side. Moreover, the unique staff situation of an ANSP is noteworthy, as half of the staff operates in the regulated operational area of the organisation, whilst the other half operates in the business area.

All of this presents an interesting and challenging environment, where the trade-off between efficiency to satisfy economic regulations and safety to maintain HRO principles is of a unique nature. Based on the nature of the phenomenon and the qualitative approach, the researcher considered several qualitative designs such as case study, grounded theory and narrative inquiry strategy. The following chapters thus give some general information on the case study and the level of analysis.

3.5.1 **Case Study Design**

The use of case studies as research approach has been applied by many scientists and will also be the approach used in the present thesis. In the field of HROT, a deep understanding of organisational structures, culture and interactions is required to create a deep understanding of the phenomenon under investigation (Schneider & Grofman, 2006). To gain such a knowledge of individuals or groups of individuals, a single case approach will serve as the most appropriate methodology. A case approach focuses on understanding the dynamics and relationships within a determined setting (Yin, 2003). A case study approach has also been used by the Berkeley group on work surrounding the Gerro Grand Fire, the Davis-Besse nuclear power plant, and the Federal Aviation Administration enroot air traffic control in Fremont, California (Weick & Sutcliffe, 2007). More recent work has also focused on an individual case as i.e. Highway maintenance (Busby & Iszatt-White, 2014).

Following the existing research in the field, a single case study will be conducted in this thesis. The chosen case is an illustrative of a high reliable organisation as per the definition of HROT (Busby & Iszatt-White, 2014), which is at the same time exposed to market dynamics. This will allow an in-depth exploration of the deeper relationships within the various functions of such an organisation. However, there are some notable disadvantages associated with case study research. A case study provides penetrating insight and returns answers that remain relevant to the sample, but it is possible that the case itself may not be representative of the broader population. As such the results cannot always be safely extrapolated and applied to other firms or nations (Yin, 2003). There is also the potential for samples within the case study to contain a bias which will skew the results. Moreover, expressions of these biases may be impacted by political issues within the firm, with the case study format making it difficult to distinguish between fact and opinion (Yin, 2003). However, many of the issues examined in this study draw upon standardised aspects of ATC instead of company policies and definitions, meaning that the potential for a non-representative sample is minimised. The possibility of political influence must not be fully ignored, but this issue can be mitigated by an appropriate choice of methodology. Furthermore, the selection of a large and respected organisation with a high level of transparency may also minimise this impact; this is demonstrated in the current study with the case study selection.

The German air navigation service provider, Deutsche Flugsicherung GmbH, will serve as the case study for this research. The case company has been chosen purposively by the researcher as he is an employee of a subsidiary company, affording access to required security clearances in site access, documents and employees without the requirement of obtaining specific access rights, which may otherwise not have been granted. Access to the required organisation to serve as a case study is the biggest difficulty, as HROs are high security organisations because of the critical nature of their tasks, such as air traffic control or a nuclear power plant (Weick & Sutcliffe, 2007).

The study utilises the single embedded case study approach of the Deutsche Flugsicherung (DFS) Group as an organisation. Qualitative methods will be applied to provide detailed and in-depth findings on the research problem and to create knowledge and understanding of the phenomenon subject to investigation.

In the applied single embedded case study, the DFS-Group acts as the overarching case with the three distinct ANSP functions that the DFS Group has. These are: German ATC for area and international airports (DFS GmbH); German ATC for regional and small airports (DAS GmbH); and U.K. ATC for Gatwick and Edinburgh Airport (ANS Ltd.).

Case studies are a research approach to investigate *how* or *why* questions, when the researcher has little control over the case but also when the phenomenon subject to investigation is in a real-life context (involving people in their real life environment) (Yin, 2003). Yin describes three conditions that define the type of research strategy to be used: "[…] *(a) the type of research question posed, (b) the extent of control an investigator has over actual behavioural events, and (c) the degree of focus on contemporary as opposed to historical events"* (Yin, 2003, p. 5).

In the present research, the question is of a *how* nature, exploring the extent of the integration of HRO principles into the case and how this is influenced by the external factor of economic pressure through regulation. There is no direct control from the researcher over the case and/or phenomenon and the research is about a contemporary phenomenon. With this, all three conditions of the most appropriate case studies are met. Gerring (2007) provides some examples in his definition, when he states that case study *"[…] is an inquiry that focuses on describing, understanding, predicting, and/or controlling the individual (i.e., process, animal, person, household,* ***organization, group, industry****, culture, or nationality)"* (Gerring, 2007, p. 16).

The highlighted terms are of particular relevance for this research, as it is about an organisation, hence why the case study is an appropriate approach. Furthermore, this research will provide an in-depth insight into the phenomenon. Gerring (2007) refers to case studies as a means to provide insight into a certain subject, which is to that point unknown, while also others such as Yin (2003), Scholz et al. (2002) or Woodside (2010) state the same.

Contrary to an embedded approach to a case study, Yin (2003) also describes a holistic approach. Yin stresses the fact that the researchers need to have a distinct delineation between holistic and embedded case studies. Whilst an embedded approach uses multiple units of analysis as in the example of this research - three separate companies of the same kind within the overarching case group - a holistic approach focusses on a single unit of analysis. As holistic case studies encompass the difficulty of investigating an individual phenomenon (Yin, 2003), it is deemed less suitable for the nature of this research project. To show an overview of case study classifications according to Yin (2003), figure 15 provides the most relevant case study approaches:

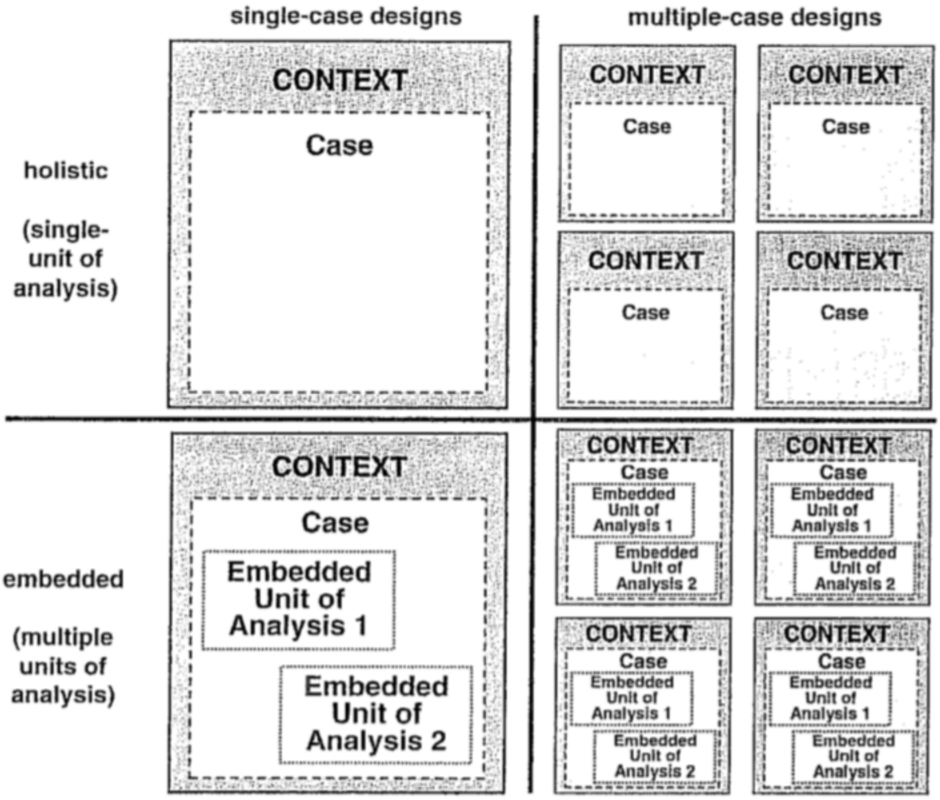

Figure 15: Case Study Approaches, Source: Yin, 2003, p. 40.

3.5.2 **The Case Study Selection**

For the purpose of the case study, there will be a focus on only one of these functions, which allows for easier access to the relevant subject matter experts.

Within the selected case organisation, the DFS Group, there are numerous sub-units, which operate in similar yet not identical way. In order to gain an understanding of the subtle difference, it is important to understand the high-level structure of air traffic control.

As was already introduced in the literature review, any ANSP organisation is set up in two major areas, operational support and operations. The operational support area (sometimes referred to as administration) follows the same structure across all organisations and also within subunits. As the levels of analysis will focus on three managerial stages within the organisation, this area will be covered in the same way across all levels of analysis. The operations area requires a deeper understanding in order to select the most appropriate area to reflect the relevance and reliability of data across all levels of analysis.

For the purpose of this research, the TWR has been selected, which will result in operational experts for interviews during this research originating within the operational area working in TWR operations. The selection provides the greatest potential for gaining research responses combined with the greatest level of divergent experience. This is due to the access to subject matter experts by the researcher. During setting up the research, access to a variety of TWR representatives has been found easier than to other areas of ATC. On top of that, the professional background of the researcher (Former trained ATCO) allows some additional insight on the way of work in ATC, which supports the selection.
APP normally only controls the aircraft for 4 to 5 minutes unless there is congestion. Therefore, APP is limited in terms of the level of exposure, with ad hoc decision making limited due to the task being heavily reliant on technological landing aids. ACC controls aircraft for more extended periods, with the flying time controlled being greater than 10 minutes. Again, there is minimal ad hoc decision making required due to long-term planning. By comparison TWR has a greater variety of tasks, combining the long-term decision making with the use of visual sight of the aircraft and radar for ad hoc decisions. Therefore, TWR subjects will have the greatest level of diversity of experience coving different aspects of ATC. The structure of TWR air traffic control services is the same across all embedded units of analysis, which allows for the collection of data on all relevant levels. Also, all air traffic controllers, managers, and executive managers are within the same regulatory setting and subject to the same or similar challenges. This provides comparable data as each question answered is done so on the basis of the same theoretical and operational background.

3.5.3 **Levels of Analysis**

This research applies a single embedded case design looking at three data collection areas within the same organisation (DFS-Group), with three levels of analysis in each site. The embedded case design will allow for the investigation of various elements within a site and the comparison of the findings against each other. The key narrative that led to the selection of the embedded case design is that the level of integration of

HRO principles as well as the level of influence from the economic regulation on the site takes place individually on each site. There may or may not be cross-relationships within the organisation's sites and this research will be able to draw conclusion on that, but the management of each site is largely independent from the other sites, hence why the same levels of analysis do exist and co-exist across the organisation. Figure 16 shows a graphical display of the embedded units of analysis based on the embedded case study design.

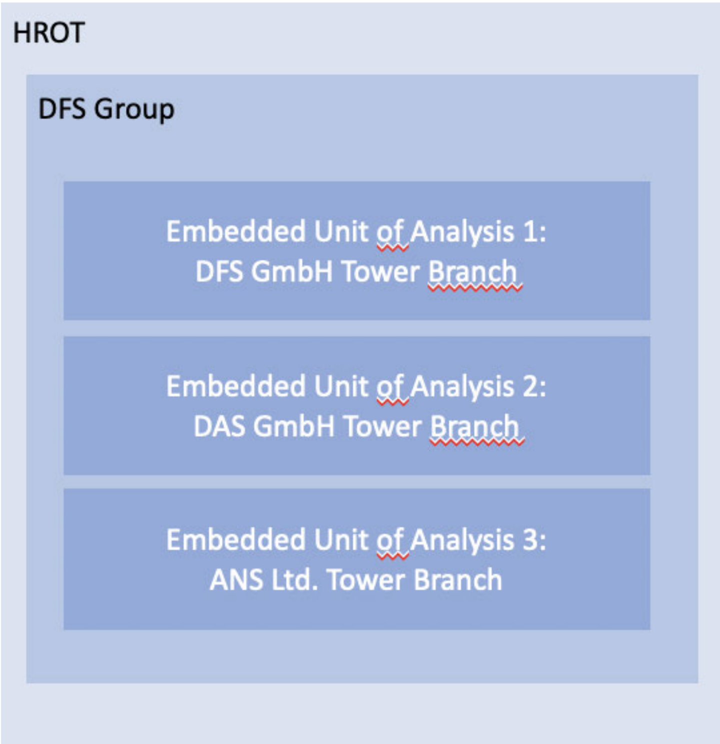

Figure 16: Embedded Units of Analysis, Source: own figure

Each unit operates within the same organisation and according to HROT principles. Each unit is managed independently but provides the same type of service: Tower Air Traffic Control. The selection allows for a comparison based on the same service provision, which is subject to the same regulatory framework yet in different sizes, forms and areas, where it is applied.

Whereas the DFS GmbH Tower Branch provides Tower Air Traffic Control for international airports within Germany, the DAS GmbH provides the same service at regional airports within Germany. The ANS Ltd. provides Tower Air Traffic Control at major airports within the U.K.

The level of analysis within each unit will include

- *executive management* (level 1),

- *senior management business* (level 2A),
- *senior management operations* (level 2B),
- *front-line employee business (*Level 3A) and
- *front-line employee operations* (level 3B).

Note: front-line employees will be invited for surveys but will not participate in interviews.

Figure 17 provides an overview on the level of analysis within each unit:

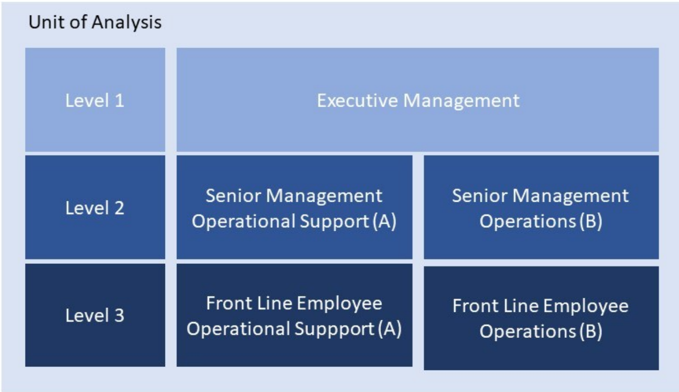

Figure 17: Level of Analysis within each Unit, Source: own figure

3.5.4 Summary of Case Study Design

This chapter provided an overview of the research design. This research applies a single embedded case study, which according to Yin (2003) and Gerring (2007), are most suited to covering a single case with various embedded units of analysis. The levels of analysis are the three major management levels within the operational support and operational area of the case ANSP. As the structure of ANSPs across the globe is similar (and within Europe and the case organisation it remains the same) any findings will be transferable across the wider community of ANSPs and beyond into similar setups. The sampling will be purposive as, according to Yin (2003), Gerring (2007) and Woodside (2010), small-N samples such as this research require specific non-probability sampling strategies to select the most relevant data points to the phenomenon subject to research. Figure 18 shows a summary of the case study design:

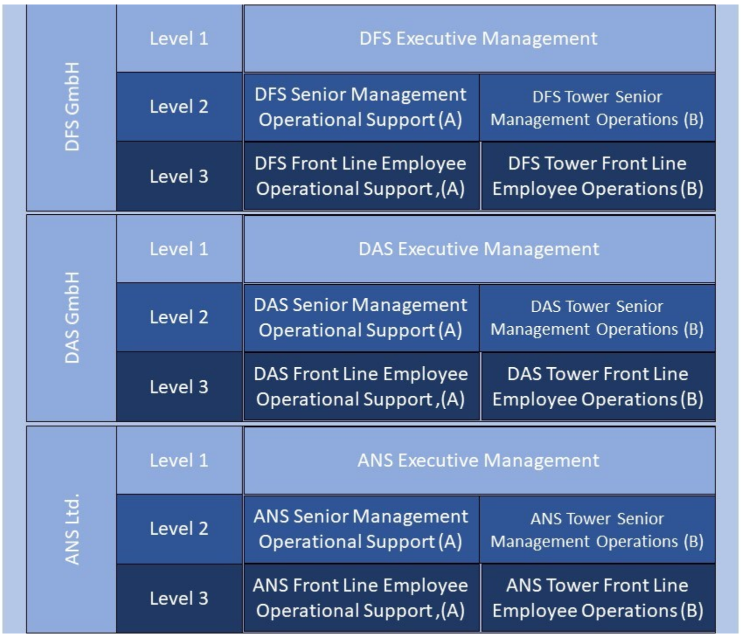

Figure 18: Research Design, Source: own figure

3.6 Selection of Data Collection Instruments

This chapter will outline the data collection strategy and provide justification for the chosen data collection tools of document analysis, in-depth interview and survey.

As mentioned previously, this study focuses on a specific target group within the case organisation that has relevance to the phenomenon under investigation. This specifically selected purposive sample is part of the case organisation in the two main areas of administration and operations and acts as part of a highly reliable organisation. Being part of such an organisation requires an understanding of the principles of HROT. For this research, the influence of external factors that might have an effect on HROT principles is key. Moreover, internal understanding or, in other words, the level of integration of HRO principles in the whole organisation is essential. The selected case allows for the investigation of this from two different angles: the main organisation (DFS) and its fully independent subsidiary in the U.K. (ANS Ltd.).

Although the researcher himself is a member of the case organisation and has access to most of the relevant data, documents, and personnel, the high security standards do not simply allow the use of it. It is a challenging thing to uncover and see highly relevant data that is forbidden by internal guidelines from being included in the research. On the other hand, this proximity is beneficial when it comes to accessing the gate keepers or interviewing partners directly. The researcher can identify himself with the highest security clearances and is able to meet the research participants or their gatekeepers in their own environment during normal business. This allows to keep any potential distraction at a minimum. However, it is also necessary to assess the potential of researcher bias, which may be present when any researcher undertakes a study which contains an existing relationship, equating the role of the researcher to that of a potential participant, particularly in qualitative research (Rajen K Gupta, 2015). Whilst there are some disadvantages to being involved in the case study organisation, there are also benefits to having a relationship with some of the participants. In doing so, there is a greater potential to gain the trust of the employees over time. However, there is also increased potential risk of skew in the qualitative research interviews or surveys where the respondents are known to the researcher (Creswell, 2003). In the current case study, the qualitative research anonymises answers, which will help to overcome this issue, while the relationship with some employees may support increased depth of investigation.

To draw attention to the relevance of this research again, it is important to put emphasis on prior research on HROT and safety. This highlights the importance of external factors on complex organisations such as HROs. The recent push for economic regulation within air traffic control is a subject of sustained interest amongst researchers (Cook, 1998; Papatheodorou & Platis, 2007).

It is essential to fully understand what influences HRO systems:

"The potential for catastrophic outcome is a hallmark of complex systems. It is impossible to eliminate the potential for such catastrophic failure; the potential for such failure is always present by the system's own nature" (Cook, 1998, p. 2).

In particular, Nemeth et al. (2011) stress the need for further research on factors that influence or impede highly reliable systems and gain further (deeper) understanding of them. The selected data collection methods of document analysis, a survey and in-depth interviews will provide the intended and expected level of detail and return an understanding of the phenomenon, which otherwise would not be possible.

Each method will inform the research and they will support each other in a triangular way to provide a complete picture, as well as balance the strengths and weaknesses of each method.

In order to gain an understanding of the selected case, it is of importance to select specific representatives to collect data from within the three embedded units of analysis. The selection for this research is based on purposive sampling (Eisenhardt, 1989). It is important to achieve comparability across all selected data to gain relevant and important knowledge that can contribute to research.

The three different methods of this research, document search, survey (also referred to as questionnaire) and semi-structured interviews address different aspects within the case organisation. Whilst the document search and the survey cover a large sample of relevant elements, the semi-structured interviews require careful selection of specific individuals relevant to the topic, which results in a rather small sample of less than 20 participants. The benefit of this approach is to gain a broad understanding of the topic across the whole organisation. It also provides in-depth knowledge on the phenomenon from selected individuals who hold key functions and responsibilities. Comparing these two will allow an investigation into whether the organisation has the same or different understanding of HROT than the decision makers. Within the small sample a comparison will be possible whether the understanding and integration varies between the levels.

All methods together will not only provide an overview on the phenomenon from different angles through methods, but different views are also possible within the methods. Research on HROT shows that a case in this area normally has a small sample to choose from (small-N). Within such a small sample, random sampling is likely to return unreliable data (Gerring, 2007). To achieve relevance and importance in aiming to gain a deep understanding of a given phenomenon, it is however important to select the most appropriate type of sampling (Yin, 2003). Sampling serves the purpose of providing the relevant data for representativeness of the case but also a within case variation of data (Gerring, 2007).

Literature on case studies suggests purposive sampling as most appropriate sampling approach within small-N case studies (Gerring, 2007; Woodside, 2010) but also HROT research grounds on specific cases with small samples such as the Cerro Grande Fire (Nisengard et al., 2007; Weick & Sutcliffe, 2007) or the Three Mile Island incident (Hopkins, 2001). The benefits of purposive sampling are evident and reflected in this research. It is possible - unlike with random sampling - to study a specific element of a phenomenon (Babbie, 2009).

Different understandings among key decision makers and front-line employees about the same subject is of interest. It requires this study to identify the most appropriate candidates based on their background and knowledge of the phenomenon. Babbie (2009) describes this as appropriate approach, when *"certain types of subjects seem more central to understanding than others do"* (Babbie, 2009, p. 220).

The specific sites (airports) chosen in the operational area are irrelevant for the purposes of this study, due to the same ruleset and structure being in place at each site. The specific sites have been kept confidential to protect the identity of the selected participants. Other research in HROT approaches these phenomena in a similar way. For example, Weick and Sutcliffe (Weick & Sutcliffe, 2007) used surveys and interviews when they developed the first ideas about HROT. In line with the other researchers in this field, this thesis also applies the same principle. In the following chapter, the three data collection methods of document search, survey, and expert interviews are explained in detail.

3.6.1 **Document Search**

Document analysis is the first method of collecting data in this research project. This method primarily serves the purpose of providing supportive evidence and justification for the primary data collection, which will take place with a survey and semi-structured interviews. A key strength of document analysis is that it is an unobtrusive measure (Robson & McCartan, 2016). This term refers to artifacts that people make on purpose, which provide additional (secondary) data for researcher to make sense of the world. Pieces of data - artefacts - made on purpose reveal something about the creator and the nature of his or her view of the world.

People reveal something about themselves – either intentionally or unintentionally - in this process, which can be used by researchers. Document analysis has the advantage of allowing data to be collected without influencing the nature of the data. A document's content, regardless of how long ago it was created, will not change once it has been used in research (Kitto et al., 2004; Robson & McCartan, 2016). Yin (2003) stresses the fact that document search is a valid way to achieve validity in triangulation across primary and secondary data.
Document analysis is highly important in HROT, as there is a clear relationship between safety and high reliability. Organisations keep records of safety related topics and to the benefit of this research, the requirements from the regulator are strict and robust. The documents not only tell a story of what happened, but how it has been investigated, who investigated it and what factors have been taken into account. These are the areas with which this study is primarily interested.
Babbie states that document analysis is *"particularly well suited to the study of communications and to answering the classic question of communications research: "Who says what, to whom, why, how, and with what effect?"* (Babbie, 2009, p. 333). Reports will be used for the purpose of this research. They are not transcripts of what has been said or by whom, but they document the result of discussions and conversations in a way that focuses on the facts, hence why the same principle applies to this research.
Another big advantage of document analysis and one that makes it relevant to this study is that documents reflect a change over time. An archive is built over years in an organisation and documents on the same subject, such as safety or HRO, show how the organisation and their actors have changed their approaches over time. These subtle fractions of information cannot be easily traced by surveys or interviews as they reflect the present view and opinion rather than over an extended a period (Babbie, 2009).
Finally, document analysis allows the repetition of certain portions if case initial results reveal false or irrelevant data. In survey or interview search, this is much more difficult to achieve as access to the information is limited

and, in interactions with individuals, it becomes naturally biased (Yin, 2003; Babbie, 2009).

Document search is also limited in some respects, meaning it is important to complement it with other methods. Document analysis requires a very clear structure that outlines how the documents will be analysed and what is hoped to be found within the documents. Any organisation, including this thesis's case organisation, keeps thousands of documents. Only a fraction of these are relevant for this research. Should the scope be set too large, the most relevant information may be hidden or become less obvious due to the variety of content. In order to overcome this issue, the key aspects from the literature review on HROT will be applied, which is that HRO principles are reflected in safety and crisis management. This gives a clear guidance on where relevant documentation can be found.

An even more relevant disadvantage in document analysis is the document itself. If there is no document or the document lacks (relevant) content, then the information is lost and cannot be recovered. Documents, as stated earlier, often reflect communications or results of investigations. If a specific investigation has not been recorded (properly), the information cannot be used for document search and it might even skew the result if only parts are recorded (Yin, 2003; Babbie, 2009; Woodside, 2010). The highly regulated environment of the case environment will reduce the risk of non-documentation and irrelevant content but cannot eradicate it.

The document analysis is not only a data collection process but at the same time an analysis in its own right. For the sake of completeness, the data analysis chapter will provide similar information on the document analysis as the software used for this method will also be used as the overarching software to analyse the whole data set.

The selection of documents is based on their potential to inform the understanding of the organisation's understanding of HROT principles and/or their ability to provide data regarding a potential external influence on the application of these principles through economic factors.

Documents come from mostly organisational safety management records. These documents stretch across all units of analysis. They are created by investigators from the group of front-line employees with the support and input of the whole of this group. Thereafter, the panels and review bodies are led and guided by the senior management team. At the same time, these documents are brought to the attention of the executive management, which then will discuss and analyse the content together with the senior management. The structure of all these documents is similar and cover all aspects of HRO relevant areas. Some of these documents are publicly available as per regulatory requirements, but the vast majority of these documents are strictly confidential for organisational security reasons or due to data protection requirements.

No specific names or details on the content is used in this research, as this information is not relevant to the investigation of the phenomenon. It also safeguards the sensitive nature of the potential commercial or personal information contained in the documents. Documents are not specifically named, but a generic description of the nature of the documents is given (i.e. Investigation Report, Safety Case, etc.). All documents were investigated against the five principles of HROT (Weick & Sutcliffe, 2007) and traits of external influence through regulation (Arblaster, 2018). The data is compared with results from the survey and the interview data collection to identify similarities, differences and/or patterns. Specifically, the presence of key terms and traits from HROT, which has been identified in the literature review, were the main anchors in the review.

The benefit of this approach is that the document analysis can identify what the company actually does in contrast to what the individuals within the company perceive as being done or being the intent of what is done. Furthermore, the documents reflect the real influence against what the individuals on the three units of analysis perceive or think. To support the analysis of the documents, the qualitative data analysis software suite NVivo is used. The software is available free of charge from the university and has a sound user base, which allows easy access to training, tutorials and support.

3.6.2 Survey

The second method chosen for the purpose of this thesis is the survey research. Conducting a survey is a method that gathers qualitative or quantitative data from a sample of respondents in sending a standardised set of questions to them (Babbie, 2009). The researcher is not necessarily present or required to be present.

Surveys are an appropriate method for case studies as well as any research that has individual people as unit of analysis (Yin, 2003; Babbie, 2009; Woodside, 2010). They are commonly used for descriptive, explanatory and exploratory studies, hence why they fit the requirements for this research.

Babbie (Babbie, 2009) specifically states that surveys are *"the best method available to the social researcher who is interested in collecting original data for describing a population too large to observe directly"* (Babbie, 2009, p. 254).

This research deals with a group that spread out over various sites and management levels with a population of several thousand individuals. Even a fraction of this population - enough to serve the purpose of this study - could not be observed within a reasonable period or by a single researcher. In the context of identifying a certain common opinion about HROT principles and their application, the survey is suitable to return relevant data that is capable of informing the investigation process. Moreover, it can be used to integrate people into studies that are hard to reach (Flick, 2008), which is particularly useful in this research as it stretches across borders.

It is obvious where the main strengths of surveys lie. They allow data collection directly from the individual in an easy way and across a larger sample without investing too much time. Considering one of the key questions of this thesis, the knowledge of the HROT principles across the organisation, the survey is the most appropriate way to get primary data on the topic. In the context of this research, the individual’s perception or opinion on the subject of HROT as well its influence on the principles is important. Babbie stresses the fact that *"Surveys are also excellent vehicles for measuring attitudes and orientations in a large population"* (Babbie, 2009, p. 254), which is in line with the intent and aim of this thesis.

For the analysis of the survey data, SPSS 27 has been used by the researcher alongside Nvivo 12 and manual analysis by the researcher for the qualitative aspects.
The survey-platform (lamapoll.de) also provided many analysis functions from within the platform, hence why some of the analysis was carried out within the survey provider and did not require additional software.

3.6.3 **Semi-Structured Interviews**

To gain deep insights into the topic, the present paper uses the qualitative method of data collection by means of guided expert interviews as a survey instrument. The main reason for selecting guided interviews is that this kind of data collection allows for the superior acquisition of specific knowledge as well as the experience of the interviewed experts. The third method that is applied in this thesis thus is the semi-structured interview. A triangular approach to data collection has been selected. This shall serve the purpose of supporting the document analysis and survey method with additional, in-depth knowledge on the phenomenon, collected from key representatives within the organisation. This method serves as the most important data collection method. The main benefit for the purpose of this thesis is the combination of gaining knowledge about the phenomenon at the same time as collecting data (Kajornboon, 2005). Kvale states that *"the interview is an instrumental dialogue"* (Kvale, 2008, p. 15).
In saying that, he highlights the key elements of an interview process: dialogue and intention. Whilst any interview requires a dialogue between the interviewee and the interviewer, this is not done for the purpose of light conversation. Rather, this provides a context of a high-level structure that the conversation will follow.
Similar to surveys or document analysis, interviews are a good way to explore topics that are under-explored. Examples include the extent to which highly reliable organisations apply HROT principles in daily organisational practice across all business functions against the influence of economic regulation. Interviews are commonly used in the context of safety science, risk management and HROT, as for example the Three Mile Island accident investigation, where all key personnel has been

interrogated during the investigation (Rogovin, 1979) or when the Berkeley Group interviewed the staff of a nuclear carrier in order to gain knowledge and understanding of the HRO principles on board (Weick & Sutcliffe, 2007).

A wide variety of interview techniques are available, which serves as a proof for the flexibility of this method. The main structural approaches are *(i) structured, (ii) unstructured and (iii) semi-structured.*

Unstructured interviews aim to collect a great breadth of data. The interviewer allows the interviewee to decide what they want to say independently. The data is not directed into a certain area, nor does it contain questions that must be answered. The most common unstructured interview type is the ethnographic open-ended interview or the non-standardised interview (Fontana & Frey, 1994). The psychological interview is another form of an unstructured interview, where the interviewer follows the interviewee through active listening without interrupting or influencing (Zhang & Wildemuth, 2009).

Lofland (2006) points out that an unstructured interview is similar to the participant observation. Informal interviewing while observing is the most common approach in participant observation. An unstructured interview can be seen as an alternative to the participant observation and vice versa. It allows the interviewer to become part of a conversation and therefore personally involved in the data collection process (Fontana & Frey, 1994).

While the biggest benefit of the unstructured interview is the unbiased approach to the data collection, this inherits at the same time two major problems, namely time constraints and focus. The unstructured interviews allow room for discussion and relegates the interviewer - to a certain extent - to the role of listener. Within a research environment such as a PhD project, time constraints usually apply and as the unstructured interview lacks a specific frame and structure, the researcher may have to end any interview before enough relevant information could have been collected.

Structured interviews as an approach to interviewing are similar to surveys. A pre-defined set of questions and answer choices is given to the interviewee and the answer is recorded. The interview follows a specific path through a set of questions that leave little to no room for variation (Fontana & Frey, 1994). They further argue that the supervisor has a very high control over this type of research approach, as they may be involved in the design of the questions as well as controlling them. The interviewer is reduced to a research assistant, which reflects their involvement in the set of questions rather than the actual performance (Fontana & Frey, 1994; Schostak & Schostak, 2005).

With this approach, the structured interview aims to produce an almost ideal way of gathering data through personal interaction. The high standardisation allows maximum comparability within the area of social interaction. The interview guidelines are very strict and highlight the independence of the interviewer i.e.

"Never deviate from the study introduction, sequence of questions, or question wording" or "*Never improvise, such as by adding answer categories, or make wording changes"* (Fontana, 1994, p. 364).

This represents one of the shortcomings of this interview approach within a social context. Here, with the interaction of individuals and their unique backgrounds and the fundamentally subjective – as well as interpretivist - nature of social interaction, the potential for bias and errors is very high. Even with the standardised approach of structured interviews, it remains the responsibility of the interviewer to take the difference of the individual interviewees' backgrounds and the context of the interview into account and to make appropriate alterations to the results (Fontana & Frey, 1994).

Semi-structured interviews are the hybrid version of interviews. They allow a certain degree of flexibility and freedom yet provide guidance questions to address a specific aim set out by the interviewer. It uses a relatively accurate interview guide - if the interviewer has a certain knowledge about the research object already - to base the interview on presumptions (McIntosh & Morse, 2015). The analysis of the prevailing knowledge of the researcher is the baseline for developing an interview guide and based upon the interview questions. Their major aim is to focus the interviewee as well as the interviewer on the topic, whilst allowing the interviewee to answer relatively open and without direct influence. Those two factors constitute the difference between structured and unstructured interviews (McIntosh & Morse, 2015).

Barriball et al. (1994) state the semi-structured interviews are complementary to surveys as they overcome the poor response rates that surveys usually suffer from. Whilst this alone would hold true for almost any interview or inter-personal interaction, semi-structured interviews address questions that have not been answered yet if they are combined with a survey and prevent the respondent from receiving help as they are answering. As a result, the validity of the data collection is much higher. Semi-structured interviews allow the interviewer to pick the initial responses from a survey and add in-depth information to it while using the survey structure as a relative guide for the interview approach. Barriball et al. (1994) further conclude that semi-structured interviews are a valid approach to explore the opinions and personal perceptions of individuals on complex and difficult matters. In terms of academic research, the semi-structured interview is the most common because it returns valid results with a manageable amount of work. This is particularly important for any project carried out by inexperienced researchers.

The semi-structured approach has been considered as the most suitable for the purpose of the present thesis. This is mainly because it is impossible to predict the full extent of a conversation on such a complex and subjective matter as HROT principles. At the same time, an unstructured approach would not allow for the specific guidance provided by HROT principles.

With the help of the interview guide, which will be presented in chapter 3.7.3.3., irrelevant information can be excluded a priori. In this context, the interviewer's strong control function is a great advantage. The individual expert interviews are therefore most suitable to develop the knowledge and the opinions of the experts. At the very least, the interviewer can entirely concentrate on the corresponding conversation partner during the interview.

The aim of the expert interviews is to systematically acquire information, since the interviews experts are able to describe facts and to represent their own insights with regard to the topic. With respect to evaluation, the

focus is on a thematic comparability. The results, which could be generated from the interviews, can subsequently be categorised and compared.
To further understanding of expert interviews, the following chapter deals with some theoretical information before introducing the experts who could be used for the interviews. This is of high importance, since the practical part of the present paper mainly depends on the evaluation of the conducted interviews.
The analysis of the interviews was carried out with the support of Nvivo 12 and manual coding.

3.6.4 General Information on the selected Experts

The present chapter answers some fundamental questions regarding the methodology of the planned expert interviews. The proposed interviewees are called experts because of their long-standing experience in specific areas, their high degree of unit-specific knowledge, as well as their special skills. The specific knowledge that has been acquired over the years is the crucial requirement of the expert's selection. General education or even knowledge from other areas are irrelevant for the expert's selection. Although personal contacts in general do not belong to the crucial criterions, they can be helpful during the selection of experts.
This by itself contains a certain risk of an interviewee bias as the subject matter experts might want to place a certain message with their answers or want to hold back specific information on purpose for personal or organisational reasons. Firstly, the careful planning and execution of the interviews alongside the cross-referencing of the collected information with the survey and document analysis is required to reduce any bias as much as possible. The guiding question in the interview will provide a standard across all interviews, which allows standardised data on the one hand topped up with insight on the different views that might uncover potential bias. Also, the selection of interview partners across the organisation from the different levels of management will reduce possible bias. The various organisational structures are highly similar yet not the same and allow for some variance. If the background and focus of an expert is similar but not identical, bias can be easier identified, when analysing the interview data.

On top of that, the selected interview partners have been chosen from different business functions (see 3.7.3.) to spread the view on the topic across the organisation as much as possible.
The optimal preparation of expert selection - as well as the expert interview itself - is predicated by the assumption that the interviewer has become familiar with the specific matter prior to the interviews taking place. This does not only extend to fundamental findings or specific terms, but rather be a familiarity with the central issues and an intellectual curiosity, which is related to the central questions. Based on these principles, the interview guide that is presented in chapter 3.7 is created. Contacting experts can happen in different ways. The various possibilities are through writing, contact via telephone via personal contacting at sector-specific trade fairs or conferences. It should be kept in mind that a concrete and convincing presentation of the planned survey’s contents and objectives is of high importance while contacting experts. Once the expert agrees to the planned interview, he or she will be given the date of the proposed meetings as well as their likely duration. They will also be provided with the interview guide itself. In the present survey, each interview lasts approximately one hour. Every interview is conducted at the expert’s workplace, where the acquisition of additional information can take place more easily. In addition, the expert is in his or her usual environment, reducing distortions while also increasing the chance of commitment to the interview. It means that the experts do not have to travel a long way and do not need to leave their workplace. In essence, they do not bear any costs except the hour for the interview.
As already described in the previous chapter, the expert interviews are conducted in a semi-structured manner with the help of a pre-defined, standardised interview guide. The interview guide ideally starts with a very simple introductory question. In this way, the conversation can be relaxed directly from the beginning. Subsequently, a transition to the main part can be made. The interview’s main part includes the questions that are relevant for the specific topics. With regard to the formulation of the individual questions, the interviewer can use different questioning techniques, whereas psychological questions are avoided. After having

given some general information on conducting expert interviews, the next step will be the selection of the documents to be analysed, along with the sample for the planned survey and the experts who shall be questioned.

3.7 Sample Selection and Data Collection

The present chapter aims to determine and present the samples for the three data collection instruments. Starting with a brief description and subsequent analysis of the documents, the following chapters deal with the survey's sample and a presentation of the interview partners.

3.7.1 **Document Collection Approach**

The experts chosen provide some documents before and during the interviews, or alternatively provide them after the interview, which have to be analysed with regards to safety and HRO aspects. 672 documents have been provided to the researcher in total for the analysis, which are introduced in more detail in chapter 4.2.
The following three documents can be seen as an example. A full List of all documents can be found in Appendix A:

3.7.1.1 Example Safety Notice 1

Title: Safety Notice 001 of 2018 "Operational Distractions"

Introduction

Distractions in operational areas can lead to a significant risk to the safety of air traffic. The potential for distractions in operational areas is very acute, particularly during the current set of unique circumstances facing this unit. This has been raised within the USSG as a potential safety risk. It is the responsibility of all unit personnel to ensure that operational staff are not distracted from their tasks.
MATS Part One reference Appendix E4 should be read in conjunction with this USD.

Noise in Operational Areas

The level of noise in any operational area must be kept to a minimum. The Watch Supervisor is responsible for monitoring the level of noise and should take appropriate action if necessary. Visitors must not be allowed to distract staff in operational positions. Visitors permitted to plug into operational positions should only be allowed to do so in compliance with the company policy. The unit has taken steps to reduce the number and frequency of visits, particularly by non-operationally relevant groups. This will continue to be monitored.

Discussions on a range of issues affecting the unit are frequently taking place in operational areas, with the ongoing potential to distract operational staff. These discussions must not take place close to operational staff who are providing an air traffic service to traffic on frequency.

Use of Non-operational Literature & Personal Electronic Devices

The reading of non-operational literature when actively providing an air traffic service is not normally permitted and must be not be used during core operational hours Monday – Friday 0600-2000. It is understood that during quiet periods, particularly during night shifts, some form of activity such as reading may be beneficial in order to maintain alertness. The use of personal electronic equipment such as mobile phones, tablets, laptops, electronic readers or any other unauthorized electronic media by ATC operational staff is not normally permitted whilst actively providing an air traffic service. Personal electronic equipment must not be used by other members of staff if this will be visible or audible to operational staff providing an air traffic service. Outside of core operational hours, and strictly in accordance with the guidelines outlined above, non-operational literature and electronic media may be authorized.

3.7.1.2 Example Safety Notice 2

Title: Safety Notice 009 of 2018 “IRVR and LVPs”

Following a recent incident in which ATC Low Visibility Procedures should have been in force, but were not, ATCOs are reminded of the following MATS Pt1 and Pt2 instructions relating to IRVR and Low visibility Procedures.

System Availability

IRVR systems are operational at all times, unless notified to the contrary by the DEO.

Duration of Assessment (Mats Pt1 Section 3 Chapter 3)

IRVR reporting to aircraft is started:
(1) whenever the aerodrome meteorological report shows the visibility to be less than 1500 metres;
(2) whenever the IRVR display is indicating an RVR value equal to or less than the maximum for that system;
(3) whenever shallow fog is reported and during the period for which it is forecast.

Implementation of Low Visibility Procedures

MATS Pt2 ADC Chapter 4 Section 4.1.2 states:
Subject to safeguarding, LVPs become effective when:

• the touchdown IRVR is 600m or less (or midpoint if T/D is unserviceable or the meteorological visibility if the IRVR system is unserviceable), or
• the cloud ceiling is 200ft or less.

For clarification, if either of these criteria apply, then LVPs should be implemented irrespective of the visibility from the VCR or pilot reports. If there is any doubt about the accuracy of the IRVR system, it should be reported to the DEO who will determine the serviceability status.

Guidance

Due to the vicinity of the River Almond and surrounding agricultural land, the airport and its close environs are susceptible to shallow fog, which may or may not be forecast. Typically, the fog will form on clear, calm nights as sunrise approaches. As the IRVR system is designed to suppress any RVR readings when the runway edge lights are set below 10%, spotting the phenomenon in the dark can be difficult.
If a controller suspects shallow fog may be forming, the runway edge lights should be periodically selected to a value of 10% or more to obtain an RVR reading. In addition to this, if an RVR value is being supressed by the system, ///// ///// ///// will be displayed on the Met screen in the RVR section.
With the VCR being some 50m above ground level, the visibility may appear to be well in excess of 10 km, even when fog is forming at a lower level. However, an indication that something is happening may come from the Metcom visibility sensor, which is positioned close to the IRVR transmissometer. If the Met system is offering a visibility that is

significantly lower than that observed from the VCR, the possibility of shallow fog should be considered. Finally, if in doubt ask Airfield Ops. They are out and about on the airfield all night and their new office is better positioned than us to spot the fog forming.

3.7.1.3 Example TOI

Title: TOI 020 of 2018 “Runway Rehabilitation Guidance”

Introduction

This TOI should be read in conjunction with PH OPNOT 03318.
This TOI gives further guidance on procedures pertaining to production of METARs and handing over of the airfield to Airside OPS.

Procedure

1. Production of METARs

Each evening before runway rehabilitation takes place, the Met Office must be advised of the times when METARs will not be produced.
The 0020 METAR must be produced. In this METAR, the message in the TEMP folder named “RWY REHAB” must be selected. This message says “RUNWAY IS CLOSED. ATC IS CLOSED UNTIL 0500”.
In order that the 0600 TAF is generated, METARs must be completed at 0450 and 0520. The RWY REHAB message must be removed and replaced with all appropriate messages at the time of reopening e.g. runway in use, GMC closed, RIT etc

2. Runway / Airfield Closure

Once the last landing aircraft has vacated the runway, ADC/RIT may hand control of the runway to Airside Ops. Once the last landing aircraft has parked on stand, ADC/RIT may begin to hand the airfield to Airside Ops. ADC/RIT must inform AFS and ACC that the airfield is closed and that ATC will be unmanned between 0020 (or later, if necessary due to late running flights) and 0500 but available on-call, and that Airside Ops has a call-out number (07470 142855 – do not give this to AFS or ACC.)
Once these calls are complete, ADC/RIT must advise Airside Ops that the airfield is under their control, that ATC is unmanned and that ATC service will resume at 0500. Airfield Ops must also be advised that the airfield lighting is delegated to them to allow the Engineers to work freely on

lighting circuits. Airside Ops is to be given the on-call telephone number. ATC must then make a broadcast that ATC is closed.

The controller shall ensure that a Runway Obstructed strip is displayed in the EFPS Runway bay. ATCOs are reminded of MATS Part 1, Section 2 Chapter 1 Paragraph 25C - Availability of Aerodrome Services Outside Published Hours:

C.1 To cover the possibility of an aircraft which departs within 15 minutes of normal aerodrome closing time having to return, the Aerodrome Operator will normally retain sufficient services and equipment for 15 minutes after ATD.

In the unlikely event that an aircraft departs after midnight, Airside Operations must be reminded that the runway must remain open for 15 minutes after ATD.

The “on-call” controller must ensure that they have the call-out mobile phone with them at all times. It will be kept in the VCR to the left of the Tower Assistant position.

3. Airspace Requirements

When the airfield closes, INT/RIT must inform PC GS Scotland that the airfield is closed. The “on-call” number (see above) must be provided to PC GS Scotland. The GS will also require an estimate of the time that it will take for the frequency to be ready to use, if requested. The runway is not be available for emergencies.

INT/RIT must inform Glasgow that the airfield is closed, ATC is unmanned and provide them with the “on call” number should they have traffic that wishes to transit Edinburgh’s airspace.

4. Airfield / Runway Opening

ADC/RIT service should resume no later than at 0500. Prior to re-opening the controller must contact Airside Operations to obtain a briefing of known activity on the airfield (and to confirm that Airside Operations still has control of the runway). AFS, ACC, PC GS Scotland and Glasgow are all to be informed that ATC service has resumed. The controller shall check that the Runway Obstructed strip is displayed in the EFPS Runway bay prior to re-opening. ATC must make a broadcast stating that ATC is open and that any vehicle operating on the taxiway system is to report their position and intentions.

Co-ordination shall take place between ADC/RIT and Airside Ops for opening of Runway 06/24. Airside Ops will ensure that all parts of the manoeuvring area are clear of works parties before declaring Runway 06/24 available for use. Runway 06/24 is expected to be available by 0530. The “on-call” mobile phone must be returned to the desk to the left of the Tower Assistant position by the end of the shift.

3.7.2 Survey Approach

The difficulties in survey research are twofold. Firstly, the sample itself presents an issue. The relevant sample as well as the sample size must be chosen carefully. Whilst we know from document analysis that it can be run over and over again without ruining the input data, any individual that has participated in a survey is unlikely to return relevant information in a second or further attempt (Babbie, 2009; Woodside, 2010). The sample must be large enough to return sufficient and relevant returns. To maximise the potential for accurate data collection, the questionnaire was trialled among several parties to ensure the questions were clear and that the answers could be categorised. The questionnaire was altered slightly to clarify some of the questions.

"Respondents must be competent and willing to answer" (Babbie, 2009, p. 258).

This brief but cogent statement summarises the most important aspect of the chosen sample that will allow for a high return rate with relevant information. However, research into survey searches also shows that a response rate of more than 30 % is not likely. An overly small sample size may therefore only return a few responses, which makes the purpose of the survey - achieving cross-organisational understanding - impossible (Aldridge, 2001).

This research will address this issue in sending the survey to four times as many individuals as the intended number of responses. This will still be less than 50 % of the relevant population. On the one hand, this means that a response rate of 25 % will be enough, but also reserve respondents for a potential second poll, should it become required.

The survey itself must be carefully designed, which presents the second challenge in survey search. Badly designed surveys will affect both response rate and the relevance of results (Babbie, 2009). There are many guidelines on survey question design available, including in books on social research by Babbie (2009) or on case studies (Benbasat, Goldstein, & Mead, 1987; Yin, 2003; Gerring, 2007; Woodside, 2010). There are also books concerned solely with survey research or survey design (Floyd J Fowler & Mangione, 1990; Aldridge, 2001; Iarossi, 2006). Nonetheless, all of them jointly state that the researcher needs to carefully decide on the most appropriate questions for the purpose of the research. To evaluate the relevance and aptness of the survey questions and structure, a pilot survey with five pre-selected individuals will take place and feedback will be collected. The individuals are experts in ATC operations, have exposure and knowledge about HRO principles in the context of aviation, as well as an understanding and knowledge about the economic regulation of ATC within Europe.

As stated previously, sampling for surveys is one of the most important elements in the construction of an effective survey (Yin, 2003; Babbie, 2009). Access to the intended sample is a challenge in its own right. Data protection and confidentiality is a key aspect when distributing the survey amongst the chosen sample, which has been carefully addressed as shown in the following chapter.

3.7.2.1 Survey Sample Selection

As this survey does not require any internal information from the case organisation, access to the sample has been gathered through gate keepers. Several key employees have been identified to participate in the research and to distribute the survey among their colleagues so that only the relevant members of the sample will participate. All gate keepers themselves are part of the sample and will contribute to the survey.

A cross-check within the survey has been included to verify the relevance of an answer. Figure 19 shows the sampling approach:

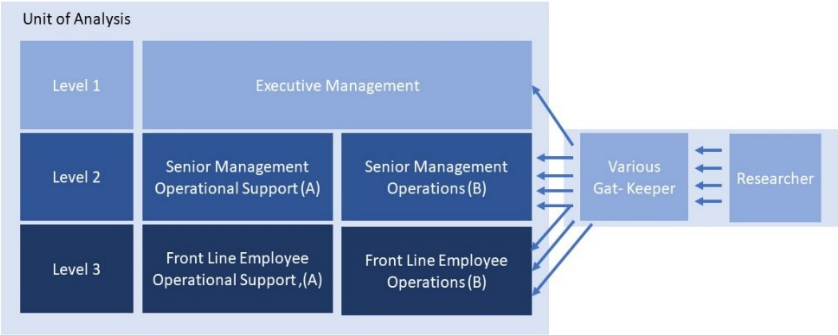

Figure 19: Survey Sample Approach, Source: own figure

Overall, a total of 341 surveys were sent out. 303 people choose to participate in the survey – 93 of them have answered all questions whereas the rest failed to answer all of them. This resulted in a response rate of 88% and a full response rate – of respondents who answered each question - of 27%. Having presented the document and the survey sample, the last section concerns itself with the selection of appropriate interview partners.

3.7.2.2 The Survey Structure

This chapter provides a complete overview on all questions asked and the possible answer to choose from (if applicable):

1. How familiar would you consider yourself with the principles of High Reliable Organizations?
2. How familiar would you consider your superior with the principles of High Reliable Organizations?
3. How familiar would you consider your colleagues with the principles of High Reliable Organizations?
4. Fill in three keywords that describe HROs
5. What is the most important element of a highly reliable organization?

6. Which of the following principles would you consider essential for HRO? Please choose up to a maximum of 5

Preoccupation with failure
Reluctance to simplification
Commitment to resilience
First come, first served
Safety first
Sensitivity to operations
Lean Management
Efficiency Thoroughness Trade Off Scheme
other (please describe)

7. How close does your day to day work environment include the HROT principles into the work?

8. How often are the HROT principles or related topics part of chats at your workplace (on a break, at the desk, over a coffee, etc.)?

9. Thinking about High Reliability: How well would you consider the HRO knowledge of the other area in your organization?

   Answering options: much better, better, about the same, worse, much worse

10. What do you think, how did your daily work environment follow these principles before 2012?

    Answering option: much better, better, about the same, worse, much worse

11. Please describe briefly, what the main reason for your answer is?

12. The European Regulation for ATC introduced four main areas with which ANSPs are monitored, measured and regulated today. Please order the four areas from top (biggest influence on your organization) to bottom (least influence on your organization).

Answering options: Introduction of Performance Scheme, Functional Airspace Blocks , Introduction of European Network Manager, Revised Charging Scheme

13. Would you provide a brief statement on what made you choose your order?
14. As part of the performance Scheme, the European Regulation set out specific targets in four areas for any ANSP. Please order the four areas below from top (biggest influence on your organization) to bottom (lowest influence on your organization).

    Answering options: Capacity of Airspace, Cost of Service, Environmental Targets, Safety (monitoring only)

15. Would you provide a brief statement on what made you choose your order?
16. How would you rate the change/effect from the regulation on your area (operational/non-operational)? Scale: 1-100
17. How would you rate the change/effect from the regulation on your entire organization (operational/non-operational)? Scale: 1-100
18. Final question: Please rate the following influence factors: Regulator (CAA/BAF, etc.), EU Regulation, ICAO Rules, Airline Demands, Airport Demands, Internal Demands, Cost Drivers

3.7.3 Interview Approach

The selected interviewees have been accessed and selected in the same way as in the survey sample. Through specific gate keepers, who are also part of the interview sample, relevant key members of staff have been accessed and chosen for the interview stage. All interviewees have also been invited to participate in the survey, which allows for a better background of the subject. This was done intentionally, as the interview is a tool to gain in-depth knowledge and further data on the phenomenon. Through his process, it becomes possible to increase the depth of knowledge enclosed in the data.
Protecting the identity of all individuals that participate in the interviews is a key aspect and was mandatory in order to gain access to the sample.

Hence, no personal details or job titles of the interviewees or direct citation of any interview content is part of this thesis. In order to maintain confidentiality and integrity of data, it has all interview responses of one level have been combined across all units of analysis.
The interviewees are later on presented in a coded way (i.e. E1, E2, etc.). The coding is presented in chapter 4.4. *Expert Interview Results*.

3.7.3.1 Interview Sample

The following number of interviewees at each level has been selected:

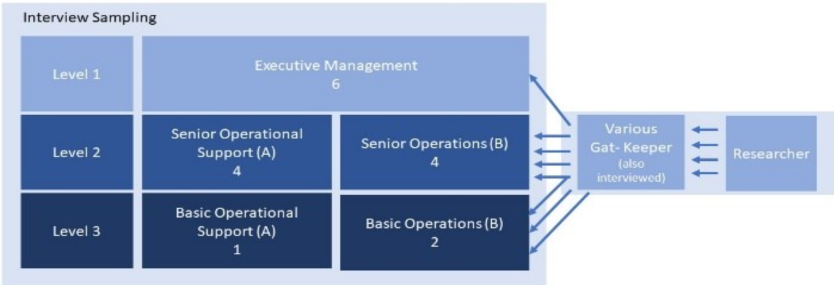

Figure 20: Interview Sampling, Source: own figure

As per the figure 20 above, a total number of 17 interviewees across all units and levels of analysis have been participating in the interviews.
As already introduced in chapter 3.6.4., in the context of this thesis, an expert is defined as a person who has extensive knowledge in their profession and department within the case company. Sometimes these experts are also referred to as *subject matter experts* but because the interviews used managers exclusively, the term has not been used in this thesis as normally these types of experts are regular employees rather than managers.

3.7.3.2 Interview Structure

The present chapter provides some general information regarding the conducting and processing of the expert interviews. Before starting with the expert interviews, a pre-test was conducted. In this way, the interview guide was tested by independent parties with the aim of reaching a good comprehensibility of the single questions. The goal was for each question to lead to the expected answers. To better prepare for the interviews, the interview guide was given to the experts some days before starting with the interviews. This was implemented for several reason. First, to afford the experts enough time to focus on the interview guide's content, giving them time to consider their answers in advance. If they had any uncertainties or found anything to be unclear, the experts had the opportunity to ask questions. At the very least, was to allow all experts to be able to answer the questions. In addition to that, the pre-test helped to generate additional comments and even for the experts to propose modifications to single questions. In the present study, no subsequent changes had to be done. The interviewees participation in the pre-test phase were not taken into account in the analysis. Their responses have therefore been discarded, as the replies were mainly about the process, structure and questions and not about the content rendering the information irrelevant for the purpose of this thesis.

Each expert interview began with some small talk to set the interviewee at ease and an to appraise the time that the experts had set aside for the interviews. Subsequently, the interviewer introduced himself by mentioning his full name, the reason for the planned survey as well as a short introduction of the thesis's topic. It was then explained why the expert's opinion was of high importance to the present paper's topic and how much time the interview was expected to last. With the help of the introductory question ″Do you have any questions before we start with the interview?″, it could be clarified in advance whether the respective expert has been informed sufficiently about the topic and the reasons of data collection. They were asked to sign the consent form before the start of the interview. Before starting with the relevant questions from the interview guide, the interviewer asked some general information regarding the personal details of the expert. All the interviews were recorded using a dictation machine. All recordings have been checked for integrity and completeness before transcription. In a later step, they have been transcribed and stored electronically.

As the interviews have been conducted in parallel with the survey and the document analysis, the questions asked during the interviews were slightly adjusted, subject to intermediate findings. The overall structure and guiding questions remain identical throughout the whole interview process. The interview was set up for 45 minutes, with a 15-minute non-interview part at the beginning to allow for clarification of questions and administrative topics before the start. All interviews could be completed in the given time and no interview had to be shortened or was only partially completed.

Additionally, notes have been made where required by the interviewer to capture specific points or to help with follow up questions during the interview itself. This approach is recommended by interview guidance (Fontana & Frey, 1994; Seidman, 2015) and reduces the chance for errors und erroneous data. The interviews have been conducted in German and English, based on the mother tongue of the interviewee, which allows the individual to speak freely and in his or her own language. As the interviewer is equally comfortable in both languages, no translation before conducting analysis was required. For the purpose of analysing the data it has to be noted that the key terms, phrases and words within the research setting are English terms as well as all documents, which are regardless of the organisation, are also only written and stored in the English language. This allows to eliminate any translation error by the researcher or misunderstanding in the interview, which is further outlined in chapter 4.4. In addition, by making notes about body language, if noticed, some captured data could be supported by additional observations and allows for the balance of some data for relevance.

3.7.3.3 Expert Interview Guide

The semi-structured interview is planned to last for a period of 45 minutes. It is recorded by a dictation machine and starts with the following introduction:

"I would like to thank you very much for taking the time to share your experience and knowledge with me. Do you have any questions before we start?"

Subsequently, the present paper’s author introduces himself briefly and starts the interview with:

"May I ask you to tell me about yourself, your background? For instance, your position, responsibilities and time with the organization etc." The interview guide itself is structured in four main question-banks, as table 9 below shows. The whole interview thus is divided into main questions and central questions.

1. Question-Bank: HRO awareness – personal and organizational
Main question:
Can you please describe, what High reliability Organizations mean to you?

Central questions
How familiar are you?
How familiar is the company?
Which employee groups are more and which are less?
How do you yourself see the HRO?

2. Question-Bank: HRO awareness – factors
Main question:
What is the most important aspect of HROs and how is this reflected in the organization?

Central questions
Safety?
Risk Management?
Admin side of things?

3. Question-Bank:
External Influence
Main question:
Where does the main influence for HRO in your organization come from?

Central questions
From the outside or inside?
Who influences?

4. Question-Bank
Type of Influence
Main question 1:
How are you/your company/your colleagues influenced?
Main question 2:
What does that result in? (good/bad/ugly)
Main question 3:
What is the main "countermeasure" or way to deal with it?

Central questions
What would be needed to be done?
Who could do something?
Is it a risk? If so, for what? Safety, Finance, etc.?

Table 9: Expert Interview Guide, Source: own table

Having presented the survey's questionnaire and the expert interview guide, the next chapter deals with the applied methods of data analysis.

3.8 Methods of Data Analysis

The purpose of this chapter is to provide an overview of the approach that this thesis takes to analysing the collected data. Without data, any analysis would be meaningless by definition. The process of data analysis is to develop conclusions from the collected data in a structured way from a range of data points. Moreover, it aims to explore themes and patterns within the data without purely converting them into numbers, as this thesis follows a qualitative approach (Babbie, 2009).

For this thesis, *content analysis* has been chosen as the approach to data analysis. All collected data in its raw form will be a written text from either participants' opinions (interviews and survey) or from reports (document analysis). This form of data is of a purely qualitative nature. The aim of this thesis is to identify the level of integration of HROT principles into day-to-day practice. This will be done mainly to explore the extent to which external influence factors such as regulation may have an effect.
A qualitative approach to capture the essence from written evidence is required to analyse this data set.
"*Content analysis entails a systematic reading of a body of texts, images, and symbolic matter, not necessary from an author's or user's perspective"* (Krippendorff, 2004, p. 3). With this brief statement, Krippendorff outlines the main reason that content analysis has been chosen as the most appropriate approach for this thesis.
Qualitative content analysis is a data analysis approach with regards to creating meaning from textual data. Other methods in this branch are grounded theory, historical research or ethnography. The most significant difference that content analysis takes to other approaches is the focus on language (written or spoken words), or in other words the communication between individuals with a particular focus on the underlying (perhaps even hidden) meaning of the text (Ifversen, 2003).
"The method can be used for several purposes, such as ***revealing the focus of individual, group, institutional,*** *or societal attention; determining psychological states of persons or groups;* ***reflecting cultural patterns and beliefs****; describing themes, trends, goals, or other characteristics in communication content; analyzing open-ended survey data; and* ***describing attributes of the sender of a communication and attitudinal*** *and behavioural responses of the recipient(s) to the communication"* (Downe-Wamboldt, 1992, p. 314).
The highlighted parts of Downe-Wamboldt's statement are of particular importance to this thesis. Regarding the evaluation of the results, the generated data can be evaluated by means of a qualitative content analysis. For this purpose, the Meuser and Nagel's (2009) approach or

that one of Mayring (2020) can be used. In the following, the processing of a qualitative content analysis will be explained briefly.
According to Meuser and Nagel (S. Pickel et al., 2009), the content of the conducted interviews is top priority. The aim of the qualitative content analysis' is thus to identify the similarities of the different expert interviews as well as to reduce the volume of data. The qualitative content analysis consists of single successive steps, paraphrasing, thematical arrangement, thematical comparison, conceptualisation and theoretic generalisation.

1. The paraphrasing step is used to structure the content in single sections and to reflect it with words, with particular attention placed on the wording.
2. The next step of thematical arrangement identifies appropriate keywords and headings to the single sections. All text segments will be arranged thematically, whereas there should be a strong orientation to the original text.
3. The comparison step compares the identified text segments of all interviews and unifies the headings. In this way, thematic categories can be formed.
4. The conceptualisation step compares the identified categories with other empirical studies, with own knowledge or with experiences and reformulates them in an academic language. Hence, the results can be interpreted and evaluated.
5. The last step, the theoretical generalisation, includes specific theory to enhance the interpretation. Single topics can now be put into a theoretical context (S. Pickel et al., 2009).

It is also common in the field of safety and resilience research to apply qualitative content analysis. For example, when Weick and Sutcliffe (2007) and others investigated the Cerro Grande Fire (Johnson, 2001; Nisengard et al., 2007), they primarily relied on analysing written evidence from various sources that collected peoples' opinions. Moreover, the goal of this thesis is to ascertain the level of integration of HROT principles within the organisation through the opinions of individuals within such an

organisation. This is done most efficiently through the outlined methods, which will return documented opinions that require analysing.
A similar narrative for applying content analysis was given by Hsieh and Shannon (2016). They investigated the qualitative application of content analysis and concluded that *"content analysis offers researchers a flexible, pragmatic method for developing and extending knowledge"* (Hsieh & Shannon, 2016, p. 11).
As can be seen from above, there are numerous approaches to qualitative content analysis. The present research will apply a directed approach to content analysis, as described by Hsieh and Shannon (2016). This approach follows a more structured method and applies known patterns for the analysis from existing theory (Hickey & Kipping, 1996).
This thesis approaches data analysis in three stages:

1. *data preparation,*
2. *within method analysis* and
3. *cross method analysis (triangulation).*

To facilitate analysis of the survey's results, the present paper also uses statistical methods, such as the calculation of median values, averages, absolute and relative frequencies as well as percentages. The analysed data will be presented with the supporting help of diagrams, tables and figures.

3.9 Ethical Considerations

Finally, the present paper's empirical part is accompanied by some ethical considerations, which are explained in the present chapter.

3.9.1 Code of Conduct

This research has been conducted subject to the research ethics guidelines of the University of Gloucestershire (The Research Committee, 2018). These guidelines provide a sound framework by which the researcher is able to conduct his project in a fair and ethical way. Of particular relevance to this research are the following principles, which have been applied throughout the whole research process:
"1. ...Respects the integrity and dignity of persons (that this intrinsic worth protects them from being used for greater perceived benefits);

2. ...Follows the "Do no harm” principle. Any risks have been clearly communicated to subjects involved;
3. ...Recognises the rights of individuals to privacy, personal data protection and freedom of movement;
4. ...Honours the requirement of informed consent and continuous dialogue with research subjects;
5. ...Respects the principle of proportionality: not imposing more than is necessary on your subjects or going beyond stated objectives (mission creep);
6. ...Treats societal concerns seriously - a researcher’s first obligation is to listen to the public and engage with them in constructive dialogue, transparently, honestly and with integrity;
7. ...Builds on the understanding that any benefits are for the good of society, and any widely shared expressions of concern about threats from your research must be considered (with the acceptance that perhaps certain research practices might have to be abandoned)." (The Research Committee, 2018, pp. 7-8)

3.9.2 Data Protection

Before the data collection process began, all participants were asked to give their consent to participate in this research and to consent to the data being analysed.
It has been identified in the early stages of this research that anonymity of the participating individuals is of utmost importance for this thesis. As such, the decision has been made to not identify any individuals and to simply refer to them with generic descriptors.
Additionally, direct quotes are not used in this thesis and job titles have been replaced with generic management level descriptors such as *senior management*.
Advice from the supervisors was sought at any stage where an embargo of data was likely to occur or subsequently arose as a result of a change in regulation. Although the strictness of data protections risk limiting transparency, it was considered a necessary to comply with the ethics requirements in order to collect data about the opinions of the individuals, which had not been possible to collect before.

Two consent forms have been used:

1. The survey consent page, which outlines the research background and nature, what will be asked in the survey and how the data is used. It also highlights what will be collected regarding personal data and finally and how an individual can withdraw from the process.
2. The interview consent form, which detailed information regarding the requirements from the participant for the interview stage. It took particular note of the rights of the interviewee regarding being recorded and the requirements regarding data protection.

The documents have been discussed with and approved by the research supervisor. The research ethics approach has been approved by the University of Gloucestershire Research Ethics Committee in the application process for this thesis. After having gathered all relevant data and information from the three data collection instruments, the next step will be the data analysis. The following chapters will now present the results.

4 Part 3: Research Findings

4.1 Presentation of the Results

The presentation of results in this part of the thesis will provide an overview of the respondents' input. This will be followed by a discussion of the findings against the research objectives. It must be first mentioned that the embedded unit 2 (DAS GmbH) could not be analysed, since no documents or interviewee could be gained in the planned time window. As shown by figure 16, only the embedded unit of analysis 1 (DFS GmbH Tower Branch) and the embedded unit of analysis 3 (ANS Ltd. Tower Branch) will be analysed in the following chapter. The survey has been sent to members of ANSPs within all units of analysis. It was then offered for this to be sent on to other subject matter experts in case it was deemed useful. Due to confidentiality requirements, it is not possible to determine which responses are from which unit of analysis, but only down to a country level.

4.2 Document Search Results

To get enough relevant documents, each interviewee has been asked for HRO-relevant documents that could be made available for the present thesis. Two days after conducting the interviews, the interviewees were asked again for documents, to address the possibility that some new ideas could have been appeared in the meantime. The following documents were gathered:

- Unit 1

The embedded unit of analysis 1 has shown some documents, but these documents could not be kept due to data protection and security guidelines. While having viewed the relevant documents, the present paper's author could state that the documents' nature is identical to the documents that could be gathered from Unit 3.

- Unit 2

Although initial contact has been established to embedded unit 2, no documents were made available due to data protection and confidentiality requirements, which could not be resolved within the period of investigation.

- Unit 3

The embedded unit of analysis 3 distributed all documents pertaining to HRO on the condition that any references to members of staff or locations would be masked. In total, **672** documents have been presented to the researcher. The documents cover a period of 2 years of operations (2017-2018). Regarding the type of documents, the following categories and numbers have been gathered and analysed:

1. Operational Notices (OPNOT)

Information pertaining to all members of staff with relevant information that does not affect the current standard operating procedures. A total of **27** documents of this type have been provided.

2. Safety Notices (SN)

Information to all members of staff regarding relevant safety related information. A total of **9** documents of this type have been provided.

3. Safety Case (SC)

Documents that describe intended changes to systems or organisational structures and assesses them against inherit risks that need to be mitigated. A total of **77** documents of this type have been provided.

4. Supplementary Instructions (SI)

Instructions to ATC and ATC-Support Staff about operating procedures. Supplementary instructions replace standard operating procedures. This permanently changes the procedures that are laid out in the operating manual -Manual of Air Traffic Services Part II– (MATS-Pt.II). They are lifted into the MATS-Pt.II once a year. A total of **211** documents of this type have been provided.

5. Temporary Desk Instructions (TDI)

Temporary instructions to staff manning the “Desk” (operational managing position), advising the managing staff about how to deal with certain situations. This does not directly affect the procedures laid out in the MATS-Pt.II. A total of **3** documents of that type have been provided.

6. Temporary Operating Instructions (TOI)

Instructions that temporarily changing the contents of MATS-Pt.II, which would then result in a SI. A total of **345** documents of this type have been provided.

The document analysis was undertaken using the NVivo software, which is a useful platform for identifying keywords and trends within the data. Three rounds of analysis were undertaken with the aid of the software.
In the first round, the different documents were categorised based on their nature, such as temporary operating instructions, safety cases, et cetera.
In the second round, the documents were analysed with reference to the five principles of HROT indicated by Weick and Sutcliffe (2011). A third analysis was used to create the word clouds, which were used to correlate the most frequently employed terms across the various documents, thus making them comparable to HROT.

4.2.1 **Organisational HRO awareness**

The documents provided by the interviewees were investigated against indicators for organisational HRO awareness. As the documents are all organisational, individual or personal HRO awareness cannot be gathered from this.
The literature review has shown that HROs aim for three distinct principles (see Chapter 2.3.3.1.). The document categories can be referred to these as follows:

i) Aggressively seek to know what they don't know

Document category 3 – SC – aims to identify risks in systems and evaluate mitigation strategies before a change of the system (technical or organisational) is advanced. Without a SC, the organisation would not continue with a change. Document category 4 -SI- changes operational behaviour, while each SI contains a brief risk analysis similar to the one in a SC. This outlines potential risks and mitigation strategies, or which risk can be mitigated through the use of a SI. Each of the documents works within a framework of assumptions, i.e. potential risks.

ii) Keep the balance between efficiency and reliability to stay safe

All of the reviewed documents provide either direct reference to maintaining safety (i.e. SC or SN) or operational instructions, which are implemented after risk analysis has been conducted (i.e. SI, TOI). All documents keep the focus on safe and resilient operations.

iii) Commitment to operations

The documents provided have a strong focus on operations. Each of the 6 document categories address topics with operational relevance from various vantage points. There have been no documents provided other than these. Indeed, HRO related documents considered relevant to the organisation as a whole or focussing on operational support could not be provided by the Units of investigation.

It is also interesting to examine a word frequency query, run with NVivo. This returned the terms “safety” and “System” as the most common words across all documents.

Figure 21: Word Frequency, Source: own research

The top three most commonly words across all document categories are as follows:

Word	Count	Similar Phrases
safety	13849	safety
system	10635	system, systems, system’
case	7435	case, cases

Table 10: Word Count all provided documents, Source: own research

Within a total of 1344 documents, the word *safety* was used 13849 times resulting in an average of roughly 10 times per document.
In addition to the three principles, five dimensions of HROs have been identified in the literature review (see Chapter 2.3.3.2.) that the documents can be referred to:

(1) *preoccupation with failure*

The attention to detail in the presented documents, which describe every aspect of an operational instruction, or the detailed risk analysis performed for each SI or SC shows a strong preoccupation with likely failure.

(2) *reluctance to simplification*

The detailed description of operating principles or the additional information and background, which is provided in every document in a transparent way, shows an attention to details rather than a simplification of a topic.

(3) *sensitivity to operations*

Similar to what has been identified in the three principles, the documents clearly focus on the operations and steps required to run a safe and resilient business, which clearly reflects this dimension.

(4) *commitment to resilience*

Document category 3 provides information on redundancy of technical systems, which is an indicator of resilience. This is the only overt reference to this principle that could be identified.

(5) *deference to expertise*

All documents are signed by a minimum of three different members of staff. As a minimum, this consists of one member of staff (as subject matter expert), one member of managerial staff and one safety oversight member of staff being listed. This provides an assurance that the required expertise is available in the process of document production.

4.2.2 External and internal influence factors

In reviewing the cover pages of each document and their respective contributors, it is relatively straightforward to gauge the kind of influences that the contributors had in mind. The following factors were identified:

i) External

- **Airline**: Airline operating procedures that require special attention. For example, the operation of a Code E aircraft (Airbus A380) needs to be different from other aircraft handling.
- **Airport**: Specific requirements from the airport need to be adhered to. For example, the closure of parking stands and/or taxiways for rehabilitation measures reduces the number of routes available to ATC.
- **National Regulator**: A regulator, such as the CAA or the NSA, publish regulations that must be adhered to by ATC and require changes to operating procedures. The most common publications are Civil Aviation Publications (CAPs), as for example the U.K. CAP670 about Air Traffic Services Safety Requirements (CAA, 2019).
- **International Regulator**: EU Regulations (i.e. 340/2014 on licensing (European Commission, 2015)) require procedures to be changed.
- **Government**: Air shows from military aircraft or military exercises require special procedures that ATC needs to adhere to.

In summary, the external influence comes mainly from customers (Airlines, Airports) or regulatory bodies (CAA, EU, Government).

ii) Internal

- **Safety Requirements**: Internal reporting requirements change subject to company guidelines and require operational procedures to be changed.
- **Engineering**: Availability of systems changes for technical reasons such as upgrades, maintenance or failure, which is managed by the organisation’s´ engineering department and require changes to procedures.
- **Updates and Errata**: Changes and updates to published procedures require attention and corrections, which are identified after initial publication. This in particular shows that the organisation continues to review existing procedures and amend them as required.
- **Project and Development**: Internal projects and the development of new equipment require changes to the operating procedures to run test scenarios in a live environment.
- **Staffing**: Availability and staff training requires changes to operating procedures.

In summary, the internal factors can come from any department that deals with either operational staff, operational equipment or procedures themselves. No direct reference to business needs such as cost effectiveness can be identified from any document.

4.3 Survey Results

In the following chapter, the survey questions presented in chapter 3.7.2.2. will be analysed. The survey has been created with Lamapoll, a German online survey provider, which is fully Datenschutzgrundverordnung (DSGVO) compliant (the German equivalent of the GDRP). Likewise, it is compliant with and certified by the Bundesamt für Sicherheit in der Informationstechnik (BSI), the Federal Office for Data Security in Germany. The analysis has been conducted through the Lamapoll analysis options and SPSS if the options, provided by Lamapoll where not sufficient.

4.3.1 Survey Response Rate

The response rate in the questionnaire differed with the nature of the distribution. The pilot study resulted in a 100% response rate, which is not surprising given the fact that each participant was personally known to the researcher, resulting in higher chances of a contribution. At the same time, the sample size of ten participants was rather small. The response rate for the main part of the survey, which ran from 05.07.2019 until 20.12.2019, was 30.69 percent. In summary, a total number of 409 visitors of the online survey were counted. As the table 11 shows, 303 participants began to fill out the questionnaire, whereas 210 dropped out at some stage during filling in the survey.

Participation-Overview

	Number	Quote
Visitors	409	-
Participations	303	74,08%
Returns	93	30,69%
Drop-outs	210	69,31%

Table 11: Participation Overview, Source: own research

The responses can be classified in two different parts. 40.59 percent of the participants finished questions 1 through to 9, which were questions about the perception of HRO knowledge throughout the organisation. As of question 10, the response rate dropped and gradually declined to reach the final 30.69 percent participation rate. Question 10 and beyond went into the details of either HROT or European regulation and its influence, with questions that required text to be typed in. One reason for the lower response rate might be the higher effort that was required to fill in the survey questions. Another factor was potentially a lower familiarity with the regulation or influence factors. However, no evidence or pattern in the analysed data could be found to support either of these assumptions.
The response rate can be concluded to be representative. The case organisation conducts employee surveys on a regular basis. A member of

the staff development department - responsible for surveys - confirmed an average response rate of approximately 33% across the organisation. This survey sits slightly below the average stated. Taking into account its length (24 questions) and the requested information, it is considered a satisfactory result by the researcher.

4.3.2 Net Promoter Score

The survey results often refer to the Net Promoter Score (NPS). This simple figure, developed by Frederick F. Reichheld (2003), express a tendency between the range of a strong critic (detractor) and a strong promoter. To derive the net promoter score out of the participants' ratings, the scale is divided into three areas:

- Participants who gave nine or even ten points are promoters
- Participants who gave seven or eight points are considered as neutral and are not taken into account regarding the calculation of the net promoter score
- Participants who have zero to six points are counted as critics or detractors, since they are not very familiar with the principles of HRO.

To calculate the net promoter score, the percentage of critics is subtracted from the percentage of promoters. The net promoter score always lies between -100 and 100. Lower numbers would refer to an expression such as “strongly disagree”, with higher numbers best described as “strongly agree”. Whilst this value is typically widely applied in marketing (Fisher & Kordupleski, 2018), it is also beneficial to this research, providing an easily calculated and applicable number that can express a prevailing tendency among respondents.

4.3.3 Sociodemographic Data

It must be said that the population of the results presented in this chapter is not the same for every question. This provides an explanation as to why some people did answer a specific question and some did not. In order to show the difference in replies, any question in the survey results will provide the overview on number of replies in case relevant to the replies.

The analysis of sociodemographic data was focussed on data, relevant to the study, The most relevant information is regarding the area of business alongside managerial level the respondents are located as they will be used for further detailed analysis later in this chapter. More data has been collected such as age areas, country of origin but also whether a participant likes to receive a copy of the final study. The data can be found in Appendix B but will not be taken into account in the analysis.

Initially, employees were asked which area of the organisation/business they considered themselves to work in. Figure 22 shows that most of the participants (76.6 percent) work in the operational area, whereas only 23.4 percent work in the non-operational business. As this might point towards a one sided view on the questions asked, the results are provided in a way to show differences between the two business areas to increase validity. Questions in this chapter will also provide an overview of the replies given by each area alongside other breakdowns.
It is important to note that the question used the term *business* rather than operational support as for most employees the common terms are *operations* and *business* area. However, for the purpose of this research business is *synonymous* to *operational support.*

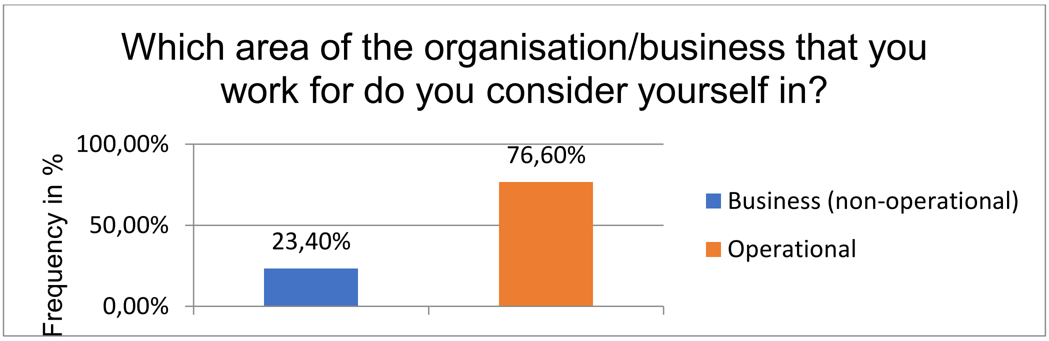

Figure 22: Working Area of the Participants, Source: own research

When questioned about their role at work, the majority (60.64) answered with ATC, followed by training (8.51 percent). As can be seen from the following figure, 12.77 percent answered “other” and specified this option in a second input field.

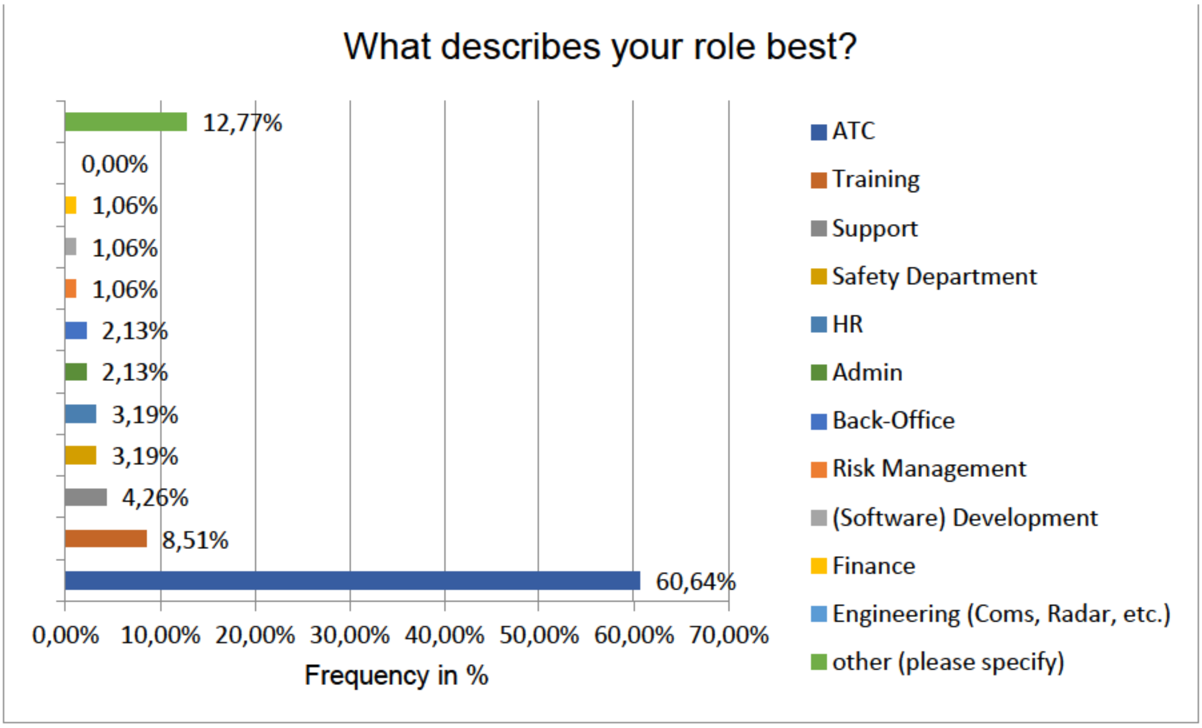

Figure 23: Participants' Role in Working Life, Source: own research

The replies in the field “other” were then manually assigned by the researcher to one of the pre-defined categories in the following way:

Answer	Assignment
academy	Training
Advisor	Support
ATC with numerous additional Tasks (and insights) with a new Management role	ATC
Compliance with regulations	Risk Management
Commercial	Finance
Military Advisor	Support
Operations Development	Support
Project office	Support
Project Manager	Support
R&D	Engineering
Stakeholder Relations	Support

Table 12: Assignment of other replies, Source: own research

Additionally, employees were asked what level of management they consider themselves in. Figure 24 shows the distribution of different management areas. Most of the participants considered themselves in the non-line management bracket (44.57 percent), followed by basic management (32.61 percent), senior management (16.3 percent) and finally executive management (6.52 percent).

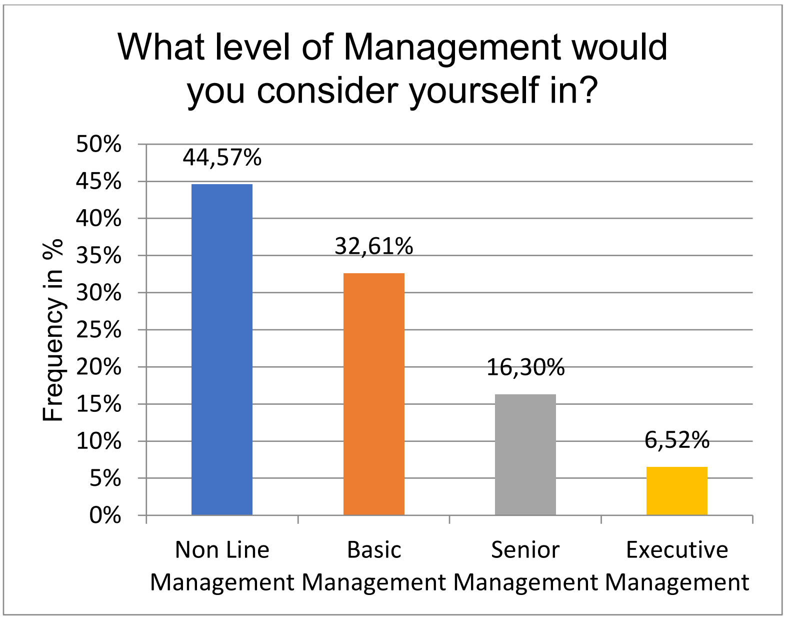

Figure 24: Participants' Level of Management, Source: own research

4.3.4 **Familiarity with HRO Principles**

HROT states that all information is available to anyone within the organisation and that any member of the organisation is aware of the principles. The first part of the survey investigated how familiar the participants are with the principles of HRO.

i) How familiar would you consider yourself with the principles of High Reliable Organisations?

In question 1, participants had to rate their familiarity with HRO principles on a scale of 0 to 10. Figure 25 shows the results. 30.54 percent can be rated as so-called promotors of HRO-principles, whereas as many as 57.14 can be rated as critics, since they are not familiar with HRO-principles. However, it is notable that several of the respondents gave negative answers, which also impacted the results. This might be interpreted as demonstrating their total lack of familiarity with the principles.

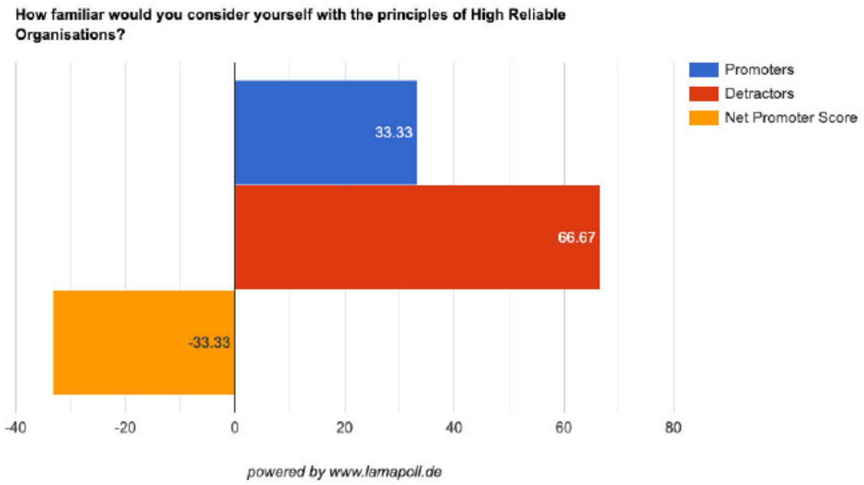

Figure 25: Results Survey Question 1, Source: own research

In the graph above, the net promoter score is at -26.6, meaning that there is a tendency across all participants to consider themselves rather unfamiliar with the principles of HRO. A breakdown into the different management levels of the organisation paints a similar picture:

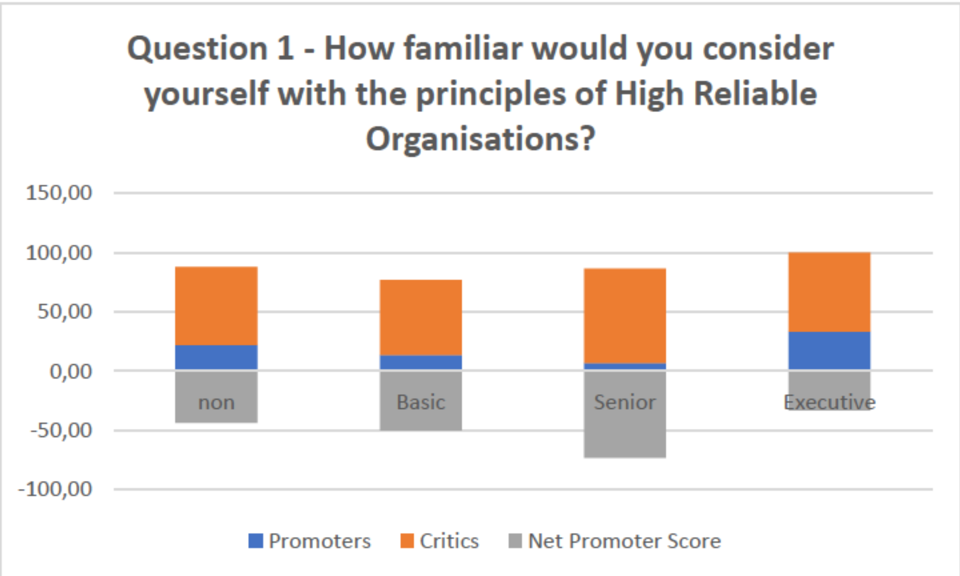

Figure 26: Comparison of Management Levels in Q1, Source: own research

The only small exception was in executive management, where, although still negative overall, there was a tendency to be more confident about one's own knowledge of the principles. Senior management staff tended to be the least confident about their own knowledge of HRO principles. Non-managerial staff and basic management level staff showed a similar level of confidence (or lack of confidence) in their knowledge.

ii) How familiar would you consider your superior with the principles of High Reliable Organisations?

Question 2 focussed on the familiarity with HRO-principles of the participants' supervisors. Figure 27 shows the results. In contrast to question 1, there are even more critics and less promoters, with the net promoter score at -39.11 across all employees. This shows that even with a relatively low confidence of their own knowledge, perceptions of knowledge among supervisors tended to be even more subject to critique.

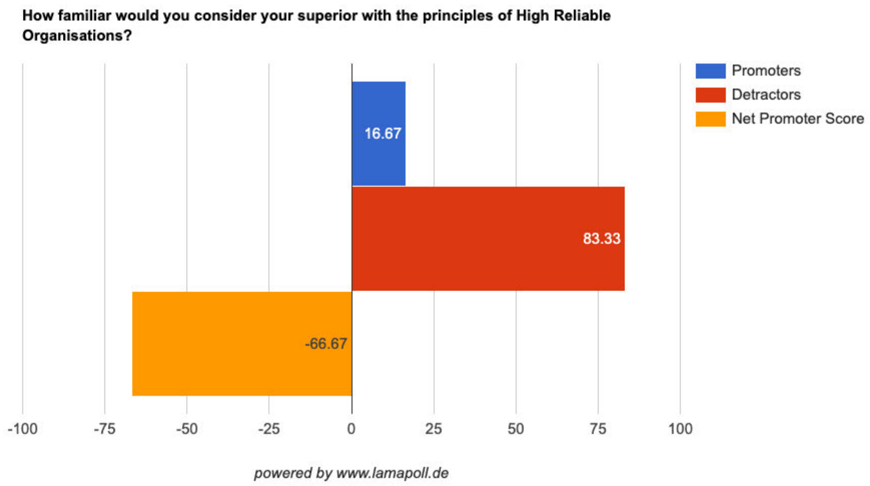

Figure 27: Supervisors' Familiarity with HRO Principles, Source: own research

This shows that - in most of the employees' opinions - their supervisor is not particularly familiar with HRO principles. A NPS of -66.67 shows a very strong inclination towards little familiarity.

The comparison of the managerial level shows that the non-managerial level and senior management staff consider their own knowledge similar to the knowledge of their superiors, whereas basic management and executive management considers the level of knowledge significantly lower.

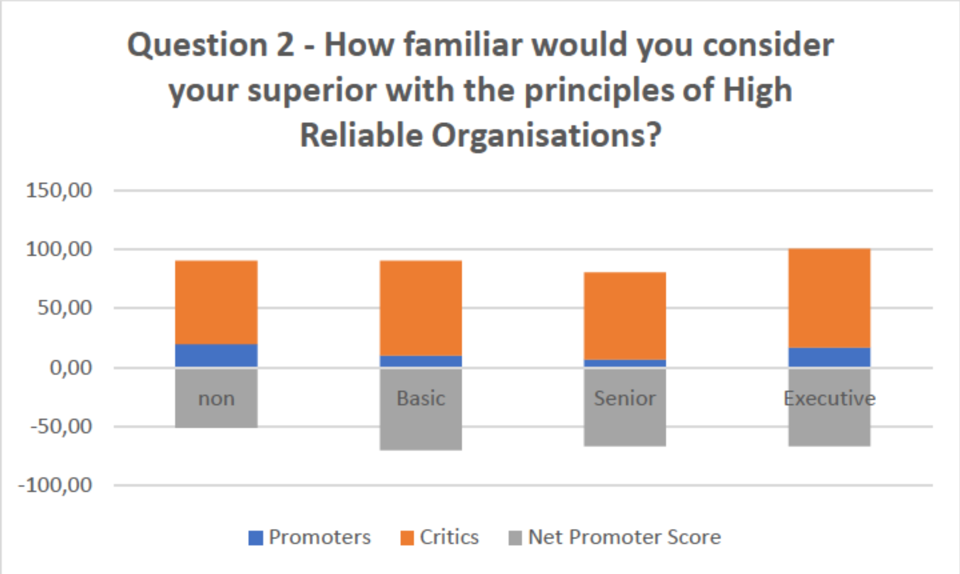

Figure 28: Comparison of Management Levels in Q2, Source: own research

To compare the results of questions 1 and 2, while there may be a general view that superiors will have a greater understanding of HRO's, there does appear to be a correlation between the two views. Those who had a greater personal perception of their own understanding of HRO's also believed their superiors had a higher level of HRO understanding, as evidenced by the scatter chart below in figure 29. The trend line shows a very close correlation, and the R^2 statistic of 0.8529 indicates a strong correlation between the two variables, reinforced by the equation of the line also shown in the graph. Within the context of this research, it may be argued that this result supports the hypothesis that there is a direct relationship between an individual's familiarity with HROs, and their perception of their superior's familiarity with HROs

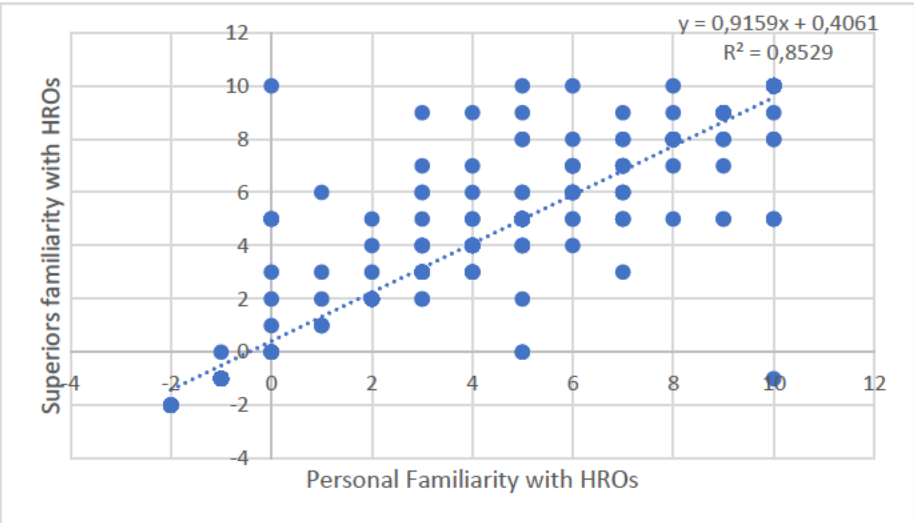

Figure 29: Comparison of Personal Familiarity with Perceptions of Superiors' Familiarity with HROs, Source: Own research

iii) How familiar would you consider your colleagues with the principles of High Reliable Organisations?

In question 3, participants were asked to think about their colleagues' familiarity with HRO principles.

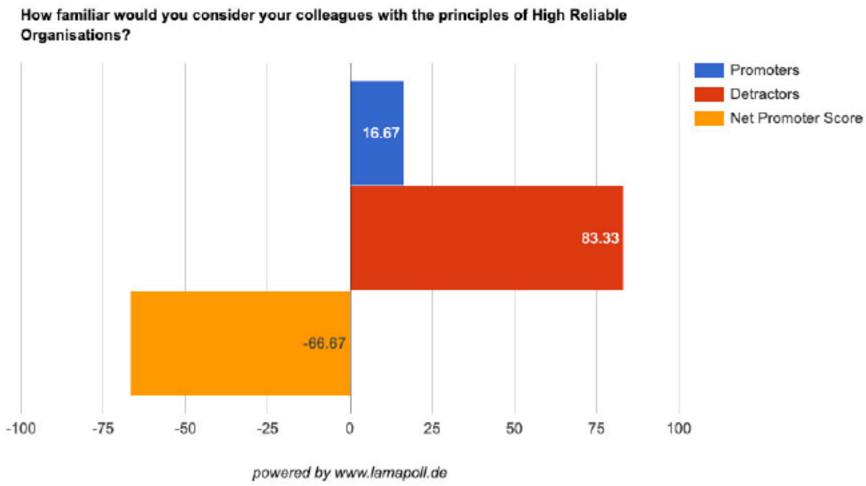

Figure 30: Colleagues' Familiarity with HRO Principles, Source: own research

The result is the same as in question 2, in participants across all managerial levels believed their colleagues had a lower familiarity HRO principles than their themselves. The breakdown into the different management layers shows a slight difference to the previous question:

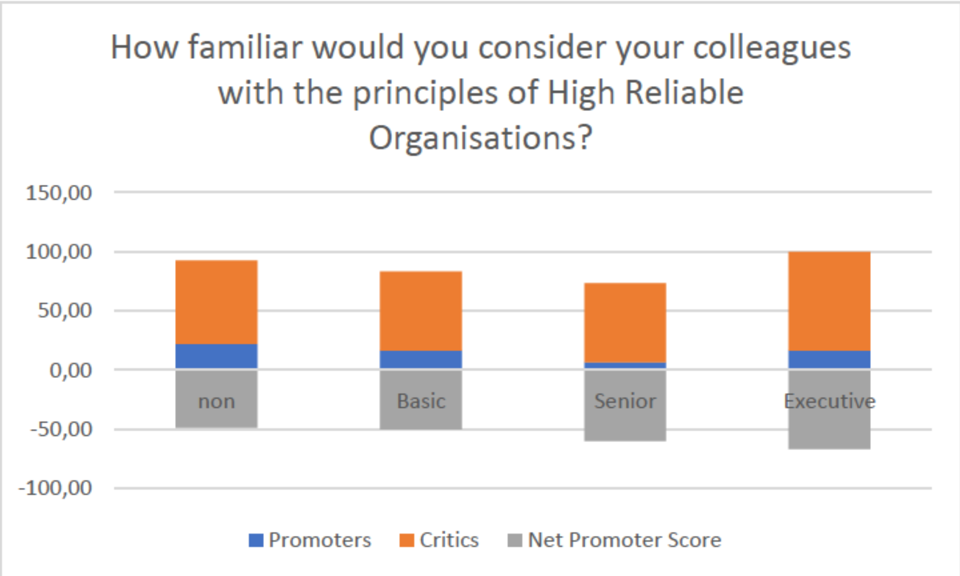

Figure 31: How familiar would you consider you colleagues with the principles of HRO, Source: own research

Non-management staff and the Basic Management level hold a similar view, whereas senior management and executive management levels share the opinion that their colleagues are less familiar. Again, there appears to be a direct correlation between the views an individual has about their own familiarity with the principles and the perception that they have of their colleagues' familiarity. This is illustrated in figure 32 where there is a clear upward sloping trend line with an R^2 value of 0.8529.

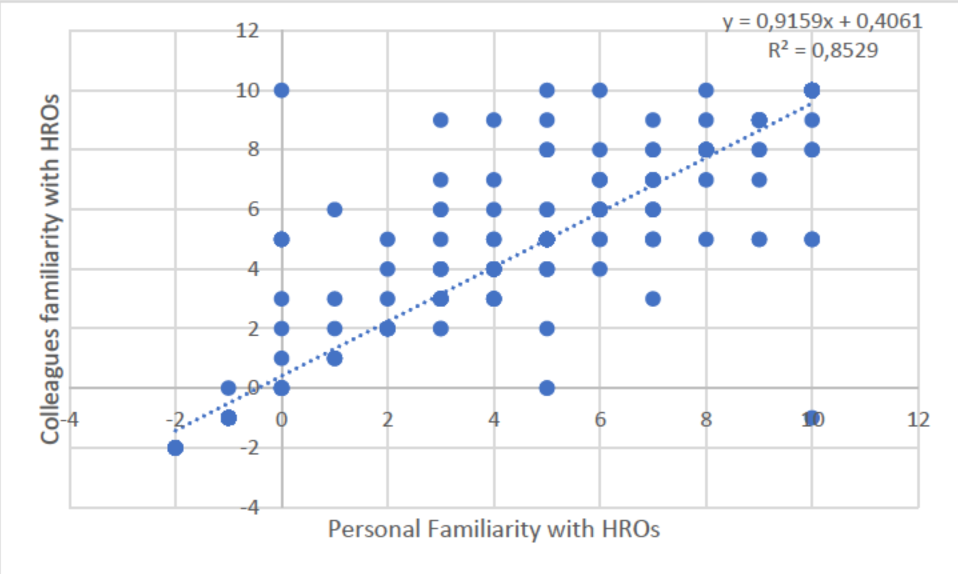

Figure 32: Comparison of Personal Familiarity with Perceptions of Colleagues Familiarity with HROs, Source: own research

This suggests that the sample was highly aligned, and any beliefs of the familiarity of others appear to be related to the individual responses regarding their own level of familiarity. Interestingly, when looking at the equations for the trend lines, it appears that there is a greater propensity for the respondent to believe their colleagues have a slightly higher level of knowledge compared to their own, whereas their superiors are deemed to have a level of knowledge closer to their own. As an overview on the initial three questions, the following figure 33 shows the results next to each other:

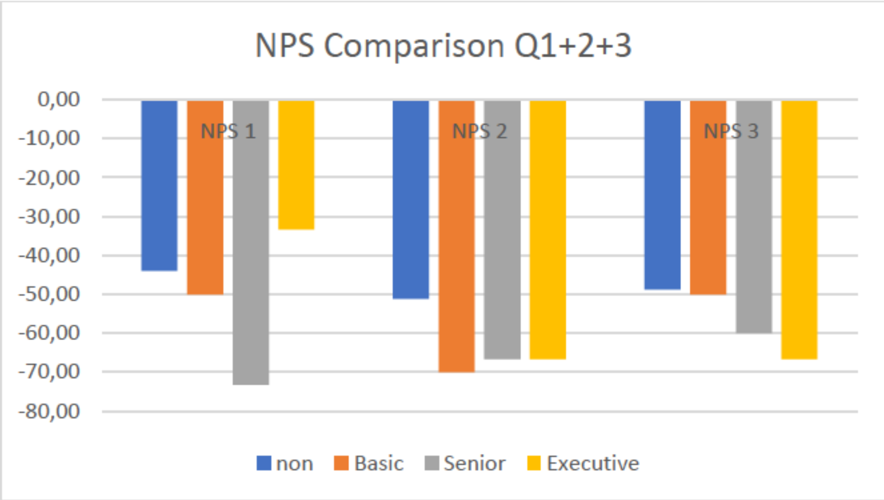

Figure 33: NPS Comparison questions 1,2, and 3, Source: Own research

The participants' perceptions of familiarity with HRO principles across all levels and among their own colleagues was notably low. The Senior management staff results are of significance as they do not consider themselves familiar with these principles, while the non-management staff (blue) was at a relatively consistent level.

iv) Please fill in three keywords that describe HRO

With question 4, participants were asked to fill in three keywords that describe an HRO. The question aimed to understand whether - independent of the answers in Q1-3 - the participants were able to name standard HRO keywords.

126 people answered the question, and the word cloud below shows the top 10 most frequent replies for each keyword. The bigger the word appears, the more often it has been mentioned. *Safety, honesty* and *redundancies* are the most common answers when the respondents thought about HROs, followed by *integrity*, *resilience* and *security*.

Figure 34: WordCloud Q4, Source: own research

Some of the most common key terms that were identified in the literature review were safety, redundancy and resilience, hence why there is a clear reference to HROT in the keywords provided by the participants. Table 13 below summarises the top 4 words, which clearly indicate their relevance.

Term	Frequency
Safety/safety and terms including safety	19
Resilience/resilient and similar words	8
Redundancy/redundant and similar words	7
Responsibility/responsible and similar terms	6

Table 13; Top 4 Term, Source: own research

Of the 177 different terms that were counted when tallying the different terms, it is notable that only 11 terms were not directly relatable to HROT, with terms such as ‘no outside advertising’, ‘none’ and ‘Y’ among the unrelated phrases. This is remarkable given that the individual perceptions (in reference refer to Q1-3) were very negative.

v) What is the most important element of a highly reliable organisation?

Whilst question 4 asked for three keywords, question 5 asked respondents to think about the most important elements of HROs. As question 5 was an open question, participants had the chance to fill in their individual opinions. 105 different answers were provided in sentence form by the participants. A quick glance at the word frequency shows the general trend of the individual statements. Next, a semantics search was conducted to extract the meaning of the sentences in relation to HROT.

The top 3 words used by the participants were safety (24 times), organisation (19 times) and reliable (16 times). This means that around 25% of the replies referred to safety alone. For example, one participant stated *"A HRO is able to maintain a safe operation in a highly dynamic environment and never stops looking for possible weaknesses and drifts, in order to eliminate them before they might result in unwanted outcomes"* whereas another one said *"Highly skilled professionals who need a good management with a realistic plan and trust in their workers. Redundancy on all levels. A just culture to learn from mistakes".*

These two statements contain references to all five dimensions of HRO. Similar statements can be found amongst the participants' replies, which also strengthen the image of understanding of HRO dimensions and principles.

vi) Which of the following principles would you consider essential for HRO?

Question 6 asked participants to choose up to five principles that they would consider essential for HRO. This question offered all participants some words to choose from, in contrast to the previous questions, where no guidance was given. This question was constructed in a multiple-choice format, as this would provide all five dimensions of HROT alongside others to find out, whether the key terms from literature were known to the participants. Due to a failure in the survey, only four of the five principles were offered to the participants. The fifth principle, “deference to expertise”, was not an option.

Figure 35 shows the results: Again, the aspect of safety was of the highest importance for most employees (86.99 percent), followed by sensitivity to operations (72.36 percent), commitment to resilience (69.92 percent), preoccupation with failure (38.21%) and reluctance to simplification (26.83%). All four offered dimensions of HROT were mentioned in the top

5 replies amongst all participants. Yet again, the knowledge of HROT principle can be seen from this question.

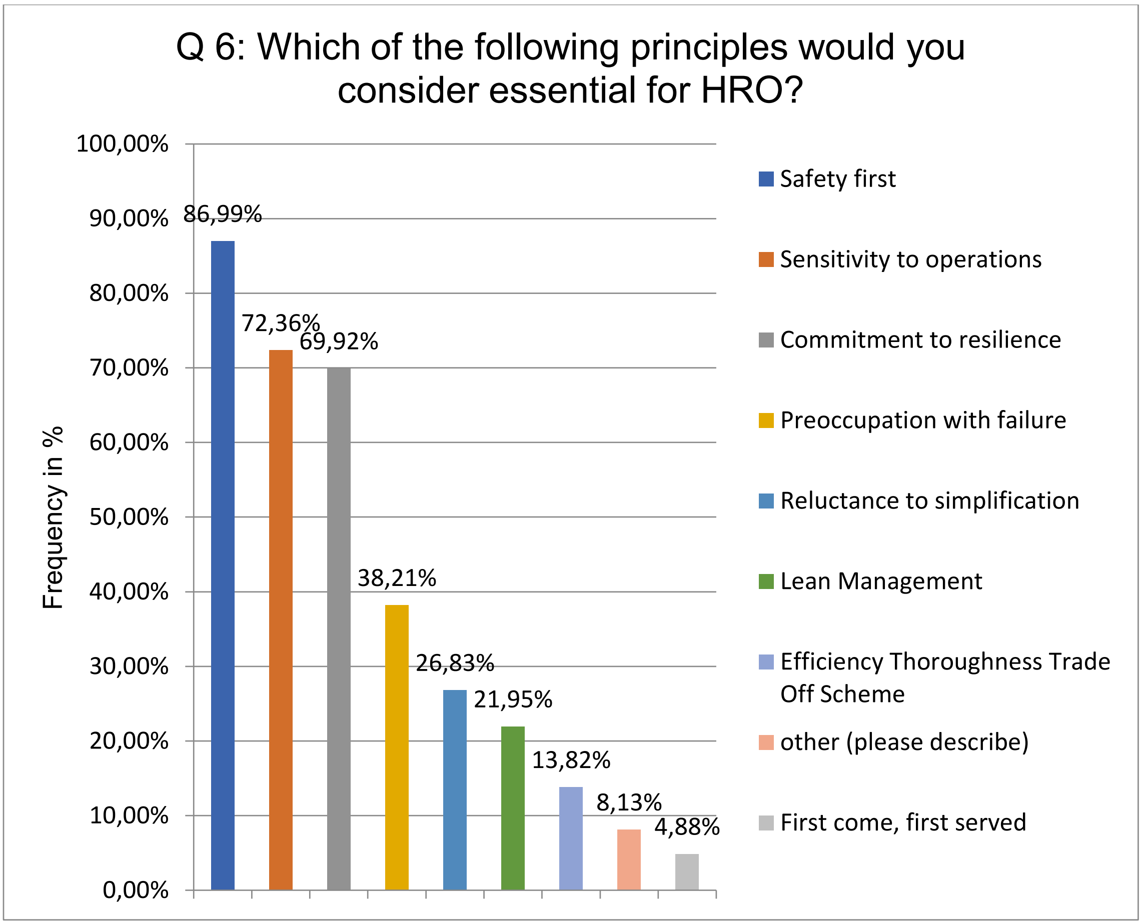

Figure 35: Essential Principles for for HROs, Source: own research

ix) How well would you consider the HRO knowledge of the other area in your organisation?

Question 7 and 8 will be addressed in the following chapter regarding how the principles are adhered to within the organisation. The final question in the survey that focusses on familiarity is question 9, where the participants were asked to give their opinion about the other area in the organisation. As mentioned in the literature review, ANSPs have two major areas, operational and non-operational. This question addresses these two areas. Participants that consider themselves operational would give their opinion about the non-operational area and vice versa. The result shows that non-operational staff consider knowledge among operational staff to be higher than their own. Operational staff mirror this, believing knowledge among non-operational staff to be lower than their own.

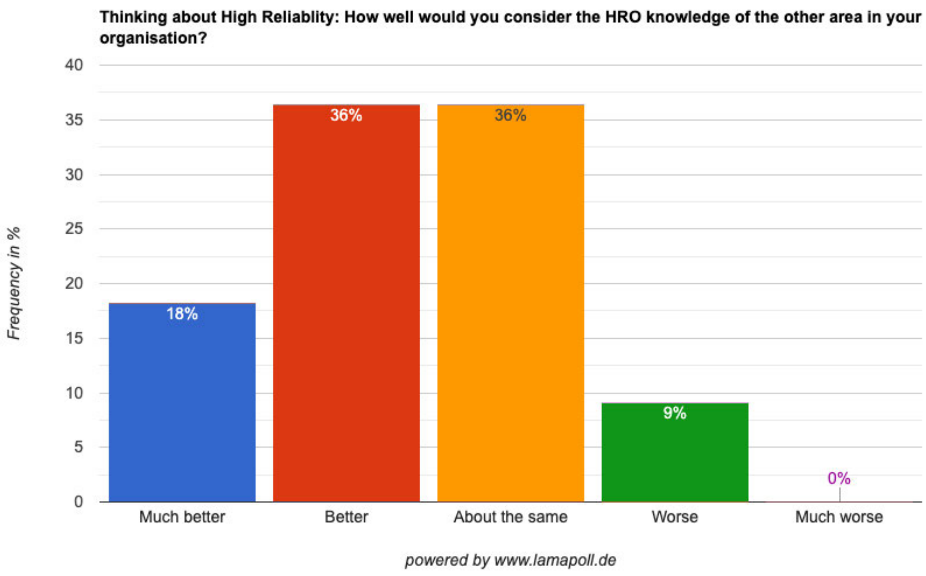

Figure 36: HROT Knowledge of operational arera as seen by non-operational, Source: own research

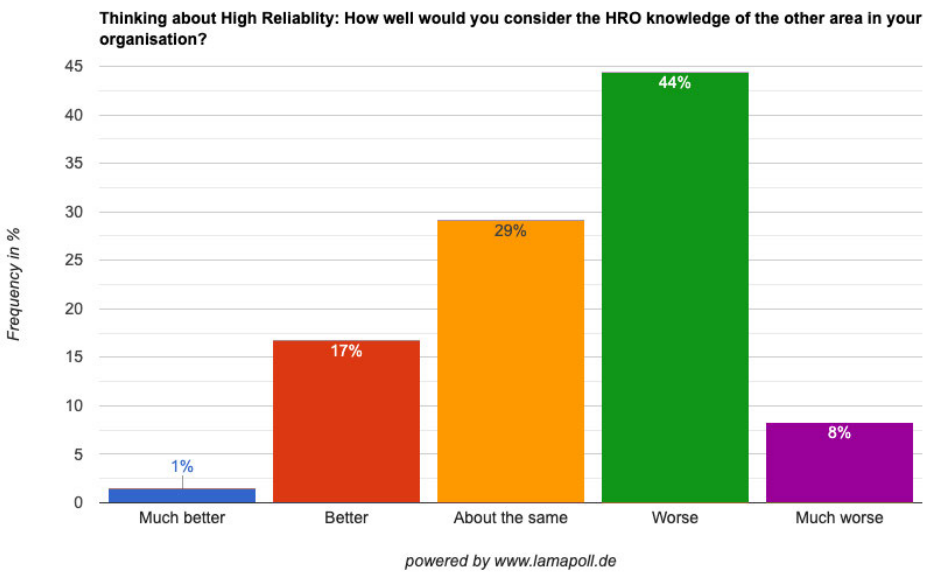

Figure 37: HROT Knowledge of non-operational area as seen by operational, Source: own research

4.3.5 **Following HRO Principles and Regulation**

In the previous chapter, the results of questions relating to the participants' own opinions surrounding familiarity with HROT principles were presented. A satisfactory intermediate summary would be that participants see their own familiarity as higher than that of others. In particular, senior management considers their own familiarity the lowest in comparison to other management levels. Moreover, the estimation of familiarity within non-operational area is lower than in the operational area, a trend confirmed by all participants. However, all participants were able to name and identify key principles of HROT with little difference between managerial levels, hence why a good knowledge of the principles can be assumed. The following chapter will now show the participants' opinions of how well the organisation adheres to the HROT principles.

vii) How close does your day-to-day work environment include the HROT principles into the work?

In the previous set of questions, the principles of HROT have been shown to the participants towards the end of the set. This will aid participants who are potentially not as well informed about the background to this set of questions. The first question regarding this was how whether each employees' day-to-day work environment included the HROT principles into work. On a scale from 0 to 100, participants were asked to rate the involvement of HROT principles in their work.

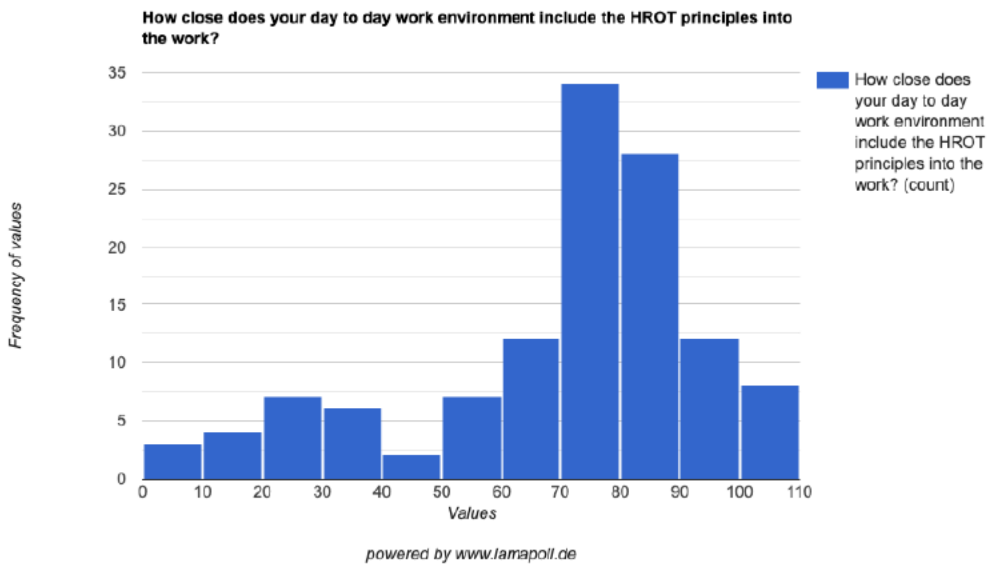

Figure 38: How close does your day to day work environment include HROT, Source: own research

As the data shows, participants consider the integration to be at a fairly high level. An average inclusion of 68.29% was found in the survey.

Mean	68,29	Median	75	Standard Deviation	24,00

Table 14: Including HROT Principles into Work, Source: own research

Even with a standard deviation of 24 - mostly due to the few very low values - the median of 75 supports the opinion of a high inclusion into daily work.

viii) How often are the HROT principles or related topics part of chats at your workplace (on a break, at the desk, over a coffee, etc.)?

It is not only the direct workplace that is of high interest to the present thesis. People might talk about HROT principles during their break, at their desk, over a coffee and so on. Hence, within the scope of question 8, participants were asked how often HROT principles or related topics are part of informal workplace conversations. Table 15 below shows that on a scale from 0 to 100, some employees chose 100 points whereas some chose zero points. In summary, an average of 48.86 and a median of 54.5 represent the entire sample's ratings.

Average	48,86	Median	54.5	Standard Deviation	26.87

Table 15: HROT Principles as Part of Chats, Source: own research

It is illuminating to look at the relationship between the presence of HROT practices and the degree to which the concepts associated with HROT are discussed. This does appear to display a moderate correlation, with an R^2 result of 0.6899. A score of 0.7 would be required to argue that this is a strong relationship. The finding seems to support the hypothesis that higher amounts of discussions about HROT increase HROT practices.

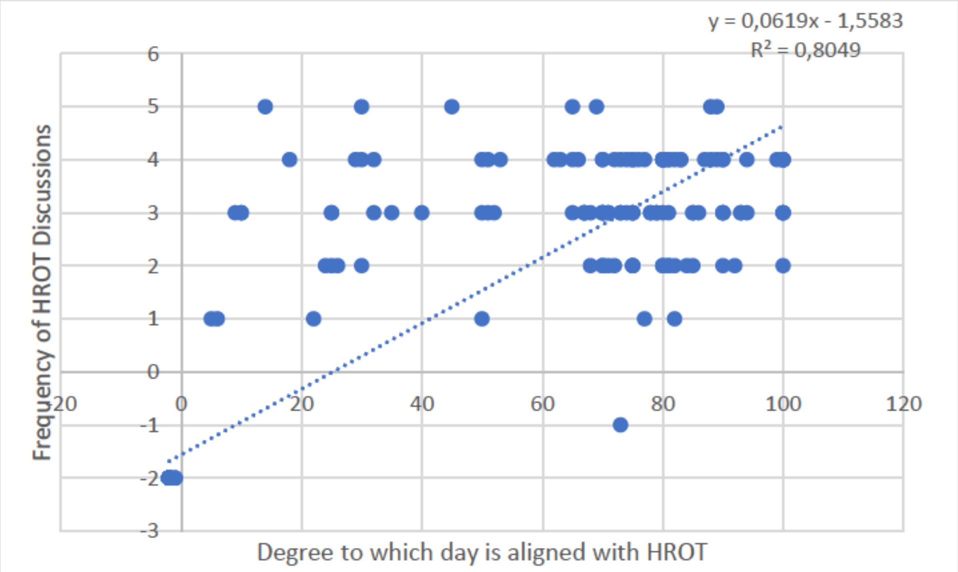

Figure 39: Frequency of HROT Discussions, Source: own research

With the scores, it is also possible to statistically test the relationship between these two variables. In a paired samples correlation (Pearson Correlation) rather than a regression analysis, the relationship appears stronger, at .830. The relationship may also be assessed using a pair t-test; this gives a t-test, shown in table 16. With the extremely low p values it becomes clear that the probability of gaining these results by chance was very low. Therefore, there is a clear relationship between these two variables.

	Question 7 - Degree to which day is aligned with HROT	*Question 8 - Frequency of HROT Discussions*
Mean	26.54455446	18.48185
Variance	1429.533604	915.8598
Observations	303	303
Pearson Correlation	0.830610309	
Hypothesized Mean Difference	0	
df	302	
t Stat	6.656196631	
P(T<=t) one-tail	0.00000000006616	
t Critical one-tail	1.649914828	
P(T<=t) two-tail	0.00000000013	
t Critical two-tail	1.967850227	

Table 16: T-test for Relationship between Daily Practices aligned with HROT and Presence of Discussions regarding HROT, Source: own research

x) What do you think, how did your daily work environment follow these principles before 2012?

As has been identified in the literature review, economic regulation started in 2012. If the perception of the presence of HROT principles changed from before 2012 to today, this would give a strong indication of a potential external influence from the regulation. There is no data available from before 2012, hence why this question is the only viable approach to achieve this.

As figure 40 below shows, most of the participants (53.39 percent) believe that HRO principles were followed to about the same extent before 2012 as they are today. The percentages on the left side (much better and better) and the percentages on the right side (worse and much worse) are nearly the same: 23.73 percent believe they are “better/much better” and 22.88 percent believe they are “worse/much worse”.

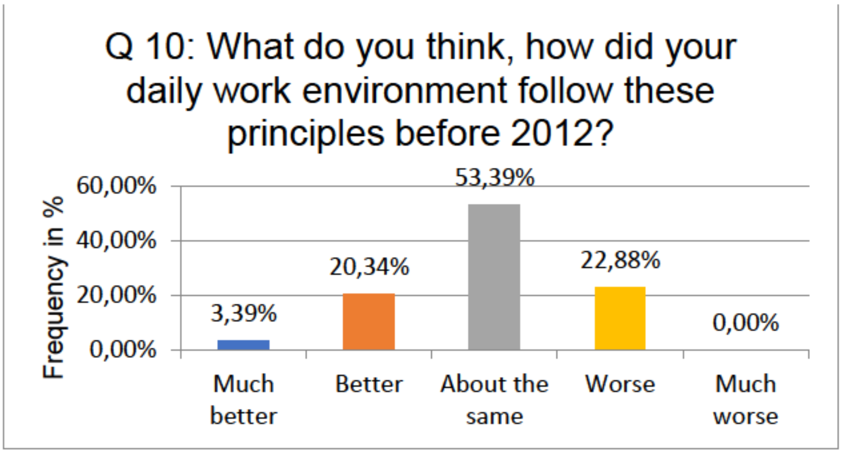

Figure 40: HRO Principles before 2012, Source: own research

The result shows an almost exact 50/50 split, which does not return reliable data to base a statement on it. Further analysis is thus required. The first consideration was to assess the degree to which the answers for the current time and that of before 2012 were aligned, to determine any possible divergence. This can be assessed with a scatter chart to identify the potential presence of a correlation. The results suggest there is a strong correlation with the R^2 of .8049, with the pattern showing that while there is a positive correlation, the pattern indicated by the equation shown in the top corner of the graph dictates that the higher the perceived performance in 2012, the higher that perception will be today.

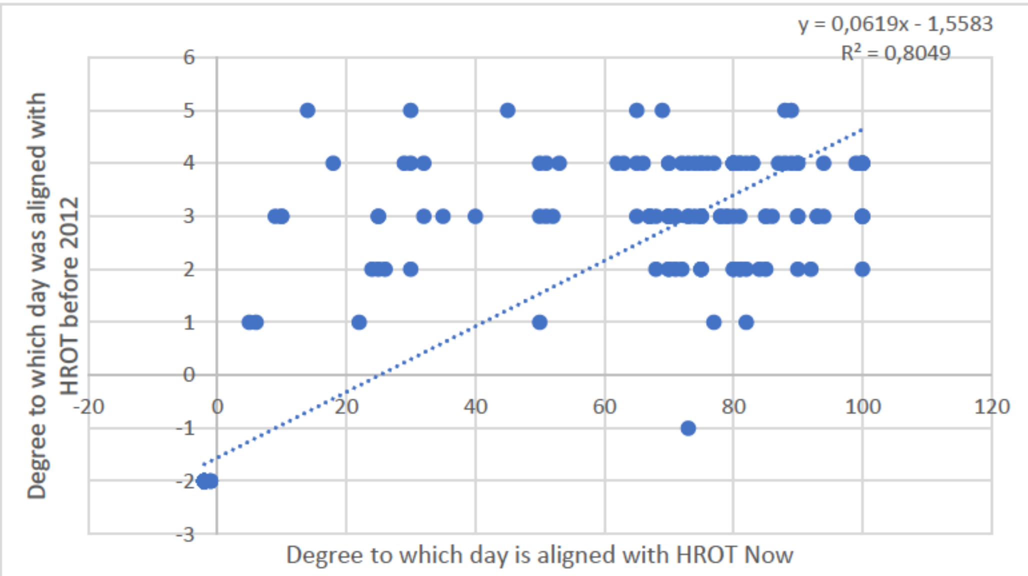

Figure 41: Correlation of HORT now and before 2012, Source: own research

This can also be subjected to a T-test, presented below in table 17. This demonstrates that there is a negligible probability that these results were obtained by chance, and that past levels of HROT practices are directly related to current levels.

	Question 7 - Degree to which day is aligned with HROT Now	*Question 9 - Degree to which day is aligned with HROT Before 2012*
Mean	26.54455446	0.085809
Variance	1429.533604	6.813805
Observations	303	303
Pearson Correlation	0.897139268	
Hypothesized Mean Difference	0	
df	302	
t Stat	12.97873776	
P(T<=t) one-tail	0.0000000000	
t Critical one-tail	1.649914828	
P(T<=t) two-tail	0.0000000000	
t Critical two-tail	1.967850227	

Table 17: T-test to Assess the Relationship between HROT practices in 2012 and Now, Source: own research

xi) Please describe briefly, what the main reason for your answer is? Question 11 tried to further elucidate why the participants answered as they did in the question before. For this question, employees were offered a free input box, which is why not all of the answers can be presented in this chapter. For a better overview, 5 representative replies from 3 different clusters of participants were selected, which were - in the researcher's opinion - relevant to the thesis. The three clusters consist of participants who answered question 10 with 1) *better* or *much better;* 2) *about the same;* 3) *worse* or *much worse:*

As the organisation has group improved structures and expertise has been developed.
Communications have improved
Lessons learned out of the past. Stronger Regulator
More awareness
Repetition of safety aspects and Knowledge

Table 18: Replies of Group one on Q11, Source: own research

Aviation is a safety critical therefore reliability critical environment
Aviation is slow to adapt in some areas and changes do not take effect quickly.
HROT principles already part of ATC culture
regulation
Safety first has always been the main consideration.

Table 19: Replies of Group 2 on Q1, Source: own research

Before 2012 I had the impression that systems and procedures were tested more carefully.
cost efficiency ruled over safety
EU regulations developed
More regulation than before
The demands in the airspace is higher and with higher demands comes more efficient solutions.

Table 20: Replies of Group 3 on Q11, Source: own research

It becomes clear that many employees believe that, before 2012, more tests, less cost pressure and lower demand were present. After 2012, more and more cost aspects appeared, and people were of the opinion that the focus has changed from safety to economy. The majority of participants (53.39%) believed that there was no (perceived) change from before 2012 to after 2012, mainly due to the high attention to safety in the business, but also due to the inclusion of HROT into the organisational culture, which had already begun prior to 2012.

Note: The relevance and importance of this particular year is in reference to the introduction of the European Regulation for ATC in 2012. This was considered a critical change in the approach to air traffic control as it introduced market economics through regulation, which has already been touched on in the literature review. It is important to understand whether there is any evidence that suggests an impact on HRO principles.

As the following Chi-2-Test shows, there is no significant difference between the management level (non-line, basic, senior and executive) and how participants rated the question “How did your daily work environment follow these principles before 2012”.

Chi-Quadrat-Test			
	Value	df	asymptotic approximation
Pearson-Chi-Quadrat	12,114[a]	9	0,207

Table 21: Chi-2-Test for Line-Management level vs. Q10, Source: own research

What level of Management would you consider yourself in? * Question 10 - What do you think, how did your daily work environment follow these principles before 2012? Cross-Table							
			Question 10 - What do you think, how did your daily work environment follow these principles before 2012?				
	Management		Much better	Better	About the same	Worse	Total
What level of Management would you consider yourself in?	Non Line	Responses	0	9	19	13	41
		Expected	0,9	8,9	21,8	9,4	41,0
	Basic	Responses	1	5	19	5	30
		Expected	0,7	6,5	16,0	6,8	30,0
	Senior	Responses	0	5	8	2	15
		Expected	0,3	3,3	8,0	3,4	15,0
	Executive	Responses	1	1	3	1	6
		Expected	0,1	1,3	3,2	1,4	6,0
Total		Responses	2	20	49	21	92
		Expected	2,0	20,0	49,0	21,0	92,0

Table 22: Chi-2-CrossTable Line-Management vs. Q10, Source: own research

Additionally, potential differences between the participants' area of business (non-operational and operational) and their opinion of whether the daily work environment has followed HRO-principles before 2012 have been analysed. As table 23 and 24 below show, there is no significant difference.

Chi-Quadrat-Test			
	Value	df	asymptotic approximation
Pearson-Chi-Quadrat	4,961[a]	3	0,175

Table 23: Chi-2-Test for Business Area vs. Q10, Source: own research

Which area of the organisation/business that you work for do you consider yourself in? * Question 10 - What do you think, how did your daily work environment follow these principles before 2012? CrossTable							
			Question 10 - What do you think, how did your daily work environment follow these principles before 2012?				
	Business Area		Much better	Better	About the same	Worse	Total
Question 19 - Which area of the organisation/business that you work for do you consider yourself in?	Business [non-operational]	Responses	0	2	12	8	22
		Expected	0,5	4,9	11,5	5,1	22,0
	Operational	Responses	2	19	37	14	72
		Expected	1,5	16,1	37,5	16,9	72,0
Total		Responses	2	21	49	22	94
		Expected	2,0	21,0	49,0	22,0	94,0

Table 24: Chi-2-Cross Table Business Area vs. Q10, Source: own research

4.3.6 Influence Factors

In the previous chapter, the main focus was on identifying how well each organisation followed the HROT principles. Alongside that, some influence factors were mentioned, such as *(EU-)regulation* or *economic pressure.* This chapter will now present the results of the survey that specifically addressed the influence factors on HRO principles.

xii) The European Regulation for ATC introduced four main areas with which ANSPs are monitored, measured and regulated today. Please order the four areas from top (biggest influence on your organisation) to bottom (least influence on your organisation).

From the literature review, the European Regulation for ATC has already been identified as an influence factor as its purpose was to set rules for ANSPs. It introduced four main areas with which ANSPs are monitored, measured and regulated today. In question 12, participants were asked to order these four areas from top (highest influence on their organisation) to bottom (lowest influence on their organisation). Table 25 below shows that “introduction of performance scheme” has the highest influence, whereas “functional airspace blocks” comes in at fourth.

Main Area	Average	Position
Introduction of Performance Scheme	1,738	1
Introduction of European Network Manager	2,476	2
Revised Charging Scheme	2,845	3
Functional Airspace Blocks	2,942	4

Table 25: Ordering the Performance Scheme Areas, Source: own research

It is clearly shown in the data that amongst all respondents, the introduction of the performance scheme has been ranked highest the most often (on average the position is 1.738 out of 4). Meanwhile, the other three areas are very close together. A closer look at the difference in managerial levels reveals that all managerial levels have the same positioning, but with different weighting. Whereas the non-managerial staff sees all areas apart from the performance scheme as being of very similar levels of importance (similar to the overall result), management staff showed a clear tendency value the Introduction of the Network Manager more, whilst valuing the Charging Scheme and/or the Functional Airspace Blocks less. This might be related to the fact that non-managerial staff have little to no direct link to the activities of the network manager.

Area	non	basic	Senior	executive
Introduction of Performance Scheme	1,902	1,733	1,333	1,5
Introduction of European Network Manager	2,439	2,533	2,333	2
Revised Charging Scheme	2,829	2,6	3,133	3,167
Functional Airspace Blocks	2,829	3,133	3,2	3,333

Table 26: Ordering the Performance Scheme Areas subject to managerial levels, Source: own research

In another way of viewing the results, a further breakdown of the two business areas shows a slightly different perspective. The operational staff place the Functional Airspace Blocks in fourth place and the Charging Scheme on third place, whilst the non-operational participants put them the other way around.

Area	non-ops	operational
Introduction of Performance Scheme	1,5	1,819
Introduction of European Network Manager	2,545	2,403
Functional Airspace Blocks	2,864	3,056
Revised Charging Scheme	3,091	2,722

Table 27: Ordering the Performance Scheme Areas subject to business area, Source: own research

xiii)Would you provide a brief statement on what made you choose your order?

To further investigate the motivation of the participants for selecting the order in question 12, they were once again asked to provide a brief statement on what made them choose their order. Analogous to the other open questions that have already been presented, the following statements do only represent a selection from 99 different answers. The top ten answers, chosen by the researcher, are as follows:

- The performance scheme relates to delay which is probably the most relevant to XXX and hence goes top
- Change of charging scheme led to less controllers, which has a big influence in our daily work right now
- FAB & charging have little impact on the direct application from the ANSP
- FABs are not working, are theoretical nonsense, are of political nature and have not fulfilled the expectations
- Faster, better, cheaper = European performance scheme - hence the issue that we encounter today
- Network management is the prerequisite for all the others
- Performance is highly important and performance scheme drives our business strategy

- The NM has probably the biggest influence and impact for the European ATM system
- Functional airspace blocks are theoretical non-sense. Performance schemes as well.
- As operational staff, charging system and FABs are given facts from admin. NM and performance needs are experienced on a daily basis.

xiv) As part of the performance Scheme, the European Regulation set out specific targets in four areas for any ANSP. Please order the four areas below from top (biggest influence on your organisation) to bottom (lowest influence on your organisation).

In question 14, participants were asked to order the four areas from top (highest influence on their organisation) to bottom (lowest influence on their organisation). As table 28 shows, capacity of airspace came in at first place, whereas environmental targets took last place.

Main Area	Average	Position
Capacity of Airspace	1,835	1
Cost of Service	2,291	2
Safety (monitoring only)	2,388	3
Environmental Targets	3,485	4

Table 28: The Four Areas for ANSPs, Source: own research

To get a better impression of how participants ranked the four areas, figure 42 visualizes the results by means of a bar chart. It represents the percentage of participants that put a certain area at each position. As an example, capacity of airspace has been put on position 1 (highest influence on the company) by 34.95% of all respondents and at position 2 by 50.49% of the respondents. In other words, the capacity of airspace regulation accounts for the highest influence on the case organisation. At the other end, the environmental targets are perceived to have the lowest influence, as they have been put at position 3 by 33.01% of the respondents and at position 4 by 58.25%.

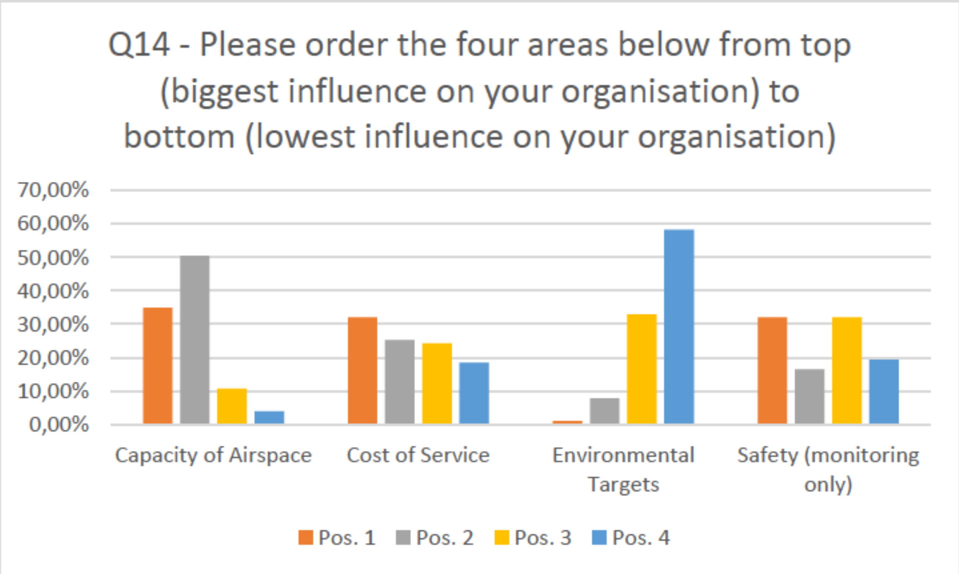

Figure 42: Please order the four areas below from top to bottom, Source: Own Reasearch

The difference between Capacity of Airspace and Environmental Targets is quite substantial. The higher the blue bar the more often it has been placed at position 4. This is almost never for Capacity, whereas it represents the most common choice for Environmental Targets. This could lead to the conclusion that capacity and environmental protection are in conflict with each other.

xv) Would you provide a brief statement on what made you choose your order in Q14?

Following the same approach as in question 12, participants were again asked to provide a brief statement on what made them choose their order. 97 different answers were gathered, with the top ten as chosen by the researcher below:

- Money rules our organization
- Although the 'workers' would like safety to be the priority target - there is a belief that cost cutting to make profit is the priority of those at the 'top'
- As safety has to be paramount for an ANSP all of the targets of the regulation have to follow this

- Attempting to reduce costs has been a challenge for every department/NL and will continue to be so
- Because safety is the highest priority, it doesn't require additional monitoring
- Capacity and cost-efficiency are the main focus areas as safety is a must and always comes first, whatever happens
- Capacity biggest topic right now in every unit, influences even pure business units
- Capacity is most important at the moment followed by cost - environmental targets are less important compared to the others
- Costs and capacity sometimes seems to be more important especially to the airspace users than safety...
- Safety is NOT first, capacity is more important

Many employees returned to the issue of capacity vs. cost-efficiency, which again highlights the influence that it has on the ANSP.

xvi) How would you rate the change/effect from the regulation on your area (operational/non-operational)?

Previous questions focussed on regulation and the influence factors that arise from regulation. Question 16 now asks the participants for a more generic reply. Due to the information provided to the participants in the past questions, even the participants familiar with regulation have some conception about it and its elements. By answering the past questions, they made up their minds and formed an opinion on the matter.
Table 29 shows the results: Whereas some employees even gave zero or 100 points, the average is at 44.76 and the median at 50.

Average	44,67	Median	50
Standard Deviation	23,93		
Lowest Value	0	Highest Wert	100

Table 29: Effect from Regulation on Area, Source: own research

Particularly interesting in this question is the difference in replies between the non-operational and operational area or whether there is a relationship between the two.

Area	Average	Median	std. deviation
operational	42,61	43,5	23,56
non-operational	52,41	57	23,92

Table 30: Effect from Regulation split by area, Source: own research

It becomes clear that non-operational staff consider the influence significantly higher than operational staff.

A Chi-2-Test reveals that there is no dependency as seen in table 31:

Chi-Quadrat-Test			
	Value	df	asymptotic
Pearson-Chi-Quadrat	45,978[a]	49	0,596

Table 31: Chi-2-Test Q16, Source: own research

As it cannot be identified from the current results why there is such a difference in their perspective, the next question might shed some light on the situation as it addresses the same topic from a different viewpoint.

xvii) How would you rate the change/effect from the regulation on your entire organisation (operational/non-operational)?

Question 17 asked participants to rate the change/effect from the regulation on their entire organisation. As seen in the table 32, the average, median as well as the lowest and highest value do not differ very much from the rating of the employees' area.

Average	46,45	Median	50
Standard Deviation	25,02		
Lowest Value	0	Highest Value	100

Table 32: Effect from Regulation on Entire Organization, Source: own research

As in question 16, the split into the two business areas reveal an even more marked difference this time:

Area	Average	Median	std. deviation
operational	42,11	42	23,88
non-operational	60,64	67	23,34

Table 33: Effect from Regulation on Organisation split by average, Source: own research

Whilst operational staff see minimal difference between the influence on the organisation compared to the own area, non-operational staff consider the influence on the organisation much higher than the impact on their own area. As there are only two areas in the organisation, this leads to the conclusion that the non-operational staff considers the influence on the operational side of the organisation significantly higher than its influence on their own.

xviii) Please rate the following influence factors.

In the final question of the survey, participants were asked to rate pre-determined influence factors. These factors have been taken from the literature review and document search and provide a selection of factors to the participant, where they choose a value from 1 (low influence) to 5 (high influence). The values were:

- Regulator (CAA/BAF, etc.),
- EU Regulation,
- ICAO Rules,
- Airline Demands,
- Airport Demands,
- Internal Demands,
- Cost Drivers

Figure 43 shows the results. The approach to this question is similar to that of question 14. The participants ranked all influence factors in order from very low to very high. The results show, which factor was placed in each position, as well as the number of respondents who put it there. The higher the bar, the more respondents placed it in that position. EU regulation, followed by the Regulator and cost drivers, were identified by the respondents as main influence factors on HRO principles. This result was in line with the previous findings in this chapter. In addition, no influence factor has been identified as low or very low influence by the majority of respondents. Although some people did use very low or low in some cases, the numbers never reached more than 10% for very low and 15% for low.

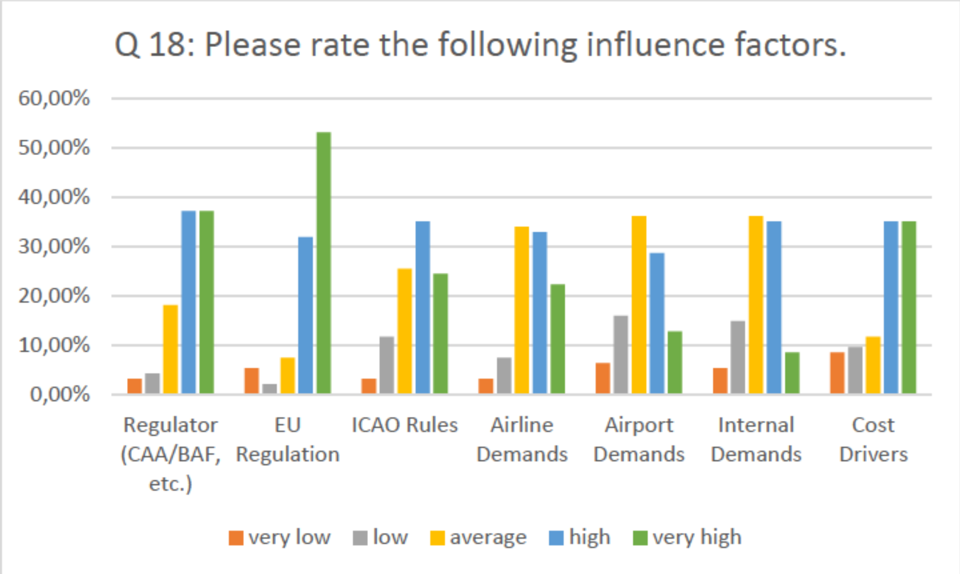

Figure 43: Rating Influencing Factors, Source: own research

4.4 Expert Interview Results

In total, 17 experts were interviewed by the thesis's author. To conform to standard ethical protocols, the interviewees were fully informed of the purpose of the research. The interviews themselves were recorded and subsequently transcribed. The content of the interviews was converted into text to be used by the NVivo software package, which identified common trends and patterns within the responses. Three rounds of analysis were undertaken utilising software. The first round consisted of a more general approach, where the transcripts of the interviews were searched for elements that related directly to the research questions identified in the interview guide. The second round of analysis was to correlate the different elements of the questions to create comprehensive answers. This was done by linking topics together even if different responses were given to different questions. The last round of NVivo analysis was based on a simple word assessment across different questions in order to identify the most common terms utilised and create a word cloud to identify the presence of words associated with HROT. Lastly, the research was broken down based on the category of interviewee.

All experts can be classified into either basic manager, executive manager or senior manager. In the following chapter, these three groups are analysed.

The analysis of the interview results did not return information, which could be seen as potentially biased. Whilst selecting subject matter experts from within the case organisation has a certain risk of bias, as outlined in chapter 3.6.4., the risk has been mitigated specifically by selecting interview partners from across a wide range of the organisation as well as a carefully structured interview approach.

It is also important to note that, due to confidentiality requirements, no direct citation has been authorised and the transcripts are embargoed.

Three different managerial echelons were interviewed:

- **Basic Manager**

There are three basic managers who could have been interviewed. A basic manager is the lowest managerial level, with responsibility for a small team of around 10-15 employees but they do not have any budgetary responsibility or general commercial power.

These experts will be cited as follows:

- Basic Manager in Training: E1
- Basic Manager Operations ATC: E2
- Basic Manager Operations Engineering: E3

- **Executive Manager**

Executive management is in charge of several senior managers and does have full commercial responsibility. They are often members of the board of directors or report directly to them. More details cannot be given due to confidentiality reasons

Six executive managers could be interviewed. They will be cited as follows:

- Executive Manager Training: E4
- Executive Manager Operational Support HR 1: E5
- Executive Manager Operational Support HR 2: E6

- Executive Manager Operational Support MD: E7
- Executive Manager Operational Support R&D: E8
- Executive Manager Operations Engineering: E9

➢ **Senior Manager**

Senior managers are reported to by several basic managers, and they are normally in charge of a branch of the business. They also have significant budgetary responsibility within their organisation and are in charge of a variety topics in their area of responsibility. The following eight senior managers could be interviewed:

- Senior Industry Expert ICAO & EASA: E10
- Senior Manager Training: E11
- Senior Manager Operational Support Safety: E12
- Senior Manager Operational Support Safety/Audit: E13
- Senior Manager Operations ATC: E14
- Senior Manager Operations Head of Unit 1: E15
- Senior Manager Operations Head of Unit 2: E16
- Senior Manager Operations Staffing: E17

As Chapter 3.7.3 explained, the interview guide is split into four main question-banks including several main and central questions. In the following chapter, the results of these question-banks will be presented.

4.4.1 **Personal and Organisational HRO-Awareness**

Figure 44 initially shows the word cloud that presents the codes, which have been used to analyse the expert interviews.

Figure 44: Word Cloud Personal and Organizational HRO-Awareness, Source: own research

As the literature review showed, HRO-awareness can be described by some specific characteristics or keywords. These keywords have been confirmed in the survey and document analysis but are also used to analyse the interviews.

To assess their frequency, the words were identified with the use of a textual analysis to tally the different terms used by respondents in the open-ended questions in the questionnaires, along with terms used by the interviewees in the qualitative research. The terms were then grouped into similar definitions and related meaning clouds to facilitate analysis. The word cloud above shows some keywords from the interviews. Once again, safety, reliability and resilience are amongst the most commonly used words. These keywords will be useful in analysing the interviews when it comes to the question of “How can personal and organizational HRO-awareness be described?”

Overall, there was a strong indication among the interviewees that ATC was very safe and reliable, which can be seen in the responses provided. According to E1, ATC is highly reliable or highly safe because of the sheer number of lives at stake. There is so much traffic and so many people, which is why ATC has to be reliable and ultimately safe. In this context,

teamwork can probably be seen as a major HRO-awareness factor, since everyone knows the need for safety, and everyone works together to make things safe. Everyone is invested in this safety (E1, 2019).
Additionally, it is not only the teamwork between air traffic controllers, but probably in aviation in general. However, at an air traffic control level, teamwork becomes even more important, since working in ATC means collaborating with almost all stakeholders. These employees (in particular ATC at control towers) work with airport, pilots, ground staff, air traffic control and engineers. Therefore, they have a greater appreciation of where things can go wrong (E1, 2019).
The specific factor that allows them to work in a team is training. This is especially true for pilots and air traffic controllers, where long and intense training courses are necessary to prepare employees for unpredictable situations. They need to learn the skills that they would deploy in that specific situation. E1 mentions that people will naturally tend to make mistakes. Additionally, there is time and slot pressure from the European network now, which in turn makes pilots feel pressured (E1, 2019).
According to E2, the main reason air traffic control is so safe is because of the air traffic controllers. E2 states that the main task of these employees is to remain calm and maintain safety (E2, 2019).
The next factor is the organisation they work for and the kind of protocols, systems and operations that ensure their procedures are safe (E2, 2019).
According to E3, redundancy is one of the main aspects that defines an HRO. Should one part of the system fail, then there is automatically a separate system (E3, 2019).
E4 states that the safety aspect is a key theme for ATC. For instance, it begins with attracting young professionals to the industry, with the word safety already used to attract people. This would result in people applying that have a specific bond towards safety as to others. During training, safe operations is the main point of emphasis. In this way, a culture of safety can be developed, fostering an open approach to mistakes and prioritising learning from them (E4, 2019). Communication plays an important role, since safety-related issues are shared and people learn from each other.
For E4, safety can be defined as the collaboration of people, processes,

and systems. On one hand, people are trained and their familiarity with safety protocols is consistently refreshed, so that they can work safely, know what to do, and be aware of the procedures. On the other hand, all processes that are used in ATC are planned in detail, so that conflicts can (preferably) be eliminated. The last aspect, the system, means that there are redundancies in all systems; people and technology. These three components (people, procedures and systems) are synchronised with the holistic approach meaning that all components are optimised (E4, 2019).
For E5, safety is a kind of philosophy that is not necessarily associated with ATC or this specific type of organisation. Regarding ATC, one thing is noticeable. It is precisely the awareness that ATC is a special organisation that deals with an exceptional service which fosters safety or the impetus to create safety. Thus, safety does not arise from inaction, but rather it must be developed. Safety can be seen as the result of accurate procedures, trainings, qualifications and human capabilities. Safety awareness is grounded in people. This is something that cannot be learned, representing a more innate aspect of human competence. Air traffic controllers need to have this special quality (E5, 2019).
One of the most important aspects that makes air traffic control such a highly reliable and safe environment is a combination of different factors. According to E6, there is a number of layers that make it safe such as procedures and regulations on what to do and how to do it. Two other factors are training and compliance. Safety is related with the culture within an organisation. ATC employs highly professional individuals that hold themselves to account and understand their responsibilities as both individuals, as well as how they work within the organisation. Coordination between people plays a big role and teamwork in ATC is far more effective than in most organisations (E6, 2019). In many of the responses there were indications of the importance of regulations in setting standards. According to E6, a high degree of regulation is absolutely essential. Airlines push for safety because they face competition in both what they do and how they do it, a competition that has not necessarily existed in air traffic. Safety is a catalyst for positive change (E6, 2019). An awareness of high reliability is definitely there. A senior management team must be in

possession of the right level of knowledge to be able to challenge decision, as well as be comfortable with their ramifications. In concrete terms, this means that managers do not necessarily need to have an ATC background. The main aspect of their job is to understand systems well enough and know what people should be doing and how they interact with each other (E6, 2019).

The key for maintaining reliability and safety standards within a naturally controlled organisation is to constantly ensure that informational data, activities, and actions are scrutinised. In other words, complacency presents a fundamental challenge, since it is the one thing that can catch businesses out. In ATC, this is mitigated by robust procedures, four eye principles and regulatory oversight with regular auditing (E7, 2019). It is absolutely essential to ensure that a business is constantly checking, evaluating, assessing, listening, observing and monitoring. Additionally, when something does happen, the question of how the organisation can learn from it and how this can be shared must continue to be asked (E7, 2019).

This company put resilience and safety first at all times. It is fundamental that any structure has the right balance of skills and expertise, coupled with sufficient understanding throughout the hierarchy as to what actually goes on. It is important for any business and structure to have the right access to expertise and skills across all layers of the business. In a high reliability organisation, an operational launch is invaluable in maintaining these principles of reliability and safety to the desired extent. The key to high reliability and safety lies within the operations (E7, 2019).

Regarding the principles of HROs, E8 mentions that most people working in an HRO experience these principles yet are sometimes unaware of this fact. This is for instance the zero tolerance for errors and reducing uncertainty by means of accurate planning and finding causes. Instructions must be defined in detail (E8, 2019).

According to E8, the difference between operations and non-operations is that all parts of the organisation have to conform to the HRO-principles. However, there is a difference regarding the extent of influence. In some areas or activities, HRO-principles must not be conformed to excessively.

Nevertheless, the organisation works as a whole. Once employees come from outside, they are unaware of HRO-principles and need to be trained. In the operational area, there are many extensive manuals and regulations, so HRO-behaviour is defined in detail: A person who is trained operationally will unconsciously adopt HRO-principles and adjust their behaviour accordingly (E8, 2019).

Someone who has not learned the principles of HROT might have problems in understanding the reasons why an HRO works in a specific way. People who are not used to operating in an HRO environments will have an HRO-deficit. On the other side, people who have experience in this environment encounter problems with the management of uncertainty. In this context, E8 mentions European regulations. These are generally made by people who work in the areas of insurances, airlines or politics, but not in the area of HROs. This results in a lack of understanding from both sides. Hence, the task is to shrink deficits to reach goals and to be productive (E8, 2019). According to E9, ATC's job is to ensure the safety of each individual flight, as well as the relationship between all the flights and the ground. Therefore, by definition, it is about safety and the resilience of the network overall.

Civil aviation – by its very definition - has been global from the outset. After the Second World War, governments recognised that there was a need for international cooperation in matters of civil aviation. Nevertheless, the initial views in those days were not driven by safety, but more so with opening routes and ensuring airports were operating in a consistent way. For E10, the most important driver of safety in air traffic control (the need for consistent common standards in operations) is also the most important driver of safety in aviation in general. Safety culture still does not exist in some nations and their air space managing remains unsafe to this day, although air traffic control in general has become safer (E10, 2019).

E11 states that regulations are the main factor in making ATC an HRO. If there is a framework and people stick to that framework, it works. If people do not, they will encounter problems. ATC is very rule-orientated and with good reason. The rules have arisen in the wake events that have happened in the past, which is what makes ATC safe (E11, 2019).

For E12, one of the major objectives of HROs is to eliminate negative occurrences by means of an open approach to mistakes. E12 differentiates between operative and non-operative areas, as safety has a higher relevance in operative areas. ATC is an organisation of high safety because of its strict selection process and high degree of training. Thus, people take their job very seriously and work precisely. Nevertheless, more money is invested into other areas, but not in safety or safety-management. According to E12, ATC as an HRO is such a stable system because of its high level of safety awareness. All employees are aware that they know they cannot afford accidents and failures, which in turn contributes to the overall safety of the organisation (E12, 2019).

According to E13, safety is the result of a combination of different factors. In this context, the adaptability of people must be seen as an external factor. Certainly, ATC is characterised by the existence of many regulations. Nevertheless, other conditions might lead to other working methods. It is absolutely necessary that people with responsibility can decide how they work to guarantee safety (E13, 2019).

E15 mentions that the commitment to safety runs through all areas of ATC, even if it cannot be seen directly in some areas. The key element is providing safety; hence the commitment of safety begins with management and ends at the single controller. It includes different pillars such as staff, regulations, technology and processes. Additionally, ATC spends considerable sums on employees' training. Regarding the above-mentioned pillars of safety, E15 states that they all influence each other (E15, 2019).

According to E16, ATC is an HRO, since there is an inherent desire amongst the people involved in the air traffic industry to be safe. Pilots, for instance, are highly incentivised to create a safe environment as their personal safety is often at stake. There is an understanding that safety is of paramount importance, so people who are sloppy, lax or risky by nature will not be employed. Even if they have been employed, the system will find them out (E16, 2019). According to E17, ATC as an organisation is so safe due to two different aspects:

1. the high level of standardization and regulation and

2. the strict selection of staff.

Processes are described in specific detail, mainly regarding operational areas. Employees need specific skills such as teamwork, cooperation capability and spatial imagination to complete tasks (E17, 2019).

4.4.2 HRO-Awareness Factors

Moving forward from chapter 4.4.1, figure 45 shows the word cloud used to analyse the expert interviews. In reference to the identified key terms in chapter 2, some specific keywords that are in some way related to HRO-awareness factors could have been identified. These are, for instance, the term *influence*, but also *ATC, ANSP, government* and *rules*.

Figure 45: Word Cloud HRO-Awareness Factors, Source: own research

As for the question of whether there is a difference in the awareness of safety between operational and non-operational staff in the company, E2 states there definitely is a difference. The operational staff generally does not care about costs, since getting the job done and getting it done safely is the main concern. According to E2, an air traffic controller is seen as the talent and everybody else is there to support the talent. Money is a big influence if it is going directly to the ATCO, since ATCOs need (want) money and they do not care about the cost of anything else. They see themselves as set apart from the rest of the company. Boeing is a good example of an attempt to save or cut costs at the expense of safety.

Therefore, the regulators have taken their eye off the ball with these three areas of aviation, air traffic and finance (E2, 2019).

According to E10, safety needs to come from the government, since this leadership flows down from the political level. The NSP is a generally appointed by the government and is owned by the government. These are the most important considerations in driving ATC safety. That does not mean undermining the work of individuals, individual units or of individuals in organisations, but the real drive comes from the top down (E10, 2019). Safety is only a by-product, while the other principal objectives are efficiency, economic validity, and environmental concern. Safety belongs to one category, but it is not always prioritised over and above everything else. It is true that airlines must be safe because if they are not, nobody will fly with them. The power lies at the government level to take a decision to make it safe or unsafe. Therefore, the regulatory framework is one important aspect in building the entire system. The whole idea of national procurement policy by the government has an impact on how good the ANSP can be. ATC itself seems to be a by-product that was considered necessary for a globalised world, yet this process was seemingly omitted from initial attempts to globalise the industry (E10, 2019).

E11 differentiates between operational and non-operational areas. Regulations are more important for operations and for everything that supports operations, such as flight data systems, the technologies that are used in an operational environment for the people who are trained accordingly. Areas such as marketing, sales or personnel have more flexibility. Certain areas are less regulated than others, but every area of life is regulated in some way. According to E11, it prevents people getting into a lot of trouble if they follow these rules (E11, 2019).

Safety awareness is not the same within ATC. For controllers and pilots, it is uniformly evident, as pilots have been trained and are used to it. According to E11, there are areas where rules are much stronger and much more powerful, and other areas where applying them makes life easier and safer, but there is a certain amount of flexibility within that area as to how they are applied. E11 mentions that the better employees feel, the better they work. It is a job where emotional strength is important. The

more people who like to come to work and like to do the job, the better they will work and the safer they will work (E11, 2019).
Employees should be trained in the same way, irrespective of whether they belong to the operational or the non-operational area, since they all are part of the organisation's culture. In this context, E13 argues that the focus is mainly on the operational area, but that commitment to safety must be existent in all areas. Managers must exemplify safety awareness. Attitude and behaviour are key qualities to ensure robustness against disturbances (E13, 2019). The key factors that make ATC so safe are regulations and an understanding of what is done. It is a strong framework to begin from and all training is then delivered against that framework, with the emphasis from day one on safety. Regulations are surely an external factor, but according to E14, training and ongoing competence comes from an external framework (E14, 2019).
When questioned whether there is a difference between different areas such as HR or finance regarding the application of HRO principles, E16 states that there definitely is a difference, since there can be risks and there can be problems, but the consequences are not that bad, and nobody is placed in danger. Therefore, the operational managing and the operational framework in which people operate is probably more important than non-operational areas (E16, 2019). Regarding safety awareness, E17 estimates that there is a difference between operational and non-operational areas, as buyers for instance do not need to have a heightened safety awareness. Nevertheless, the average level of safety awareness in ATC is higher than in other organisations (E17, 2019).

4.4.3 **External and Internal Influence**

Regarding the identification of external and internal influences, figure 46 shows the word cloud that contains the codes, which have been used to analyse the expert interviews. Some of these codes have been gathered from the literature review in chapter 2, others have been developed by going through the experts' answers. For instance, codes such as *economics, finance* and *money* have often been used by the experts – hence, they have been used as codes to analyse the entire material.

Figure 46. Word Cloud External and Internal Influences, Source: own research

E2 believes that external influence does not appear to impact air traffic control and he sees ATC as insulated from these pressures. Nevertheless, there are many non-aviation professionals that E2 has to deal with (E2, 2019).

A regulator has a big influence because you must meet all requirements, but it is not necessarily the regulator that provides the real information because it is the manufacturer that really knows the material. System design, maintenance and operation are key factors in maintaining safety. Regarding the question of which of the three parts is most likely to create an error in the whole system, E3 believes it is system design. Of course, all three parts are very important, but the majority of the systems require very little maintenance. Additionally, a lot of design issues are to do with cost such as component selection. There is so much pressure on the manufacturer to get something out quickly that they tend to have issues. E3 thinks the recent issue with the Boeing 737 Max is a prime example. Boeing invested millions in developing software packets for aircraft, but it remains unclear if they employed enough technical evaluators in the face of potential commercial pressure (E3, 2019).

One major influence on any company is cost and financial pressure. Turning away from the manufacturer, it is also a big factor for air traffic control operators as well. The system of air traffic control is probably the most expensive part of the entire aviation network. Viewed alongside all of aviation’s sections, air traffic control is extremely expensive. There are cost pressures in every part of the organisation that force each component to do the best they can with the money they have. In order to properly work in an area, employees need to know what their system does and why it does it. It is impossible to come up with a reliable system, if one does not know the exact details of what the system does (E3, 2019). E3 states that ATC is most likely the most expensive part of the aviation industry (E3, 2019).

E4 states that the entire system is highly sensitive to external influencing factors. When an unplanned change is made, this influences the system. This is the reason why several safety nets including independent backup-systems are used, which make the system more resistant to unplanned incidents. E4 differentiates between operational and non-operational areas, stating that non-operational staff are not trained with a strong emphasis on safety. Hence, there is less understanding of the procedures and the culture in the operational area.

According to E4, there is a lot of external pressure, for instance from the European Commission. The mantra that safety in aviation is something different from safety in other industries cannot be understood by many external people such as financial controllers. Nevertheless, understanding the importance of safety is something that can be learned.

Regarding potential external influencing factors, E4 mentions interfaces with other organisations that allow aircraft to pass borders. This is why there are several control centres in other countries. This can be seen as a big network, which can only improve if people are pulling in the same direction. In simple terms, if a country changes its system and procedure, leaving others unable to adapt, this will influence the entire system.

Regarding potential influencing factors, E5 speaks about economic factors such as money and the impatience of airlines. ATC is forced to handle more than is possible. Additionally, wages are rising, material costs continue to grow, and technology is getting more and more expensive. E5 is concerned about these developments, as they mean that important things might be ignored. The good aspect of this is that air traffic controllers can be seen as more or less reluctant towards changes and innovation energy. Nevertheless, they keep the system stable. Increasing the safety level means optimising the ATC's weaknesses (E5, 2019).

In his management role, E6 circles back to regulations. Senior managers have to make sure that the way they conduct their business is in line with particular regulations, as well as laws in general and that ATC is a safe operation. People need to know that when they speak up and raise issues, these issues will be transparently addressed and won't be brushed aside. The management team sets the tone, and it then filters throughout the organisation (E6, 2019).

As ATC works in a heavily commercial business, there is always pressure that must be balanced somehow. Additionally, changing a longstanding procedure internally could potentially have an impact on safety. This is why it is important to run risk analysis, hazard analysis and safety cases. Addressing the statement *"A healthy HRO will always withstand an influence that is potentially compromising the level of decisions",* E6 argues that it is all about communication: if you're aware of it and you've explained what you're doing and why you're doing it, then it won't circumvent you (E6, 2019). Complacency is a factor that influences the organisation's reliability, since the goals must be to keep the right dynamic and focus, to give people the ability to challenge organisational failures openly, and to create the right cultural environment to be able to do that (E7, 2019).

With regard to potential external influencing factors, E8 mentions regulations, the European Commission, as well as national law. An intact HRO should be able to manage external factors without questioning the HRO's integrity. With an increased number of external factors, retaining integrity becomes more and more challenging. In short, this means that if cost pressure becomes too high, an HRO will still stick by its principles, but as a company it might go bust. The European Commission is not an excuse for a lack of safety. If there is a lack of safety, it is because of a lack of functionality within the HRO.

According to E8, it is not a problem if people with HRO-deficits work in governments and are responsible for regulations. E8 even states that it might be positive, since an HRO's focus is not on efficiency and economy.

It is the HRO’s job to deal with these regulations and to defend HRO-principles. Nevertheless, the higher the stress, the higher the temptation to find a quick solution, which might potentially jeopardise safety (E8, 2019).
Regarding potential influencing factors that impact resilience or the safety of the network, E9 argues that it is all about communication. In this context, consistency of language, of message, of instruction and of exception are especially important, both between an air traffic controller and the flight and between the controllers and anything else associated. The people are therefore most important, since they communicate and work together. For E9, an HRO can be seen as a house of cards. It will fall down if one part fails, with people all relying on each other. The personal relationship between, for example, a controller and engineering could potentially influence the level of resilience (E9, 2019).
With the use of the word regulations, E11 is referring to both internal and external ones. With this in mind, E11 mentions that rules continuously change over time. ATC is a continually developing process because of rapidly changing technology. Fifty years ago, changes were not so extreme nor as rapid as they are now. In other words, rules did not change as often as they do now because they simply did not need to. Nowadays, a high number of rules are necessary because more planes in the sky means space is at a premium. The more planes in the sky, the more carefully one needs to be and the more regulations one needs to have (E11, 2019).
According to E11, the biggest influence on the safety of ATC would be taking away checks and balances, which have been put in place for a reason. For example, aircraft are regularly tested and inspected because parts fail (E11, 2019). E12 mentions cost and production pressure that arise from the motto more and more as potential influencing factors that might disturb the HROs balance. Sometimes, things have to be done even if they carry inherent risks, whereas in certain case, other solutions might be better. Additionally, there are some external influencing factors such as regulations. In fact, an HRO such as ATC needs a sort of top management, which has only on single goal: to guarantee safety (E12, 2019).

The most important influencing factor that might make the entire system unstable is a changing culture. This is often a slow process but one that threatens to undermine the stability of HROs. Because of how slowly it occurs, this can be overlooked or neglected by management over a long period. During this period, a new culture might have developed (E13, 2019).
E14 speaks of external pressure as a company is supposed to make profits. Nevertheless, safety always comes first. Bringing in fantastic managers that do not have an understanding of how ATC and safety critical industries work is an inherent weakness. Somebody without background knowledge gets the necessary training so that they can assuredly execute their responsibilities. Thus, having an ATC career first is not essential, but it is certainly desirable (E14, 2019). In answer to the question of the biggest influence on the resilience level or the reliability or safety level, E14 says: Compliance is everything – people stick within the rules (E14, 2019).
Regarding external and internal influences, E15 mentions specific regulations and institutions such as EASA as one of many regulations that have to be observed by ATC. Additionally, airlines try to interfere where they can. Nevertheless, ATC will always remain stable, no matter the external influence, due to the fact that ATC's mission is defined in the Basic Law, or LuftVG and LuftVO. HROs sometimes struggle with the financial pressure that comes from rising economic considerations. Even HROs like ATC are aware of savings and efficiency programs, they are mandated by management to be more efficient in the face of cost problems. It is thus important to strike the right balance between safety, capacity and cost efficiency. The highest cost factor is personnel, but at the same time, personnel is the most important pillar of ATC. Hence, one should not make savings with personnel (E15, 2019).
E16 mentions an airport owner that wants to run the most efficient and safest airport they can as a potential influencing factor. One element of this balances safety with efficiency, whereas the other refuses to compromise on safety. However, sometimes that means they want to respond quickly and make changes at very short notice. Having time to

assess changes is a key aspect of reliability. In order to maintain a high standard of safety it is important to have time, but this depends on the change in question. A hole on the runway is a good example of something that requires urgent action, yet urgency is not an excuse to sacrifice safety. Time still needs to be taken to consider the implications of a specific course of action. (E16, 2019).

Documents show that ATC is a highly regulated environment, which is supportive of the high safety standard. Regulations are there for the reason that something has happened previously. The lesson that has been learned prevents similar incidents from happening action. According to E16, everybody has the same safety awareness. Nevertheless, those without any experience with HRO culture often find it difficult or even impossible to replicate the same standards of safety awareness among more experienced staff (E16, 2019).

HROs are able to recover relatively well from disturbances. In regard to potential influencing factors that might impact an HRO's safety concept, E17 mentions any sort of unforeseen events. When there is no rule or defined procedure on how to deal with a specific event, the balance might be disturbed. Additionally, EU regulations can disturb the balance, since their motto is: more capacity at less expenditure and less costs (E17, 2019).

4.4.4 **Type of Influence and Potential for Optimisation**

The present chapter presents the experts' opinions regarding the types of influence as well as potential for optimisation. Optimisation in this context means any possibilities to further increase ATC's safety and resilience. Figure 47 below shows the codes that have been used for the qualitative content analysis. Again, some of them have been taken from the literature review of chapter 2, and some of them have been developed by going through the interviews.

Figure 47: Word Cloud Type of Influence and Potential for Optimisation, Source: own research

If E3 were to pick one thing that should be implemented in order to maintain further increase safety and reliability, it would probably be the licensing of engineers. One of the biggest arguments for not licensing air traffic engineers has always been the lack of incidents associated with air traffic equipment (E3, 2019). Another one was the cost of introducing licensing. But as ATC relies on standards and licensing would formalise standard beyond the ATCOs, it would further optimise the safety and resilience of any ANSP (E3, 2019). To increase the resilience or safety level, E4 would probably try to further develop the personnel, procedures and systems by means of interdisciplinary action. In this context, it helps to have a meeting to discuss what is going well at work, what is going wrong, and what in particular needs to be optimised. The results are realised consistently. Hence, to increase safety and resilience, people are the key factor. They need to be motivated to give 100 percent every day and to optimise the system (E4, 2019).

To maintain HRO-principles, E8 states that people need to understand an HRO with all its principles. Even in a highly competitive environment, nobody questions safety, because an unsafe airport directly and strongly leads to the airport’s demise through lack of customer confidence. Thus, safety is not at issue. What matters is the balance between safety, personnel and finance (E8, 2019).

To make resilience as high as possible with the focus on an organisation, E9 mentions knowledge sharing within and between organisations (E9, 2019). E9 believes that bringing together engineers, controllers, and people from outside the organisation, each group would benefit from the shared knowledge (E9, 2019).

For a high reliability organisation, E10 thinks it needs a special sort of thinking and vision, which also has to be applied by the politicians. This is the current trend, but it will take a long time to be realised. Europe is in a good position because of the legacy of European control, the legacy of the EU, and the collaboration built around the unified European sky. The opportunities for Europe are incredible in terms of aviation and air traffic control. Nevertheless, it is the responsibility of leaders in the air traffic control world to recognise the specific issues and to help their superiors and peers to better understand the real issues. The real issues are not about technology or pay levels for air traffic controllers. Instead, they are the question of how to set the strategic framework for the industry on the right path to allow it to evolve efficiently and effectively. As of yet, this is not the case (E10, 2019).

To increase the safety and reliability of ATC, more money is needed. Of course, ATC is a business and has to be cost-effective, but this argument is counterproductive. One hundred extra controllers could be provided. This would be safer, because one can reduce the hours of the employees who are working and they would have more free time and come to work healthier, fitter, and more ready to do the job. Unfortunately, there are budgets and new technologies that cannot be brought in, because there is no money for it. There are so many things that cannot be done. Putting a price on safety means safety going out of the window at some point (E11, 2019).

To make the entire system more stable and safer, E13 argues that complexity should be reduced. The legislative procedure must be simplified, since new ideas or changes cannot be brought in due to its high complexity (E13, 2019). To make ATC even safer, E15 would probably change the tariff policy (E15, 2019).

5 Part 4: Discussion

To summarise the results that were identified from the document analysis, the survey, and the expert interviews, the following chapters will briefly underscore the most relevant aspects with regard to the research question from chapter 3.3.

5.1 Document Analysis

Having analysed the document analysis, it can be stated that there is a high level of agreement with the findings of the literature review from chapter 2. This is particularly evident the expressions *safety, resilience* and *air traffic control officer* having been used very frequently in the documents. This conforms with the high reliability understanding in that safety is one of the most important aspects when it comes to the principles of HROT.

It can be firmly stated that all documents describe processes and relationships as well as instructions and security-relevant topics in a very detailed and transparent way. Whenever documents directly address ATC operations such as SI or TOI, they have a risk analysis spreadsheet attached to it, addressing, and providing mitigation strategies for the potential risks identified. All documents can be viewed by all employees at any time. This is in line with HRO, as information sharing is of high relevance and is pursued actively. Each document has at least three editors from different organisational functions, ensuring a broad overview of the subject by different experts.

No explicit reference to HROT was identified within the documents. Nevertheless, the frequently used words in the documents are comparable and often analogous to the key terms of HROT. This again leads to the conclusion that the documents are of high relevance. The influence factors are from various sources but no reference to cost factors can be taken from the documents.

Regarding matches with HROT, the following results can be stated:

- It is only the operational side of the organisation that seems to document according to HROT.
- Documents are available for all employees.
- Documents clearly reference safety, a result that arises from conducting the word count.
- All company levels are involved in the creation of documents, which can be derived from the documents' editors.
- The document analysis' results indicate that HROT is deeply rooted into the operational areas, whereas in the operational support areas none of these HROT documents could be identified.

When examining these elements, the document search may be seen as the most objective element of the research, as the process drew on pre-existing documentation in a studio ex post facto approach, which provided clear indications of the approaches adopted by the organisation. The objective nature of the document search provides more certainty than some of the more subjective issues - particularly the expressing of opinions. However, it should be noted that there may have been conscious or subconscious sorting or censoring of the information provided. Despite this, there was a clear indication from these documents that the organisation was adopting HRO processes and values. It is important to note that all of the provided documents refer to the operational area of the organisation. When asked, no documentation in line with these principles has been provided by the organization indicating a gap between theory and practice as HROT refers to an organization as a whole.
Looking at the findings, this complies with the concepts of HRO or Weick and Sutcliffe (2007). There was a clear preoccupation with failure, as indicated by the dominant keywords within the document, as well as the high level of detail presented regarding the way in which precision should take place in order to avoid failure.
The safety case and the supplementary instruction documents were particularly notable for their strong preoccupations with failure, demonstrating the alignment with HRO requirements. Importantly, this was

a strong indication of a HRO element being satisfied, particularly when considering the definition of Hopkins (2007), who had stated that a preoccupation with failures was indicated by constant search for potential weaknesses or lapses within a system. Likewise, the high level of detail - including the depth of information and length of some of the documents - combined with the high degree of background data provided also demonstrated a reluctance to simplify, which was the second of the requirements set out by Weick and Sutcliffe (2011). Sensitivity to operations also appeared to be a focus within all of the documents, with the aim to create a resilient business.

It is notable that the commitment to resilience appeared to be less prevalent in the documents, potentially indicating a lower level of emphasis. However, while this was absent in many of the categories of documents, it is notable that it was present within the safety case notifications. While there are only 77 of these documents out of the total of 672, it becomes apparent that there were direct references to the commitment towards resilience. Therefore, while there appears to be a lower level of preoccupation with failure in the documentation, Hopkins's (2007) approach would indicate that the preoccupation with failure should also be indicative of attempts to increase overall resilience, as potential weaknesses within systems may be seen as precursors to larger unwanted events. Despite this, the safety case documents may be read within the context of the approaches provided by Sutcliffe (2010), Weick (1987) and Youngberg (2004), who argued that every event should be treated as a significant incident, with a high level of attention as if it was the first, and a reluctance to conclude the issue.

Deference to expertise was the most commonly observed compliance with the HRO criteria identified by Weick and Sutcliffe (2011). The deference to expertise is seen in the systems as well as the content. For example, the notation that all documents need to be signed by the three members of staff, including a subject matter expert, as well as a manager and a safety oversight employee, which provides a high level of assurance. Therefore, the difference to expertise is based not only on the issue itself, but on the management and safety of those issues, which also links back to the preoccupation with failure, while the three signatures may also support a reluctance towards complication.

Roberts and Bea (2001) stated that there are three principles for an organisation to be classified as an HRO: organisations undertaking aggressive approaches to seek knowledge regarding what they do not know; attempts to balance efficiency with reliability; and communication of the big picture to everyone in the organisation. Therefore, given the above findings, it is not only the Weick and Sutcliffe (2011) requirements that are satisfied, but also the principles laid out by Roberts and Bea (2001). This suggests that in answer to the research question, the hypothesis that HROT principles appear to be applied to a high degree appears to hold true. Despite this, it is necessary to look further at the survey and implementation, otherwise the documents may be considered as “fantasy documents” as indicated by Birkland (2009), Clarke (1999), and Rijpma (2003), where it was hypothesised that the documentation may be generated in order to prove activity.

5.2 Survey Results

The survey attracted 303 participants, with 93 fully completed and returned questionnaires. The response rate may be seen as relatively low, particularly with the dropout rate at 69.31%. However, it was not unusual to this organisation. Indeed, with the staff development department confirming that the normal response rate is 33%, it appears this survey may be representative of the organisation. It is fair to assume then that the results were not aberrations. There also appeared to be a representative sample of different employees across different managerial levels with a spread of different ages.

From the survey results, it must be mentioned that 76.6 percent of the participants work in the operational business and 60.64 percent in ATC. Hence, only a few participants come from the non-operational part such as HR (3.19 percent) or finance (1.06 percent). This composition influences the results, since there is an excess of operational business, which may have resulted in some bias. Nevertheless, the results show that the participants were not very familiar with the principles of HRO, with the net promoter score even negative across all participants. The survey results demonstrated a relatively low level of familiarity with HRO, with the level increasing as individuals becoming more senior within the management framework. Overall, promoters rather than detractors were more familiar with the concept and were more willing to believe others were also aware of the concepts. However, while individuals generally tend to project their own level of familiarity onto others, those in senior positions tended not to have the same tendencies, believing their own knowledge was superior to that of others.

The survey results also appear to support the concepts of HRO knowledge amongst the employees, because despite their lack of familiarity, they were able to identify terms associated with the concepts, especially terms such as safety, honesty, redundancy, integrity, resilience, and security. While the clustering of certain words was indicative of specific elements, it is notable that when asked to define different terms associated with HROT only 11 out of the 177 different terms were not related to HROT, with examples appearing to demonstrate that individuals who did not know the answer did not wish to answer. From this it may be argued that despite a conscious knowledge of HROT, there was a degree of understanding which may have been obtained through working within the organisation. Overall, it appeared that there was general agreement between operational and non-operational staff that the operational staff had a greater knowledge of HRO. This is quite astonishing, as the expert interviews' results show a high level of familiarity with these principles. From this point of view, it can be assumed that managers have a deeper knowledge of HRO, given the fact that all of the interviewed people were managers.

Nevertheless, the survey's results show a different perception. There are even more critics and fewer promoters of familiarity with HRO principles among respondents, and the net promoter score is at -39,11. This shows that, in most of the employees' opinion, their supervisors are not particularly familiar with HRO principles. In contrast, employees consider their colleagues' familiarity with HRO principles higher than their supervisors' familiarity (net promoter score -27.59). The result shows that people have a different perception of their own familiarity with HRO principles and that of others. Supervisors or managers consider themselves very familiar with HRO principles, whereas their employees do not.

The more detailed questions in part two of the survey on HRO-Awareness paint a different picture, as the participants were all comfortable in referring to HROT principles, even coming up with common themes in free text entry questions as well. Whilst the survey results indicated the presence of an HRO, the assessment was more challenging to analyse. Clear patterns were seen with the level of awareness as indicated by the word association exercise, where specific words associated were given. However, when seeking to identify the potential for a HRO based on Weick and Sutcliffe’s (2011) principles, these theorists argued that it would be necessary for employees to understand that they were facing a complex environment. Within this environment, where there could be unpredictable or unforeseen events, they need to ensure they have as well equipped as possible to deal with those events. Question 11, which sought to ascertain why HRO may be present, increased understanding, where aspects such as increased awareness, repetition of safety aspects, and terms like reliability, safety, and efficiency were all incorporated within the responses given. This suggested that any overt understanding of the concept may not have been present within all employees, but some elements were clearly incorporated into the way that they operated.

It shows that the principles seem to be reflected more in the organisations’ cultures than in the organisations’ documents and processes, which is slightly different to the results from the document search. Whilst the term *safety* is closely linked to HROT - as demonstrated in the literature review - it seems that most members of ANSPs are more aware of safety related HRO principles rather than others, which might relate back to ATC’s origins as an organisation with a purely safety related purpose. Nevertheless, the results show that all participants mention not only safety but also redundancy, security, resilience, honesty and others as the most important elements of HROs, irrespective of their organisational position (manager or employee) and also irrespective of their business area. The survey results show some influence factors as being of highly significant:

- Performance Scheme
- Cost Effectiveness
- Capacity requirements
- Regulator in General

Overall, the Weick & Sutcliffe (2011) measures could not be verified fully with this approach, although several could be implied. Among these elements was the differing expertise in the way operational and non-operational staff perceived the differences, and the recognition of operations that were needed in order to maintain safety, supporting the assertion that there was a preoccupation with failure. However, a commitment to resilience appeared to be lacking. The application of Roberts and Bea's (2001) principles also provides partial support for the presence of HRO characteristics. The results appear to indicate that a big picture had been communicated to everybody, as despite the lack of overt knowledge, the alignment of employees' assumptions with the concept and the practices is highly indicative of effective management communications. Indeed, communications includes documentation that is sent out, which has already been established as providing evidence of HRO characteristics. Furthermore, the statistical analysis appears to demonstrate that there was a positive correlation between past HRO practices and current practices. Discussions of HRO practices could also be interpreted as demonstrating effective underlying communications creating HRO characteristics.

The second of Roberts and Bea's (2001) principles, the balancing of efficiency with reliability, is more difficult to determine based on the answers given. The responses which include terms such as safety and reliability also include references to efficiency and effectiveness, which may be interpreted as satisfying this principle. The most difficult element of Roberts and Bea's (2001) principles is the first, a demonstration that the organisation is aggressively seeking to know what it does not know. The survey questions do not demonstrate the presence of this characteristic in an explicit manner, but neither do they undermine it. Therefore, when combining the survey results with the documentation, the balance of probabilities moves towards the positive assumption that this may be satisfied. However, there was a pattern that indicated that it was in fact regulation and performance gains that have had the greatest impact on organisational performance, which illuminates the motivation behind the move towards HRO. Interestingly, the literature review indicates that there are many potential influences or motivations for adopting HRO. However, if interpreting results with reference to (Martorell et al., 2014; Sagan, 1995), where it was noted that HRO may be an important contribution within the field of safety management, the overall emphasis on safety and resilience, combined with the documentation, indicate is the safety culture is clearly present, and therefore engenders the HRO characteristics. This suggests that in answer to the research question, the hypothesis that HROT principles appear to be applied to a high degree appears to hold true.

5.3 Expert Interviews

The experts as well as the survey's participants state that HROs can be characterised by: defined goals, consistent standards, and well-planned operations; the ability to adapt to changing circumstances and to operate safely in a highly dynamic and critical environment; doing all that is possible to avoid accidents; experienced employees providing professional services; a safety culture that is continuously reviewed and adapted; striving for improvements in all aspects and seeing mistakes as a chance to improve; a clear communication strategy and a commitment to resilience. Thus, respondents shared a consensus of what really makes an HRO. In their opinion, this is safety, reducing risks, and experienced staff. It is for this reason that E1, for instance, states that ATC is so reliable and safe because it is about human life and not objects (E1, 2020).

This is supported by the survey's results. On a scale of 0 to 100, the average of 68.29 represented the inclusion of HRO principles into the employees' work. Another important finding is that many employees consider the other area's HRO knowledge worse that their own area's HRO knowledge (33.61 percent). When it comes to a possible difference between operational and non-operational areas, the experts agree that all parts of the organisation must embody HRO-principles, but there is a difference regarding the extent of their influence. In some areas or activities, such as finance or HR, HRO-principles must not be carried out in detail. The operational staff generally are not concerned about costs, since getting the job done and getting it done safely is the main concern. Thus, safety has a higher relevance in operative areas. Nevertheless, a person unaware of HROT principles might have problems in understanding the reasons why an HRO works in a specific way, meaning they have an HRO-deficit.

Many survey participants and experts mention that there was a difference between following HRO principles before and after 2012. They were of the impression that before 2012, systems and procedures were tested more carefully and that after 2012, cost efficiency trumped safety. There were also some positive aspects, such as an improvement in communication, a better safety culture, and more open-mindedness, especially in leading positions. Both data gathering methods - the survey and the interviews - show that many people have the impression that before 2012, the guiding rule was safety first. After 2012, when more and more cost aspects appeared, an increased number of people got the impression that the focus changed from safety to economy. On the other side, many of the participants state that safety has always been a major aspect in ATC and has not changed over time. It can therefore be assumed that people’s perception is in some way associated with their individual work experiences.

One fact remained the same, regardless of whether it was experts or employees that were asked: safety has to be paramount for an ANSP, and all of the targets of the regulation have to follow this. Thus, safety is the highest priority, although capacity and cost-efficiency are the main focus areas. Opinion was fairly united that safety is a must and always comes first, whatever the circumstances.

The survey’s results show that the main influence factors are regulators (CAA/BAF, etc.), EU regulation, ICAO rules, airline, airport and internal demands as well as cost drivers. According to the survey’s results, EU regulation, regulator (CAA/BAF, etc.) and cost drivers belong to the influencing factors with the highest ratings. Nevertheless, many experts think that regulations are the main factor, which makes ATC an HRO, since it is a framework and people stick to that framework.

The quantitative research was more supportive of the five HRO characteristics outlined by Weick and Sutcliffe (2011). The high level of attention towards safety was indicative of a preoccupation with failure, particularly pertinent within the aviation sector where failure can result in significant loss of life. Furthermore, the results were indicative of a reluctance to simplify, with reference made to the governance, and the role of the regulatory framework necessitating a focus on causes of failure and ongoing prevention of failure. However, one of the respondents noted that the power to determine what was and was not safe was a governmental issue. Sensitivity to operations also appear to be present in the interviews, particularly with reference to the details of provided, and a commitment towards resilience was clear in the responses given. In line with the surveys, it is unsurprising that regulatory influences were identified as a significant influence.

The principles outlined by Roberts and Bea (2001) were more evident, as the interviews were a clearer demonstration of the desire to identify causes of failure, and the way in which it was incorporated into the organisations culture, due to internal influences regarding safety, as well as external influences such as regulations. Communication also appears to be present, with the way the interviewees indicate knowledge has proliferated throughout the organisation, even if it is different between the operational and non-operational staff. There is also a clear demonstration that there is a balancing of efficiency with reliability, with multiple respondents noting that safety is important, but that it is not the only important factor. This suggests that in answer to the research question, the hypothesis that HROT principles appear to be applied to a high degree appears to hold true.

In conclusion, the results appear to be aligned with the theoretical approaches towards HRO and HROT, although no single aspect may be seen as singularly persuasive, as each approach provides different levels of information. The most objective source of information were the documents, as these appear to demonstrate a high level of HROT, but as noted by Birkland (2009), Clarke (1999), and Rijpma (2003), documentation alone is insufficient to determine the status of an organisation, as documents do not always translate into practice. When considering the organisational holistic manner and drawing on the documents combined with the survey responses and interview answers, the claim that the organisation does adopt HRO practices (even if these are not explicitly described) is more persuasive than other suggestions.

5.4 Summary

As the most objective of the three data collection methods, the document analysis can be viewed as the most secure in the information it offered. Throughout the examined documents, the case organisation exhibited a high level of agreement with the HRO principles examined in the literature review. In fact, such was the degree of conformity with these principles that the case organisation clearly fulfils the requirements to be considered a HRO, as laid out by both Roberts and Bea (2001) and Weick and Sutcliffe (2011). Whilst there was no explicit reference to HROT found in the documents, the language used reflects close similarities to HROT principles described in the literature review.

The survey results were returned mainly by respondents in operational roles, which had a clear effect on the data. One thing that became clear after analysis of the data was the consistent ability of employees to demonstrate a familiarity with HROT principles. Moreover, internal communication within the case organisation suggested that there was a culture of safety, regardless of whether HROT principles were mentioned explicitly or not. Therefore, this data set indicated that there was a culture of safety within the case organisation.

Whilst these three methods did provide significant insight into the topic at hand, they also shed light on some intriguing conclusions that might require further investigation. For instance, the expert interviews showed the evident disconnect between how operational staff viewed their superiors' knowledge of HROT principles and the level of knowledge that their superiors could be proven to have. One of the reasons for this issue is the inherent challenge of quantifying levels of understanding, which despite the use of three different data collection methods, remains a prohibitively intangible quality.

Another interesting finding from the expert interviews was that respondents believed that 2012 marked a watershed in how safety was perceived within ATC. The experts' opinions seem to have been dictated in the main by their individual experiences within their respective roles. Despite this, there was a widespread agreement among interviewed experts that safety is the most important component of ATC.

The combination of three methods in this research represents the most complete attempt in all of this topic's literature to statistically track HRO within ATC. The use of document analysis, survey, and expert interviews provided both quantitative and qualitative data, which could then be synthesised to provide the most complete data set possible. The following chapters present some of the broad outcomes of this study, as well as a number of recommendations to future research that have arisen as a result of the project.

6 Part 5: Conclusions and Future Research

The present chapter summarises the results that could be gathered from the document search, the survey and the expert interviews. It will focus on the research question and objectives from chapter 3.2. Subsequently, the present paper's methodology will be reviewed critically as well as the application of the results above and beyond the scope of the case will be outlined. Finally, an outlook deals with future potential for research.

6.1 Summary of the Results

Chapter 2 initially introduced risk and safety management in the aviation industry. Summarising the literature review of chapter 2, the following can be stated:

- The aviation industry is one with an exceptional safety record and a very low accident rate compared to any other industry.
- In order to improve and develop highest safety standards, such an industry cannot only rely on learning from accidents but has to look for additional sources of data for the purpose of investigations.
- The aviation industry focusses on incidents that could have led up to an accident just as much as on accidents itself.
- Understanding why something almost went wrong will support risk mitigation strategies to maintain the accident rate at the lowest possible level.
- HROT provides an understanding of how organisations are set up in an environment with extraordinary safety records, whilst at the same time delivering high performance in daily operations.
- ATC has been introduced as a prime example for highly reliable operations and with the purpose of achieving, maintaining and improving safety as paramount goal.
- HROT describes three principles and five dimensions of high reliability, which are found in any HRO.
- Setting up the organisation along the lines of these parameters will allow errors to be contained within the system and maintain stable operations, even with undesirable situations occurring.
- Limitations of such systems are primarily found in external sources that put pressure onto the organisation.

- The operating point of an HRO, which should always allow enough buffer to cope with economic and workload issues to avoid safety critical events, can be affected by significant economic pressure.
- The most recent development in ATC governance is the introduction of European-wide performance regulation, which introduces market-like forces to ANSPs and exposes these HROs to economic pressure.

6.2 New knowledge gained

Subsequently, the main goal of this was to create new understanding of how HROs operate, how their operations might change when liberalisation is introduced, and whether or not market economics will ultimately bring an HRO into imbalance. Several key discoveries arose as a result of the research. Firstly, there was a significant amount of information gained about the organisation, which demonstrated the way in which HROT concepts may be present. The findings also provided an increased understanding of the way in which HROs may be created and then maintained, without requiring an overworked reference to the underlying theory. The case study provided an insight into a single organisation, where many HRO practices were being undertaken, but when explicitly asked, many of those taking part in the surveys did not have a clear understanding of the underlying concept. This demonstrates the potential difference between theory and action, with a theoretical understanding of organisational concept unnecessary from a performance perspective.
Also, that documentation related to HROT can only be found in the operational part or with direct safety reference (safety cases) indicate a difference between theory and practice.
Some of the most significant external influence factors on the HRO principles were identified from literature. These factors mainly come from economic pressure that might move the operating point into undesirable areas. Within the highly regulated framework of aviation, governance and economic regulation were identified as significant factors. In reference to chapter 3.3., the present dissertation focused on the main research question:

“To what extent do highly reliable organisations apply HROT principles in daily organisational practice across the two essential business functions Operations *and* Operational Support *against the influence of external influencing factors, especially regulation?”*

This does not contradict the underlying literature which formed the foundation of this study. The HRO literature focused on how organisations could be identified and the principles that would guide the operation, and it did not deal directly with the underlying motivations for the relevant frameworks to be identified. Therefore, this case also demonstrates the way in which regulation can impact culture and organisation and its practices, leading it towards HRO status.

By means of the three different data collection methods - document search, survey, and expert interviews - the extent to which the case company complies with high reliability principles was investigated. The results showed that employees rated their own familiarity with HRO principles as relatively poor (net promoter score -26.6). Even worse ratings were returned with regard to their superiors’ familiarity with HRO principles (NPS -39.11), but despite this they appeared to adopt many of the relevant practices. Employees rated their colleagues’ familiarity with HRO principles as poor as their own (NPS -27.59).

Nevertheless, the results show that employees are able to characterise an HRO by means of specific keywords such as safety, redundancy, security, resilience, honesty, integrity, resilience, transparency, accountability, consistency and responsibility. This demonstrates that there are effective communication methods that may be inherent within the culture, as well as potential explicit communications, as seen with the documents and everyday discussions. Additionally, most of the employees were able to identify some of the most important elements of HROs, such as defined goals, consistent standards and well-planned operations, doing all that is possible to avoid accidents, having a pattern or solutions in times of crisis, providing professional service by experienced employees, a clear communication strategy, and commitment to resilience. The present dissertation’s objective was to determine the level of integration of the five dimensions of high reliability in the different business areas of the case company and to explore the factors that account for any identified difference between theory and practice.

In reference to the defined research objectives of chapter 3.3., the results showed that HROs are generally associated with safety, reducing risks and experienced staff. The safety aspect is of highest importance for most of the employees (86.99 percent), followed by sensitivity to operations (72.36 percent) and commitment to resilience (69.92 percent). On a scale of 0 to 100, most employees ranked the inclusion of HROT principles are included into their everyday work environment at an average of 68.29. Additionally, most of the participants consider the other area’s HRO knowledge about the same (37.7 percent) or even worse (33.61 percent) that their own. Only a few employees consider the other area’s HRO knowledge better or much better (22.95 percent).

Most of the participants (53.39 percent) believe that HRO principles were followed to a similar degree before 2012 compared to today, but there were also 23.73 percent who believed it was “better/much better” and 22.88 percent who believed it was “worse/much worse”. The reasons for these statements vary. Some employees mention improved structures and developed expertise. Some state that due to the implementation of more rules regarding safety and quality management, the organisations in general became more involved in HRO principles. But answers such as systems and procedures were tested more carefully before 2012 (and before the first economic regulation by the European Commission was introduced) and that cost efficiency was preferred over safety were also obtained. In this context, many employees believed that, before 2012, the main goal was safety first and that after 2012, more and more cost aspects appeared, changing the focus from safety to economy on the contrary, many others did not see a specific change.

According to the results, the introduction of the performance scheme has the highest influence on the organisation, whereas functional airspace blocks have the lowest. The reasons for the employees’ rating are again extremely varied. On one hand, the performance scheme relates to delay, which is probably most relevant to ANS. On the other hand, everything is about cost and is driven by money. As part of the performance scheme, the European regulation set out specific targets in four areas for any ANSP. According to the results, capacity of airspace comes in at the first place, whereas environmental targets take last place. The employees argue that money rules the organisation, that there are less controllers resulting from the need of cost reduction, and that safety still has to be paramount for an ANSP. Although capacity and cost-efficiency are the main focus areas, safety is a must and always comes first, whatever happens.

Many employees returned to the issue of regulation. On a scale of 0 to 100, they rated the effect of regulation on their operational or non-operational area, with the average coming in at 44.76. Regarding the effects of regulation on the entire organisation, the average was 46.45. Respondents rated the influencing factors, which were:

- regulator (CAA/BAF, etc.),
- EU regulation,
- ICAO rules,
- airline demands,
- airport demands,
- internal demands and
- cost drivers

EU regulation, the regulator (CAA/BAF, etc.), and cost drivers belong to the influencing factors with the highest ratings. Overall, the project increased understanding of the way in which HRO practices may manifest because of internal and external pressures. It also underlined the emphasis on communication and culture that lead to the practices taking place regardless of the status of theoretical knowledge of the employees. Importantly, the role of external factors is seen as extremely relevant, along with reference to regulations, which then impact on culture and further impact on practice. The results also indicate that where there is a high level of regulation, the determination of what is deemed to be safe may be determined primarily with reference to the regulations, thus leading to internal practices.

6.3 Contribution to theory

As was mentioned in chapter 2.3.3., HROT identifies five key dimensions for any high reliability organisation such as ATC. The identified research gap was that relatively little is known about the current operational point of such an organisation and that even the organisation itself might not accurately know this but could only define it after an incident or an accident. This created a clear need for an empirical study examining this, and the present study falls within this category.

The literature provides no evidence as to whether an HRO as a whole is or is not operating according to the HRO principles, whilst HROT does not separate operations from the business area of an organisation as such. The present paper thus could extend the theory by means of survey and expert interview results, since it could show that HROs such as ATC operates according to HRO principles independent from the area of business. The results from the expert interviews show that, in most peoples' opinions, it is the employees' attitude towards safety and resilience that makes ATC so safe.

The present paper used a predominantly empirical methodology to gather results. Most publications only conducted one form of data collection, such as a quantitative survey or a qualitative interview or a document search and did not feature a high degree of empiricism. No specific paper could be identified that used three different forms of data gathering.

The three forms of data collection combined two different questionnaires and data gathering methods (qualitative and quantitative) with a third method, the document search. Both questionnaires were addressed to people working in the ATC environment and focused on the same issue, that of HRO principles in ATC. Nevertheless, both questionnaires concentrated on different perspectives. One questioned employees, and the other questioned managers. Because the common topic was HRO in ATC, both questionnaires contained some common questions.

From a more general perspective, the current research extends existing theories by identifying the way in which there may be a separation of theoretical principles from practice, where practice may be present without specific reference to the theory. Furthermore, the theory was also extended with reference to the importance of culture, and the way it may be inspected by external as well as internal factors. Most of the literature surveyed organisations from the inside out, whereas this study considered the organisation within its environment. By looking at the broader context, the importance of external influences - particularly those associated with regulations - can be seen as key influences on the development of HRO as a compliance strategy.

At its core, this project took an inductive approach to the topic. Because of the relative paucity of information surrounding the intersection of ATC and HROs, there is insufficient evidence to conduct a survey using a deductive approach. Some research has attempted to bridge this gap, and HRO experts have sometimes used the example of ATC to make wider points. There are even examples in which researchers have visited Area Control Centres. However, there has not been a specific piece of research within HRO that has dealt with these issues. As a result, the literature necessitated the use of an inductive method, as there was insufficient evidence on which to base a satisfactory deductive approach.

The combination of different data collection methods might be very useful in future research to gain deep insights into a specific topic from different perspectives.

Additionally, the present study provides many approaches to further increase safety and resilience in ATC, as many experts voiced their opinion on this issue. Therefore, these approaches can be advanced by other researchers to develop a conceptual framework to enhance an HRO’s levels of safety and resilience. In answering the research question and identifying the extent to which the principles are applied using rigorous, empirical methods, the study also filled a clear gap in the previous base of research. On top of that, the thesis provided evidence from ATC that they operate according to HROT principles, which has not yet been explicitly described in HROT research. Although ATC is mentioned in research and the key publication *Managing the unexpected* by the Berkeley Group specifically refers to ATC operations in the U.S. (Weick & Sutcliffe, 2007; p. 164), in depth research on the HRO nature of ANSP organisations has not yet been provided. With this research, the gap in theory can be closed and the understanding of HROT enhanced in a way as the theory might be applied even without an organisation already fully aware of it and that HROT principles can already contribute to an organisation as a whole if they are consistently implemented within key areas of the business, with enhancements, should it be applied thoroughly.

6.4 Contribution to practice

Many starting points for improving ATC's safety and resilience could be gathered in line with this study's results. It is not only ATC that might benefit from the present paper's results, but also policy, which is explained in the present chapter.

6.4.1 Recommendations for ATC Practitioners

As could be seen from the expert interviews' results, all the experts talked about internal and external influences on safety, reliability and the resilience of ATC. They also listed possibilities that might further increase ATC's safety and resilience. For ATC practitioners, these suggestions might be of high interest, as they can be used to make ATC more resistant towards internal and external influences.
The following contributions should be considered:

- Licensing of engineers

Based on the particular recommendation by E3, who stated that air traffic engineers are not licensed, one recommendation is to consider licensing of air traffic engineers (E3, 2019). Adhering to HRO principles also means implementing possible solutions to further increase safety and reliability even without the urgent requirement to act or react as the incidents connected to air traffic engineering are very low (E3, 2019). On the other hand, as other ATS personnel such as ATCOs are subject to licensing as laid out in the EU 2015/340 regulation (The European Commision, 2015), licensing of air traffic engineers might increase safety through a common standard. This might be achieved without a common regulation but potentially by a national agreement with the respective CAA.

- Development of personnel, procedures, and systems

To increase the resilience or level of safety, building interdisciplinary teams could help to further develop personnel, procedures, and systems. ATC meetings thus need to discuss what is going well in their work, what is going wrong, and what especially needs to be optimised. Any results obtained should be implemented consistently. It is obvious that people are the key factor in further increasing safety and resilience, as they need to be motivated to work to their potential every day and to optimise the system continuously. According to the experts' opinion, it is this balance between safety, personnel, and finance that makes ATC safe and reliable. Some experts differentiate between operational and non-operational areas, because the non-operational staff are not trained with any significant emphasis on safety. There is therefore less understanding for the procedures and the culture in the operational area. One recommendation would be to give additional workshops or training sessions for non-operational staff to increase their understanding. However, HROs such as ATC sometimes struggle with financial pressure, which comes from increased economic considerations. Like most other organisations, HROs are aware of savings and efficiency programs, because according to the management, they need to be more efficient to confront their cost problem. HROs always need to find a middle ground between safety, capacity, and cost efficiency, with personnel the highest cost factor. At the same time - and according to many experts - personnel is the most important pillar of ATC. ATC should thus never make savings with personnel but instead invest in it.

This recommendation can also easily be expanded beyond ATC as the constant development and improvement of procedures will improve operational stability across any organisation. The specific enhancement from this recommendation is the perpetual involvement of members of staff in all of these processes as the ones executing processes on a regular basis will likely know flaws in the system more than others.

- Knowledge sharing in the organisation

Focusing on the entire organisation, knowledge sharing within and between organisations increases resilience and reliability. One element is facing towards people from outside the HRO environment starting to work for ATC. It is proposed to share the existing knowledge with these new people as part of the induction. In this way, new people become familiar with the principles of reliability and safety fro the very start. This is especially needed if new staff start to work as a controller or ATC engineer. Another aspect is that people will learn to know that they can speak up to comfortably raise issues.
The second element is to share the background of why and how highly reliable organisations are set up from a more theoretical perspective. If the organisation is aware of the underlying theory, the culture will be less likely to drift away from the principles that account for the high standards.
This recommendation, just as the one before, will support any organisation even beyond HROT. Within HROs, that have a complex and tightly coupled system, there is a very high relevance that as much as possible is shared amongst the team but even is less complex or coupled systems, the benefits will allow for a more resilient business operation. A potential drift into failure can be identified even before it results in a potential error.

- Developing a vision and a strategic framework

According to many experts, a high reliability organisation and its staff need a specific sort of thinking and vision, which also must be applied by the politicians. Nowadays, HROs are moving in this direction, but it will still take a long time to implement. In this context, it is the responsibility of superiors in the air traffic control world to recognise specific issues and to help others to understand that the real issues are not about technology or pay levels for air traffic controllers. Rather, the real issues are how to set the strategic framework for the industry on the right path to allow it to evolve efficiently and effectively. This issue becomes more and more a political issue, which is why it is discussed further in chapter 6.4.2.

- Careful budgeting

According to most experts, more money is needed to increase safety and reliability of ATC. On the other hand, ATC is a business that must be cost-effective. The surveys and the expert interviews show that this has a counterproductive effect. According to some experts, it would potentially be possible to employ extra controllers on top of the budget. This would increase ATC safety, reduce the working-hours of current employees so that they would return to work healthier, fitter, and ready to do their jobs. As was reported by many experts, budgets face consistent constraints, which is why new technologies normally cannot be brought in. The experts criticise the fact that due to a limited budget, there are many things that cannot be done. Putting a price on safety will always mean that safety becomes less of a priority.
Continuously reducing costs and budgets would also reduce safety, reliability and resilience. One recommendation to counteract this would be to ensure focus is not solely placed on economics and finance. It is obvious that ATC needs to be competitive but planning a budget must be done very carefully to ensure safety is maintained at all times.

- Reduction of complexity

Some experts mention that the entire system could be made more stable or safer if complexity was reduced. Often, changes or new ideas cannot be brought in because ATC is characterised by a high complexity. Although, HROT recognises organisations such as an ANSP as a highly complex and tightly coupled environment, which cannot be oversimplified (Weick & Sutcliffe, 2007), there is a risk of creating an environment, which becomes too complex for the individuals to manage, which would result in a risk of the organisation drifting into failure without being aware of it. Organisations should constantly review their structures, processes and procedures for over-complexity with the aim to keep it at a stable level.

6.4.2 Recommendations for Policy Makers

Many external influencing factors on an ATC’s safety, reliability and resilience were obtained from the data collection. A host of these external influencing factors potentially could be impacted by policy makers.

As the results of the survey and the expert interviews show, an HRO such as ATC is strongly linked to a huge variety of regulations. Thus, the following chapter focuses specifically on recommendations for policy makers.

- Reducing pressure

Some of the experts mention that the European Commission puts much (economic) pressure on ATC. The philosophy that safety in aviation is something different from safety in other industries is not well understood by many external agents, such as politicians and financial controllers. However, it is not only the European Commission that puts pressure on ATC. One of the experts also mentioned the impatience of airlines, which forces ATC to handle more than is possible. Additionally, wages are rising along with material costs and technology is becoming more and more expensive. This economic pressure dictates that fundamental (safety related) things might be ignored. Since the system must be kept stable, reducing any sort of pressure by targeted measures must be a focus. Many experts have listed regulations, the European Commission as well as national law, as external influencing factors. Nevertheless, an intact HRO should be able to manage external factors without undermining its integrity. With an increased number of external factors, retaining integrity becomes more and more challenging. If for instance cost pressure becomes too high, an HRO might have difficulties to still sticks to its principles. In addition, the HRO might go bust, which could have a knock-on effect on the whole industry. The European Commission and its regulations are therefore required to avoid a decline in safety. The European Commission should recognize its responsibility when it comes to putting pressure on HROs. Although also mentioned by many experts that the regulations, set out by ICAO and/or the European Commission support the HRO in their task to maintain a safe and reliable operation as it defends the HRO against certain influence factors from within the industry, regulations are also able to disturb an HRO's balance. If the motto remains: more capacity at less expenditure and less costs, there is risk of an imbalance.

This very recommendation can also be extended beyond the scope of this research to be respected in regulations on other industries.
Increasing economic pressure from external factors might result in similar issues in other organisations and markets. Within the organisations referred to by this could be nuclear power plants or fire fighters but also hospitals. Beyond the current scope of HROT this might be banks or major industries with thousands of employees affected in case of a failure.

- Learning about the importance of safety

According to the opinion of experts, understanding the importance of safety is something that can be learned. Thus, policy makers should focus on learning what safety means and how it can be endangered by external pressure. It is agreed by the experts, that it is not required to have HROT background in order to step into the role of a policy maker for these organisations. The key to high reliability can be learned and adopted. But it requires an understanding of this need amongst the policy makers on the one hand and the time and training material on the other hand. Organisations such as the EASA can support such an approach as they are within the policy making framework deeply involved in HRO operations, have an understanding of the requirements and can provide the policy making framework with the relevant knowledge on a greater scale than today.

- Establishing international interfaces

One potential external influencing factor is the issue of interfaces with other organisations, as aircraft pass borders and there are several control centres in other countries. This is undoubtedly a big network, but it can be improved if people pull in the same direction. In this context, problems might occur if a country changes its system and/or procedure, which might influence the entire system if others are unable to adapt. Existing international networks are mainly industry driven (i.e. Civil Air Navigation Services Organisation, CANSO) or union driven (i.e. Air Traffic Controllers European Unions Coordination, ATCEUC). An extended and standardised international interface from a policy makers perspective would increase ATC's safety and could represent a task for the European Commission.

- Ensuring a stable system

According to the experts, ATC works in an environment, heavily characterised by commercial business exposed to a high degree of economic pressure that must be balanced somehow. Changing longstanding procedures might have an impact on safety. Policy makers must therefore keep in mind that a change always has an effect on an organisation and the organisations interacting with it. It is recommended not to change longstanding procedures often, because HROs such as ATC must be given time to run risk analysis, hazard analysis and safety cases but also to adopt to these changes. Whilst an ever-changing environment with the aviation industry being no exemption, requires any organisation constantly adopt and develop in order to maintain a sustainable business, the frequency of changes needs to be carefully considered to reduce the possible negative effects on the systems` stability.

It must not be automatically assumed a problem for people with HRO-deficits to work in governments and be responsible for regulations, because it is an HRO's job to deal with these regulations and to defend HRO-principles. Nevertheless, the greater the stress, the greater the temptation becomes to find a quick solution.

Rules continuously change over time and ATC is a continually developing process because of the evolving technological landscape. According to the experts' opinions, rules once did not change as often as they do nowadays. However, the high number of rules is needed, since the spaces between aircraft are small with more airplanes in the sky.

- Ensure and maintain frequent tests and inspections

According to the experts, one of the biggest influences on ATC's safety would be taking away checks and balances. In an environment with increasing economic pressure, the number of checks, tests and inspections is at question as they increase the costs with no directly related efficiency gains.

Aircraft for example are regularly tested and inspected because parts might fail if they will not be checked continuously. Runways at airports are regularly inspected for foreign objects that might damage an aircraft and ATC equipment is regularly tested and inspected to find eroding parts before they might fail.

An HRO such as ATC might lose safety if they were to cut back on regular tests and inspections as a result of economic pressure. Policy makers thus need to ensure a sufficient level of regular tests and inspections.

- Defining and refining an ATC's mission in the law

In relation to external influences, specific regulations and institutions such as EASA have been mentioned by some experts. There are not only many regulations that have to be implemented by ATC, but airlines also try to interfere where they can. In this context, one expert mentioned a key aspect: ATC will always remain stable, no matter the external forces. This is due to the fact that ATC's mission is defined in the Basic Law, or rather in LuftVG and LuftVO. Thus, keeping an HRO stable is also a question of embedding its mission in the law. Policy makers could provide a sound legal framework for the mission of ATC in order to support the wider policy making framework and set up an additional boundary against unwanted external influences whilst at the same time maintaining full control over the scope of the legal framework.

6.4.3 Recommendations Following the COVID-19 Pandemic

At a time of unprecedented stress within the aviation industry, this study would be remiss not to point out some of the key takeaways from the ongoing COVID-19 pandemic. With the tension between safety and financial feasibility at its most precarious position in modern memory, the pandemic's ramifications are likely to be felt long into the future. The very nature of air travel could be set to change for good, which will undoubtedly be of huge significance to this field of study.

At this point, it is hard to say just how significant (and indeed, just how permanent) this rupture will prove to be. This is especially true given the diversity of opinions amongst experts regarding the long-term impact of the Coronavirus pandemic upon the world of aviation. Some believe that there might be a permanent reduction in the number of flights (Hancock & Georgiadis, 2021). Others are more optimistic, with Overton (2020) stating that a complete recovery is possible but are dependent upon adequate distribution of vaccinations and the return of the overall economy to its pre-pandemic state.

There is clearly no consensus upon what the consequences of the virus will be for the industry throughout the years to come. In addition to this, Liu et al. (2020) note that numerous different studies aimed at ascertaining the long-term effect of COVID-19 upon airlines have been inconclusive. The future of this sector appears to be an unknown quantity.

This uncertainty means that it is difficult to gain an insight into what the future has in store. Consequently, projecting any concrete conclusions onto the febrile and ever-shifting landscape of aviation would be premature, and would likely be proven to be false. What seems certain is that substantial change is inevitable, and scholarship must keep up with the changing times if it is to remain relevant.

Although this study goes a long way in addressing many of the existing literature's shortcomings, new studies are needed to bridge the divide between the assumptions of the pre-pandemic world and the conditions that will exist in its aftermath, whatever they may be. There can be no denying that the pandemic was a global event and one that will be felt in the globalised aviation industry. The pressure that will be placed on HROs will therefore be applied at a global level. This is an unprecedented challenge and one that has no existing examples on which to base a prediction. This study must be backed up by further research that confirms the empirical evidence gathered here remains relevant into a new era.

6.5 Above and beyond ATC

The scope of the findings of this thesis not only sits within the case organisation but also in a wider framework.

ANSPs on a global scale are subject to ICAO regulations, which also define the setup and structure of an ANSP in many ways as found in the ICAO Doc. 4444 (ICAO, 2016b). The results in this thesis, which have been developed from an organisational point of view, can be applied to any ANSP, which is subject to the ICAO regulation and setup. Any organisational structure that is similar to the one found in this case, will likely return similar or even the same results.

To expand this view further, it can be stated that the aviation industry sits within the same regulatory framework of ICAO just as any ANSP does. For example, ICAO Doc. 9137, 9157 and 9184 to name only three, are defining the planning and organisation of airports (ICAO, 2006). The findings can further be applied within the aviation industry to any other organisation, which is subject to ICAO regulations.

An organisation, subject to the same regulatory principles and oversight will naturally develop similar structures.

Taking into account the nature of HROs and the applicability of HROT in general, the scope of the thesis results can be expanded even further. The Berkeley group investigated organisations with large-scale operating systems that perform at extraordinary levels of safety and productivity (Roberts K. H., 1990a) and would normally be bound to fail according to NAT. The results led to the HROT, within which they described the entirety of these organisations as HROs.

Whilst within the aviation industry many representatives of HROT are identified, which show these traits and are described in the theory such as ANSPs, Airlines, Airports (Moses & Savage, 1990; BAC Australia, 2006; Papatheodorou & Platis, 2007; Grabowski & Roberts, 2016) also many other organisations and industry such as for example Nuclear and Chemical Power Plants or Fire Fighters (Thomas, Fox, & Miller, 2015), Emergency Response Services and healthcare (Morrow, 2016) but also Navy Seal Teams (Vogus & Sutcliffe, 2017) or even aerospace (Casler, 2013) are identified as highly reliable organisations. This shows that HROT is not and has never been limited to the aviation industry or the scope of the initial work of the Berkely group but is applicable in a broad sense.

With the applicability of the findings to a subset of HROs or the aviation industry whilst revealing that this subset adheres to HROT, the results can

also be applied to any other HRO or organisation adhering and adopting HROT principles into their organisation.
And as even the theory is not able to cover any organisation, which is required to operate relatively error free over a long period, HROT can possibly be applied to organisations above and beyond todays´ scope of the theory or what has been identified from literature, which will also expand the scope of the findings of this thesis.

6.6 Methodological Limitations and Critical Evaluation

The following chapter’s aim is to critically analyse the methodological approach of the present paper. There are some limitations to this methodological approach, which require careful attention. While qualitative case studies have a strong advantage to gain a thorough understanding of a particular phenomenon, it lacks statistical data or quantitative evidence. This results in the potential issue of generalising findings compared to quantitative approaches (Yin, 2003). On the contrary, all findings are transferable to all similar or complementary situations. In the context of this research, the case of air traffic control as the HRO will be transferable to any other organisation that claims or is known to be highly reliable as outlined in the previous chapter. As such, the findings will be applicable to most areas of the industry at least in part. This research will thus provide more analytical than statistical findings and conclusions.
Another limitation from the case study lies in the selected subset within the case, that of TWR only. This has the potential to be seen as too narrow in its approach and is open to a similar critique that the ground breaking work of Perrow faced (Perrow, 2011). As has been already described, all subsets within air traffic control (Area Control, Approach Control, and Tower Control, for example) are structured almost identically. Therefore, any research regarded regulation or other phenomenon is automatically transferable to any other subset. It is proposed that any finding from this research, including its conclusions will be applicable to any organisational structure known to be highly reliable.
Regarding the qualitative survey by means of guided interviews, it can be said that subjectivity is one of the most critical aspects of a qualitative survey. Due to the subjective views of the experts, the ability to generalise

data gathered from a qualitative data collection is limited. However, this does not inevitably mean that the data has been interpreted in an arbitrary manner. At the very least, a qualitative data collection, as well as the subsequent data interpretation, require a high level of methodological control (Helfferich, 2011).

In addition to this, is must be noted that the standardised interview guideline has not been tested within the scope of a pre-test. This means that the guideline has not been checked prior to the actual questioning with regard to comprehensibility. The guideline was not modified after the first interviews, as there was no qualified feedback. Ultimately, the original version was used throughout the interviews. According to Punch (2014), data quality is highly dependent on the quality of the preparation.

Another potential influence can be the communication abilities of the interviewer, since these abilities can be seen as a key tool for the planned survey (Flick, 2008).

It becomes clear that the data - gathered by means of a qualitative data collection - does not equate to raw data, but instead depends on the specific interview situation. According to Punch (2014), the interviewer creates the reality of the whole interview situation by themselves. The personal characteristics of the interviewer such as the social class, the gender or the ethnicity affect the survey method in some way. At least, the interview should be understood as a mutual interaction between the interviewer and participant. It includes the mutual appraisal, the creation of specific expectations as well as an appropriate behaviour regarding these expectations.

Another influencing factor might be due to the specific formulation of questions. In this context, leading questions, closed questions, and unconscious answer expectations can lead to the survey results being ushered in a specific direction. As already mentioned, the interviewer's personality as well as his or her individual skills play an important role in this. Considering the author's specific challenges, one can finally note that there is a lack of experiences regarding the execution of a qualitative survey. This for instance includes the specific knowledge about

conversations, competences of interaction, nonverbal signals, the handling of interventions and contradictions, empathy, and the form of questions.
In this context, Helfferich (2011) notes that the interviewed person needs to have knowledge regarding the situational survey design, so that potential stress can be avoided. The interviews themselves require the interviewer and the interviewee to take active roles. Without a specific level of trained communication skills, this active design cannot be performed optimally under these circumstances, as such a routine is not given in the case of the author. In addition to that, the author does not have sufficient experience regarding intervention possibilities in the case of exhaustive discussions and participants who wander off the point. Therefore, it can be assumed that some potential interview errors such as long and unclear questions, the offering of answering alternatives or unconscious emotions might have led to an unconscious influence of the experts' answers. Additionally, a missing recording of the interview along with a lack of time resulted in the issue that the experts' answers could not be compared to each other, since some of them were not able to answer all of the questions. Questions were, however, posed from all of the thematic blocks, but sometimes there was a lack of time, preventing potentially relevant additional questions from being asked.
Regarding the present data analysis, some difficulties resulted in the fact that the participants often switched between future and past as well as between the single categories. To enable the identification of the relevant information, many interactions and relations had to be considered. The attempt to represent these interactions resulted in the fact that the data material had sometimes been coded five times. In this context it must be mentioned that the experts' answers had been classified in more than only one thematic category, since there was no clear allocation.

6.7 Outlook and Scope for Future Work

As the present dissertation shows, HROs can be characterised by an open approach to mistakes. This is true not only for the present case study, the DFS - classed as an HRO - but many other institutions and organisations such as hospitals and social facilities also strive for being safer and more reliable, since there are many internal and external influencing factors that might affect the organisation's safety. Considering, for instance, hospital germs and the lack of personnel, one might ask the question whether patients and clients are safe and well cared in their particular institution. Thus, it is not only ATC that deals with the aspect of safety in an environment marked by cost pressures and other influencing factors. Many organisations have to face the question of whether their safety measures are sufficient or whether processes need to be streamlined. One of the most important aspects is that people trust in HROs such as ATC, airlines, hospitals and social institutions. Such organisations are interested in evolving into an HRO. This requires an open approach to mistakes, as the organisation wants to learn from incidents and accidents in the past. It is interesting to ask whether and how HRO principles can be fully applied to other organisations such as banks, or if traditional quality management is sufficient to already fulfil such a task.

Potential for improvement might exist in the field of data gathering. In this context it might be possible that other data collection methods such as narrative interviews or ethnographic interviews lead to other results. To ensure a theoretical representation, a series of case studies should be conducted. The present dissertation used the DFS as case study and the gathered results should be correlated with results from other HROs. Therefore, further research might concentrate on other HROs and repeat the present examination. In this way, it would be possible to check whether the present results can be fully applied to other companies or other industries.

In addition, it is recommended to HROT researchers to explore the wider applicability beyond organisations, which are likely to return catastrophic outcomes in case of a failure but to less critical organisations. The principles of HROT allow an organisation to improve the resilience of their operations, which is supportive to any business continuity planning. A new category of HROs could be classified through research introducing organisations, which produce constant output with a relatively low error rate.

A qualitative content analysis by means of the analysis software MaxQDA was planned for the final analysis of the generated data. Ultimately, this proved impossible, as the qualitative content analysis with MaxQDA was not able to deal with the complex system of links and connections. The potential for improvement in the field of data analysis might lay in the coding of more than one coder, since the coding effort is very high. In this way, different variations of coding could have been discussed. Future research projects in this field could concentrate on a quantitative survey by means of a standardised and structured questionnaire. In this case, the employees of several companies from different industries could be questioned and the results might show a higher level of objectivity, reliability and validity.

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Appendix

A. Document List

OPNOT-PH-03718 Clarification of occurrences to be filed on by operational staff. - Copy

OPNOT-PH-02118 - REMT flypasts

OPNOT-PH-02618 - Use of the Departure Table

OPNOT-PH-01818 - AGL Infrastructure Upgrade

OPNOT-PH-04018 Aerodrome Elevation

OPNOT-PH-03318-Runway Rehabilitation Autumn 2018.

OPNOT-PH-02318 - C17 on North Apron

OPNOT-PH-01918 - Local Aerodrome Frequency Changes

OPNOT-PH-02518 - Exercise Chameleon 18-2

OPNOT-PH-02218 - REMT Flypast 14 Aug 18

OPNOT-PH-03018- Closure of Stand 7

OPNOT-PH-02418 - Exercise Cobra Warrior

OPNOT-PH-02018 - REMT Flypast 04 Aug 18

OPNOT-PH-03918 Radio end user testing

OPNOT-PH-01618 - Scottish National Air show 2018

OPNOT-PH-02918 - Glasgow VOR DME outages

OPNOT-PH-04218-Hogmanay Celebrations RA(T)

OPNOT-PH-03518-New Airfield Callsigns

OPNOT-PH-03618-Exercise Rising Panther 18-2

OPNOT-PH-03818-Removal of Emergency VHF radios

OPNOT-PH-03418-Removal of VHF Main radios

OPNOT-PH-03218-MATS Part 2 Issue 1.2 October18

OPNOT-PH-01718 - Remotely Controlled Aircraft Tugs

OPNOT-PH-02818 - VHF Standby radios

OPNOT-PH-02718 - Radar in the Tower Operations

OPNOT-PH-04118-ANS Unified Management Manual v5.0

SI-ANS-02516 - Tugs Calling on GMP Frequency

SI-ANS-02516 - Tugs Calling on GMP Frequency HARP
SI-ANS-01316 (v1.0) - Revised Push and Hold Positions
SI-ANS-01316 (v1.0) - Revised Push and Hold Positions - HARP
SI-ANS-02716 - Runway Crossings & Access to Hangar 6 via Block 14 for Code E Aircraft HARP
SI-ANS-02716 - Runway Crossings & Access to Hangar 6 via Block 14 for Code E Aircraft
SI-ANS-01317 - Amendments to VFR and SVFR Criteria HARP
SI-ANS-01317 - Amendments to VFR and SVFR Criteria
SI-ANS-01616 - ILS Faults
SI-ANS-01616 - ILS Faults HARP
SI-ANS-03216 - WITHDRAWN Change to Code C Restrictions on Juliet during Northern Runway Ops
SI-ANS-01916 - Use of Taxiway Yankee Undershoot by Towed Movements
SI-ANS-01916 - Use of Taxiway Yankee Undershoot by Towed Movements - HARP
SI-ANS-01916 (v1.1) - Use of Taxiway Yankee Undershoot by Towed Movements
SI-ANS-01517 - Confirmation of ‘on stand’ Engine Run procedures
SI-ANS-01517 - Confirmation of ‘on stand’ Engine Run procedures HARP
SI-ANS-00417 - Coordination of Reduced Departure Separation HARP
SI-ANS-00417 - Coordination of Reduced Departure Separation
SI-ANS-00316 - U.K. FMP Notification
SI-ANS-00516 - Airside Vehicles – Procedure Changes
SI-ANS-00517 - Coordination of reduced departure separations
SI-ANS-00517 - Coordination of reduced departure separations HARP
SI-ANS-00517 - Coordination of reduced departure separations OBSOLETE
SI-ANS-01816 - Pier1 - Standard Pushbacks
SI-ANS-01816 - Pier1 - Standard Pushbacks - HARP
SI-ANS-01516 - AIRAC 6 2016 SID Changes (IA)
SI-ANS-01516 - AIRAC 6 2016 SID Changes (HARP)
SI-ANS-01516 - AIRAC 6 2016 SID Changes
SI-ANS-02416 - ATIS messages to reduce RT congestion

SI-ANS-02416 - ATIS messages to reduce RT congestion HARP
SI-ANS-02216 - Runway Crossings & Access to Hangar 6 via Block 14
SI-ANS-03116 - Amendment to Positioning of Aircraft at DA Sierra
SI-ANS-03116 - Amendment to Positioning of Aircraft at DA Sierra HARP
SI-ANS-02116 - A380 Taxi Instructions on Taxiways Kilo & Romeo
SI-ANS-03216 - WITHDRAWN Change to Code C Restrictions on Juliet during Northern Runway Ops
SI-ANS-02116 - A380 Taxi Instructions on Taxiways Kilo & Romeo HARP
SI-ANS-00317 - Escorting of Tugs crossing the runway or undershoot HARP
SI-ANS-00317 - Escorting of Tugs crossing the runway or undershoot
SI-ANS-01416 - Duty Executive OSCAR
SI-ANS-01416 - Duty Executive HARP
SI-ANS-01416 - Duty Executive
CR-ANS-002 - ATSA ECVCR Check
SI-ANS-01116 - ATSA ECVCR Checks
SI-ANS-01216 - Flow Rates during Forecast LVPs -HARP
SI-ANS-01216 - Flow Rates during Forecast LVPs
SI-ANS-00816 (v1.0) - Document Publication Process
SI-ANS-00917 - Change to the numbering of 08R PRNAV SIDs
SI-ANS-00917 - Change to the numbering of 08R PRNAV SIDs HARP
WITHDRAWN SI-ANS-00817 - Change to the numbering of 08R SIDs
SI-ANS-00817 - Change to the numbering of 08R SIDs
SI-ANS-00817 - Change to the numbering of 08R SIDs HARP
SI-ANS-02916 - Engine Runs for Code D & E Sized Aircraft at A2
SI-ANS-02916 - Engine Runs for Code D & E Sized Aircraft at A2 HARP
SI-ANS-02616 - Lone Working Arrangements
SI-ANS-02616 - Lone Working Arrangements HARP
SI-ANS-02216 (v1.3) - Runway Crossings & Access to Hangar 6 via Block 14
SI-ANS-02216 (v1.2) - Runway Crossings & Access to Hangar 6 via Block 14
SI-ANS-02216 - Runway Crossings & Access to Hangar 6 via Block 14 HARP

SI-ANS-02216 (v1.3) - Runway Crossings & Access to Hangar 6 via Block 14

SI-ANS-02816 - Movements through unlit blocks during Northern Runway Ops HARP

SI-ANS-02816 - Movements through unlit blocks during Northern Runway Ops

SI-ANS-01017 - Code E Engine Runs at Juliet 4 (Updated)

SI-ANS-01017 - Code E Engine Runs at J4 (Updated) HARP

SI-ANS-00717 - Code E Engine Runs at J4

WITHDRAWN SI-ANS-00717 - Code E Engine Runs at J4

SI-ANS-00717 - Code E Engine Runs at J4 HARP

SI-ANS-00217 - Change to Code C Restrictions on Juliet during Northern Runway Operations - Reissue

SI-ANS-00217 - Change to Code C Restrictions on Juliet during Northern Runway Operations HARP

SI-ANS-03016 - Reporting of RPAS following near miss report

SI-ANS-03016 - Reporting of RPAS following near miss report HARP

SI-ANS-01217-Coordination and FDE Management during Northern Runway Ops

SI-ANS-01217-Coordination and FDE Management during Northern Runway Ops HARP

SI-PH-01118 - Removal of SRAs and LCIS

SI-PH-00318 - Sending Movement Statistics to SCAN

SI-PH-00119-Evacuation procedures HARP

SI-PH-00318 - Sending Movement Statistics to SCAN HARP

SI-PH-01318 - Small Unmanned Aircraft HARP

SI-PH-00519- Code E aircraft operations

SI-PH-00319-OperationalPower Supplies

SI-PH-02018-Changes to MET Procedures

SI-PH-02318 TOKAI Reporting Policy

SI-PH-00119-Evacuation procedures

SI-PH-01618-Stands 1-6 pushback procedure HARP

SI-PH-00618 - General Aviation departures

SI-PH-00418 - Flying Training and Test Flights

SI-PH-00118 - Safety Reporting and TOKAI

SI-PH-00818 - Movement Statistics Update

SI 00619 HARP

SI-PH-01018 - RFFS Category

SI-PH-01018 - RFFS Category HARP

SI-PH-02018-Changes to MET Procedures HARP

SI-PH-01218 - GMC open status on ATIS HARP

SI-PH-01718 - Model Flying at Kirknewton HARP

SI-PH-01019-Non jet pushbacks from stands 200-206

SI-PH-00118 - Safety Reporting and TOKAI HARP

SI-PH-01418 - Engine Ground Runs v2

SI-PH-00518 - Engine Ground Runs HARP

SI-PH-00818 - Movement Statistics Update HARP

SI-PH-00518 - Engine Ground Runs

SI-PH-01418 - Engine Ground Runs v2 HARP

SI00719 Removal of helispots and grass taxiway

SI-PH-00219-CVCR radios

SI-PH-01818 - Code E and F Runway Operations

SI 02218 HARP

SI010A19 HARP

SI-PH-00618 - General Aviation departures HARP

SI-PH-00419 HARP

SI-PH-00918 - South Apron Stubs and pushbacks from Stands 46A and 46B

SI-PH-00219-HARP

SI-PH-02118-Changes to Automet Procedures HARP

SI-PH-01918 Edinburgh Surveillance Radar System HARP

SI-PH-01518 - East Apron Stubs Aircraft Start and Depart HARP

SI-PH-01618-Stands 1-6 pushback procedure

SI-PH-00718 - Kirknewton Gliding Operations HARP

HARP for TOI-PH-00118, 00218, 00318, 00418 & SI-PH 00218

SI-PH-01818 - Code E and F Runway Operations HARP

SI 00719 HARP

SI-PH-01518 - East Apron Stubs Aircraft Start and Depart

SI-PH-01118 - Removal of SRAs and LCIS HARP

SI-PH-00419-Emergency Callouts by the ATSA

HARP SI-PH-02518 Frequency Changes - Copy

SI-PH-010a-Addendum-Non-Jet pushbacks from Stands 200-206

SI01019 HARP

SI-PH-01718 - Model Flying at Kirknewton

SI-PH-00718 - Kirknewton Gliding Operations

SI-PH-00918 - South Apron Stubs and pushbacks from Stands 46A and 46B HARP

SI 02318 HARP

SI-PH-00218 - Permanent Closure of Runway 12 30

SI-PH-02218-SMR Identification

SI-PH-00319-HARP

SI 00519 HARP

SI-PH-02418-Failure to maintain final approach spacing.

SI-PH-01318 - Small Unmanned Aircraft

SI-PH-01218 - GMC open status on ATIS

HARP SI-PH-02418

SI-PH-00619-Night Runway Closures

SI-PH-02118-Changes to Automet procedures

SI-PH-02518-Frequency Change

SI-PH-00418 - Flying Training and Test Flights HARP

SI-PH-01918 Edinburgh Surveillance Radar System

HARP SI-EGPH-01618 Stands 1-6 Pushback Procedures (1)

SI-ANS-00416 - Operating the AGL Panel in Test Mode

SI-ANS-00617 - Coordination of Reduced Departure Separation v3 HARP

SI-ANS-00617 - Coordination of Reduced Departure Separation v3

SI-ANS-03216 - Change to Code C Restrictions on Juliet during Northern Runway Ops

SI-ANS-03216 - Change to Code C Restrictions on Juliet during Northern Runway Ops HARP

SI-ANS-01417 (v1.1) - Reintroduction of Stands 67 and 68

SI-ANS-01417 (v1.2) - Reintroduction of Stands 67 & 68 v1.2

SI-ANS-01417 - Reintroduction of Stands 67 and 68

SI-ANS-01417 - Reintroduction of Stands 67 and 68 HARP

SI-ANS-00916 - Entering & Leaving a Receiver Site

SI-ANS-00916 - HARP

SI-ANS-02216 (v1.2) - Runway Crossings & Access to Hangar 6 via Block 14

SI-ANS-01016 - Engine Runs

SI-ANS-01016 -HARP

SI-ANS-00716 - Clarification of Scoring Requirement (UTP)

SI-ANS-01716 - Implementation of Short Process Instruction (SPI)

SI-ANS-01716 - Implementation of Short Process Instruction (SPI) HARP

SI-ANS-00117 - Aircraft Larger than Code C Passing through Stands 41M & 43M HARP

SI-ANS-00117 - Aircraft Larger than Code C Passing through Stands 41M & 43M

SI-ANS-01817 - Amendment to conventional SIDs on 26L R

SI-ANS-01817 - Amendment to conventional SIDs on 26L R HARP

SI-ANS-00616 - Currency Requirements (UCS)

SI-ANS-01617 - AFS Emergency Standby Positions HARP

SI-ANS-01617 - AFS Emergency Standby Positions

SI-ANS-01117 - Remote Holding on the 140s Stands

SI-ANS-01117 - Remote Holding on the 140s Stands HARP

SI-ANS-02216 (v1.1) - Runway Crossings & Access to Hangar 6 via Block 14

SI-ANS-01717 - Northern Runway Operations - Deactivation of 08L & 26R

SI-ANS-01717 - Northern Runway Operations - Deactivation of 08L & 26R HARP

SI-ANS-02016 - Correction to Yankee Undershoot Restriction HARP

SI-ANS-02016 - Correction to Yankee Undershoot Restriction

SI-ANS-02316 - Standard push back for Stand 102 HARP

SI-ANS-02316 - Standard push back for Stand 102

SN-PH-00218 - EGPH Lesson Learning GMC Error & EFPS

SN-PH-00618 - Operational Distractions v2.0

SN-PH-00818 - MSAW Alerts

SN-PH-00118 - Operational Distractions

SN-PH-00318 - Loss of Radio Contact

SN-PH-00418 - Multi Apron Ramp System (MARS) Stands

SN-PH-00518 - Issues with SMR Quality

SN-PH-00718 - Stand Guidance

SN-PH-00918 - IRVR and LVPs

TOI-KK-05718 - Boeing Hangar Airside Works on Taxiway Uniform - REISSUE

TOI-KK-02718 - Removal of Northern Runway Safeguarding Barriers

TOI-ANS-02917 - Stand 573 Non-Standard Pushback - Reissue 2

TOI-ANS-02917 - Stand 573 Non-Standard Pushback - Reissue 2 HARP

TOI-KK-04518 - Rehabilitation of Taxiway Juliet Blocks 46N 47N REISSUE 21

TOI-ANS-02617 - AFL position in the VCR - REISSUE

TOI-ANS-02617 - AFL position in the VCR - REISSUE HARP

TOI-KK-00518 - Stand 573 Non standard Pushbacks HARP

TOI-KK-00518 - Stand 573 Non standard Pushbacks

TOI-ANS-01917 - Change to Lighting Functionality in Blocks 33N & 39N Reissue HARP

TOI-ANS-01917 - Change to Lighting Functionality in Blocks 33N & 39N Reissue

TOI-ANS-00217 - Change to Lighting Functionality in Blocks 33N & 39N HARP

TOI-ANS-00217 - Change to Lighting Functionality in Blocks 33N & 39N

TOI-ANS-00716 - Restriction on use of Stands 41 and 43

TOI-ANS-00716 - Restriction on use of Stands 41 and 43 - HARP

TOI-KK-03018 - Departure Procedure during NOTAM Closure of Gatwick Approach REISSUE

TOI-ANS-03816 - Use of BRAVO in LVPs for vehicles

TOI-ANS-03816 - Use of BRAVO in LVPs for vehicles HARP

TOI-KK-02118 - Pre-noting TC South of any IMVUR NOVMA KENET departures HARP

TOI-KK-05318 - ASMGCS Airborne Data

TOI-KK-01518 - Boeing Hangar Airside Works on Taxiway Uniform

TOI-KK-04418 - Temporary Parking for 2 Norwegian B787 aircraft on Yankee

TOI-ANS-02016 - Taxiway Restrictions Due to Juliet Works Phase B - Reissue HARP

TOI-ANS-02016 - Taxiway Restrictions Due to Juliet Works Phase B - Reissue

TOI-KK-016185 - Change to Lighting Functionality in Blocks 33N & 39N during Northern Runway Ops

TOI-KK-01118 - Trial Removal of Leader Vehicle Escort for Stands 48R 49R

TOI-KK-01718 - Trial Removal of Leader Vehicle Escort for Stands 48R 49R HARP

TOI-KK-01518 - Boeing Hangar Airside Works on Taxiway Uniform HARP

TOI-ANS-03417 - Change to Lighting during Northern Runway Ops REISSUE

TOI-ANS-03417 - Change to Lighting during Northern Runway Ops REISSUE HARP

TOI-ANS-01316 (v1.1) - Taxiway Restrictions due to Juliet Works - Phase B

TOI-ANS-01316 - Taxiway Restrictions due to Juliet Works - Phase B

TOI-ANS-01316 - Taxiway Restrictions due to Juliet Works - Phase B HARP

TOI-KK-04618 - Taxiway Quebec Realignment Enabling Works – REISSUE 21

TOI-KK-00718 - VHF Radio Replacement Project - Reissue HARP

TOI-KK-03218 - Overnight Closures of Block 34S

TOI-KK-00418 - Amendment to Access on Zulu During Northern Ops

TOI-ANS-03116 - Update to Taxiway Restrictions due to ongoing Juliet Works

TOI-ANS-03116 - Update to Taxiway Restrictions due to ongoing Juliet Works HARP

TOI-KK-04518 - Rehabilitation of Taxiway Juliet Blocks 46N 47N REISSUE 2

TOI-ANS-00117 - Pier 5 Pushbacks HARP

TOI-ANS-00117 - Pier 5 Pushbacks

TOI-ANS-03517 - Use of BRAVO in LVPs by vehicles – Reissue

TOI-ANS-03517 - Use of BRAVO in LVPs by vehicles – Reissue HARP

TOI-KK-03118 Change to Lighting Functionality in Blocks 33N & 39N during Northern Runway Ops REISSUE

TOI-ANS-03616 - Update to Taxiway Restrictions due to ongoing Juliet Works

TOI-ANS-03616 - Update to Taxiway Restrictions due to ongoing Juliet Works HARP

TOI-KK-03218 - Overnight closures of block 34S HARP

TOI-KK-05718 - Boeing Hangar Airside works on Taxiway Uniform REISSUE HARP

TOI-KK-00918 - Change to Lighting during Northern Ops REISSUE HARP

TOI-KK-04618 - Taxiway Quebec Realignment Enabling Works REISSUE 2 HARP1

TOI-ANS-00417 - Pier 5 Pushbacks HARP

TOI-ANS-00417 - Pier 5 Pushbacks

TOI-KK-02518 - VHF Radio Replacement Project - Reissue HARP

TOI-KK-03318 - Taxiway Quebec Realignment Enabling Works

TOI-ANS-01716 - Taxiway Restrictions due to Juliet Works – Phase B (Updated) HARP

TOI-ANS-01716 - Taxiway Restrictions due to Juliet Works – Phase B (Updated)

TOI-KK-01118 - Trial Removal of Leader Vehicle Escort for Stands 48R 49R HARP

TOI-KK-00618 - Departure Procedure during NOTAM Closure of Gatwick Approach

TOI-KK-04218 - Taxiway Quebec Realignment Enabling Works - Reissue

TOI-KK-02118 - Pre-noting TC South of any IMVUR NOVMA KENET departures

TOI-ANS-00517 - Block 94 Restrictions due WIP

TOI-ANS-00517 - Block 94 Restrictions due WIP HARP

TOI-ANS-01717 - Block 94 Restrictions due to work in progress for Stand 67

TOI-ANS-01717 - Block 94 Restrictions due to work in progress for Stand 67 HARP

TOI-KK-04618 - Taxiway Quebec Realignment Enabling Works REISSUE 2 HARP2

TOI-KK-01818 - Pre-noting TC South of any IMVUR NOVMA KENET departures HARP

TOI-ANS-00416 - Pier1 – Standard Pushbacks

TOI-ANS-00416 - Pier 1 - Standard Pushbacks - HARP

TOI-KK-02418 - Pushback Trial from Pier 6 into 130s stands - VERSION 2 HARP
TOI-KK-05518- Availability of new Hold at Zulu 1 during Northern Runway Operations
TOI-KK-016185 - Change to Lighting Functionality in Blocks 33N & 39N during Northern Runway Ops HARP
TOI-KK-02418 - Pushback Trial from Pier 6 into 130s stands - VERSION 2
TOI-KK-00219 - Removal of NOps safeguarding Barriers - REISSUE
TOI-ANS-01617 - Block 94 Restrictions due WIP - Updated
TOI-ANS-01617 - Block 94 Restrictions due WIP - Updated HARP
TOI-KK-02218 - Withdrawal of Delta track and midpoint track for runway inspections
TOI-KK-03018 - Departure Procedure during NOTAM Closure of Gatwick Approach REISSUE HARP
TOI-KK-00618 - Test Instruction
TOI-KK-00818 - Stand 573 Non standard Pushbacks - Reissue
TOI-ANS-02216 - Loss of Lights in Block 39N - HARP
TOI-ANS-02216 - Loss of Lights in Block 39N
TOI-ANS-01317 - Remote Holding 140s Re Instatement Trial HARP
TOI-ANS-01317 - Remote Holding 140s Re Instatement Trial
TOI-KK-01318 - Network ACDM Trials 201
TOI-ANS-02517 - Northern Runway Operations September 2017 to December 2017 HARP
TOI-ANS-02517 - Northern Runway Operations September 2017 to December 2017
TOI-KK-01018 - DMAN Live Trial in Network Mode
TOI-ANS-02217 - Stand 573 Non-Standard Pushbacks HARP
TOI-ANS-02217 - Stand 573 Non-Standard Pushbacks
TOI-ANS-01516 - Use of Taxiway Juliet through the Worksite - Reissue
TOI-ANS-01516 - Use of Taxiway Juliet through the Worksite - Reissue HARP
TOI-KK-01418 - Departures between 2301z-0300z on the night of 23 & 24 May
TOI-KK-05218 - Change to Lighting Functionality in Blocks 33N & 39N during Northern Runway Ops REISSUE

TOI-ANS-03516 - AFL in the Tower REISSUE

TOI-ANS-03516 - AFL in the Tower REISSUE HARP

TOI-KK-01218 - Stand 573 – Non standard Pushbacks

TOI-ANS-02916 - Amended Pushback for Stand 145M - Reissue

TOI-ANS-02916 - Amended Pushback for Stand 145M - Reissue - HARP

TOI-ANS-02816 - Use of Taxiway Juliet through the Worksite - Reissue

TOI-ANS-02816 - Use of Taxiway Juliet through the Worksite - Reissue HARP

TOI-KK-01818 - Pre-noting TC South of any IMVUR NOVMA KENET departures

TOI-ANS-00218 - VHF Radio Replacement Project

TOI-ANS-00218 - VHF Radio Replacement Project HARP

TOI-KK-04618 - Taxiway Quebec Realignment Enabling Works REISSUE 2 HARP

TOI-KK-00618 - Departure Procedure during NOTAM Closure of Gatwick Approach HARP

TOI-KK-04818 - Rehabilitation of Taxiway Juliet Blocks 46N 47N REISSUE 3

TOI-ANS-00318 - Change to Lighting Functionality in Blocks 33N & 39N during Northern Runway Ops

TOI-KK-04418 - Temporary Parking for 2 Norwegian B787 aircraft on Yankee HARP

TOI-ANS-00816 - Extra Juliet Taxi restrictions

TOI-ANS-00816 - Extra Juliet Taxi restrictions HARP

TOI-KK-02618 - VHF Radio Replacement Project Software Trial July 18

TOI-ANS-00216 - HARP

TOI-ANS-00216 - 26L Undershoot

TOI-KK-04348 - Conduct of Runway Inspections - Reissue HARP

TOI-KK-04418 - Temporary Parking for 2 Norwegian B787 aircraft on Yankee HARP1

TOI-ANS-00717 - Block 94 Restrictions due WIP - updated

TOI-ANS-00717 - Block 94 Restrictions due WIP - updated HARP

TOI-ANS-00616 - Juliet Taxi Instructions

TOI-ANS-00616 - Juliet Taxi Instructions - HARP

TOI-ANS-03217 - Tactical Overnight Parking in Blocks 83 & 84

TOI-ANS-03217 - Tactical Overnight Parking in Blocks 83 & 84 HARP

TOI-KK-00918 - Change to Lighting during Northern Ops REISSUE

TOI-KK-02619 - Kilo crossing in controlled mode HARP

TOI-KK-04718 - Taxiway Quebec Realignment Enabling Works REISSUE 3 - HARP

TOI-KK-02818 - Conduct of Runway Inspections HARP

TOI-KK-01318 - Network ACDM Trials 201 HARP

TOI-KK-02618 - VHF Radio Replacement Project Software Trial July 18 HARP

TOI-ANS-01916 - Use of Taxiway Juliet through the Worksite - Reissue

TOI-ANS-01916 - Use of Taxiway Juliet through the Worksite - Reissue HARP

TOI-ANS-01416 - Escorting of Tugs crossing the Runway - Reissue

TOI-ANS-01416 - Escorting of Tugs crossing the Runway - Reissue HARP

TOI-KK-05518 - Availability of new Hold at Zulu 1 during Northern Runway Operations HARP

TOI-ANS-00316 (v1.1) - Remote Hold (amendment)

TOI-ANS-00316 - HARP

TOI-ANS-0032016 - Remote Hold

TOI-KK-04518 - Rehabilitation of Taxiway Juliet Blocks 46N 47N REISSUE 2 HARP

TOI-KK-00418 - Amendment to Access on Zulu During Northern Ops HARP

TOI-KK-04918 - Temporary Parking for 2 Norwegian B787 aircraft on Yankee - Reissue

TOI-ANS-01816 - Escorting of Tugs crossing the Runway - Reissue HARP

TOI-ANS-01816 - Escorting of Tugs crossing the Runway - Reissue

TOI-KK-01218 - Stand 573 – Non standard Pushbacks HARP

TOI-ANS-03716 - Update to Taxiway Restrictions due to ongoing Juliet Works - Code E HARP

TOI-ANS-03716 - Update to Taxiway Restrictions due to ongoing Juliet Works - Code E

TOI-KK-05818 - Activation of drone command procedures

TOI-ANS- 03416 - Escorting of Tugs Crossing the Runway REISSUE HARP

TOI-ANS- 03416 - Escorting of Tugs Crossing the Runway REISSUE
TOI-KK-03618 - VHF Radio Replacement Project REISSUE HARP
TOI-KK-03718 - Boeing Hanger Airside Works on Taxiway Uniform REISSUE HARP
TOI-KK-04518 - Rehabilitation of Taxiway Juliet Blocks 46N 47N REISSUE 2 HARP2
TOI-ANS-00817 - Use of BRAVO in LVPs for vehicles - Reissue
TOI-ANS-00817 - Use of BRAVO in LVPs for vehicles - Reissue HARP
TOI-ANS-00916 - A380 Taxi Instructions on Kilo and Romeo
TOI-ANS-00916 - A380 Taxi Instructions on Kilo and Romeo HARP
TOI-KK-00818 - Stand 573 Non standard Pushbacks - Reissue HARP
TOI-ANS-03316 - REISSUE Update to Taxiway Restrictions due to ongoing Juliet Works
TOI-ANS-03316 - REISSUE Update to Taxiway Restrictions due to ongoing Juliet Works HARP
TOI-KK-04118 - ASMGCS Airborne Data HARP
TOI-ANS-02116 - Amended Pushback for Stand 145M
TOI-ANS-02116 - Amended Pushback for Stand 145M HARP
TOI-ANS-02417 - Use of Bravo by Vehicles in LVPS REISSUE HARP
TOI-ANS-02417 - Use of Bravo by Vehicles in LVPS REISSUE
TOI-KK-04118 - ASMGCS Airborne Data
TOI-ANS-03117 - DMAN Live Trial in Network Mode - Stage 2 HARP
TOI-ANS-03017 - Sierra Crossing in Controlled Mode during De-icing Trial HARP
TOI-ANS-03017 - Sierra Crossing in Controlled Mode during De-icing Trial
TOI-KK-04518 - Rehabilitation of Taxiway Juliet Blocks 46N 47N REISSUE 2 HARP1
TOI-KK-01718 - Trial Removal of Leader Vehicle Escort for Stands 48R 49R REISSUE
TOI-KK-04618 - Taxiway Quebec Realignment Enabling Works – REISSUE 2
TOI-KK-02918 - A380 Parking on Stand 172M HARP
TOI-KK-03518 - Rehabilitation of Taxiway Juliet Blocks 46N 47N HARP
TOI-KK-05218 - Change to Lighting Functionality in Blocks 33N & 39N during Northern Runway Ops - HARP

TOI-KK-03718 -Boeing Hangar Airside Works on Taxiway Uniform - REISSUE

TOI-KK-01418 - Departures between 2301z-0300z on the night of 23 & 24 May HARP

TOI-KK-02818 - Conduct of Runway Inspections

TOI-KK-02718 - Removal of Northern Runway Safeguarding Barriers HARP

TOI-ANS-03317 - Stand 573 Non-Standard Pushback - Reissue 3 HARP

TOI-ANS-03317 - Stand 573 Non-Standard Pushback - Reissue 3

TOI-KK-03818 - Withdrawal of Delta track and mid-point track for Runway Inspections HARP

TOI-ANS-02416 - Taxiway Restrictions due to Juliet Works – Phase B - Reissue

TOI-ANS-02416 - Taxiway Restrictions due to Juliet Works – Phase B - Reissue HARP

TOI-ANS-03117 - DMAN Live Trial in Network Mode - Stage 2

TOI-KK-04218 - Taxiway Quebec Realignment Enabling Works Reissue - HARP (002)

TOI-KK-02018 - GCC Long term operation from backup facility July 2018

TOI-ANS-02316 - AFL position in the VCR

TOI-ANS-02316 - AFL position in the VCR HARP

TOI-KK-02318 - Trial of Pier 6 pushbacks into the 130 stands

TOI - ANS - 02717 - Stand 573 - Non Standard Pushback - Reissue HARP

TOI - ANS - 02717 - Stand 573 - Non Standard Pushback - Reissue

TOI-ANS-00917 - Pier 5 Pushbacks Reissue WITHDRAWN

TOI-ANS-00917 - Pier 5 Pushbacks Reissue

TOI-ANS-00917 - Pier 5 Pushbacks Reissue HARP

TOI-ANS-02117 - 1 Minute Silence for the London Terror Attack HARP

TOI-ANS-02117 - 1 Minute Silence for the London Terror Attack

TOI -ANS-02516 - Escorting of Tugs crossing the Runway - Reissue

TOI -ANS-02516 - Escorting of Tugs crossing the Runway - Reissue HARP

TOI-KK-01918 - Removal of Northern Runway Safeguarding Barriers

TOI Juliet Work Phase 1

TOI-KK-01319 - Trial of Pier 6 pushbacks into the 130 stands WITHDRAWN

TOI-KK-04918 - Temporary Parking for 2 Norwegian B787 aircraft on Yankee - Reissue HARP

TOI-KK-00819 - Boeing Hangar Airside works on Taxiway Uniform reissue HARP

TOI-KK-03518 - Rehabilitation of Taxiway Juliet Blocks 46N 47N

TOI-ANS-01216 - AFL Working in the VCR

TOI-ANS-01216 - AFL Working in the VCR - HARP

TOI-KK-02218 - Withdrawal of Delta track and midpoint track for runway inspections HARP

TOI-ANS-00318 - Change to Lighting Functionality in Blocks 33N & 39N during Northern Runway Ops HARP

TOI-KK-00718 - VHF Radio Replacement Project - Reissue

TOI-ANS-00317 - AFL in the Tower REISSUE HARP

TOI-ANS-00317 - AFL in the Tower REISSUE

TOI-KK-03818 - Withdrawal of Delta track and mid point track for Runway Inspections

TOI-ANS-01116 - Use of Taxiway Juliet through the Worksite

TOI-ANS-01116 - Use of Taxiway Juliet through the Worksite HARP

TOI-ANS-01517 - Northern Runway Operations - Deactivation of 08L 26R

TOI-ANS-01517 - Northern Runway Operations - Deactivation of 08L 26R HARP

TOI-KK-04018 - Block 46N-47N Rehab Works REISSUE

TOI-ANS-01016 - Aircraft Under Tow Crossing the Runway

TOI-ANS-01016 - Aircraft Under Tow Crossing the Runway HARP

TOI-ANS-03016 - Loss of Lights in Block 39N - Reissue

TOI-ANS-03016 - Loss of Lights in Block 39N - Reissue - HARP

TOI-KK-03618 - Radio testing procedures REISSUE 2

TOI-ANS-01817 - Use of Bravo in LVPS REISSUE HARP

TOI-ANS-01817 - Use of Bravo in LVPS REISSUE

TOI-ANS-01616 - Code C Restriction on Papa Blocks 57N, 43N

TOI-ANS-01616 - Code C Restriction on Papa Blocks 57N, 43N HARP

TOI-KK-03918 - Removal of Northern Runway Safeguarding Barriers

TOI-ANS-00118 - Stand 573 – Non standard Pushbacks – Reissue 4

TOI-ANS-00118 - Stand 573 – Non standard Pushbacks – Reissue 4 HARP

TOI-KK-04718 - Taxiway Quebec Realignment Enabling Works - REISSUE 3

TOI-KK-01018 - DMAN Live trial in Network Mode HARP

TOI-ANS-00617 - Block 94 Restrictions due WIP Updated HARP

TOI-ANS-00617 - Block 94 Restrictions due WIP - Updated

TOI-KK-03918 - Removal of Northern Runway Safeguarding Barriers HARP

TOI-KK-0342018 - Network ACDM Trial Reissue

TOI-KK-03418 - Network ACDM Trials HARP

TOI-ANS-02616 - Towed movements through unlit blocks NRW Ops

TOI-ANS-02616 - Towed movements through unlit blocks on Northern Runway Ops HARP

TOI-KK-00618 - Test Instruction HARP

TOI-KK-05118 - Rehabilitation of Taxiway Juliet Blocks 46N 47N – Reissue 4

TOI-KK-04818 - Rehabilitation of Taxiway Juliet Blocks 46N 47N REISSUE 3 - HARP

TOI-ANS-02017 - Northern Runway Operations - Deactivation of 08L 26R Reissue

TOI-ANS-02017 - Northern Runway Operations - Deactivation of 08L 26R Reissue HARP

TOI-ANS-00516 (v1.1) -Taxiway Juliet Works - HARP

TOI-ANS-00516 (v1.1)-Taxiway Juliet Works

TOI-ANS-00516 (v1.2)-Taxiway Juliet Works

TOI-ANS-01217 - Change to Lighting Functionality in Blocks 33N 39N - Reissue HARP

TOI-ANS-01217 - Change to Lighting Functionality in Blocks 33N 39N - Reissue

TOI-ANS-03216 - Update to Taxiway restrictions due to on going Juliet HARP

TOI-ANS-03216 - Update to Taxiway Restrictions due to ongoing Juliet Works

TOI-ANS-02716 - AFL Position in the VCR HARP

TOI-ANS-02716 - AFL Position in the VCR

TOI-KK-02018 - GCC Long term operation from backup facility July 2018 HARP

TOI-KK-02918 - A380 Parking on Stand 172M

TOI-KK-03118 Change to Lighting Functionality in Blocks 33N & 39N during Northern Runway Ops REISSUE HARP

TOI-ANS-01417 - Block 94 Restrictions due WIP - Updated

TOI-ANS-01417 - Block 94 Restrictions due WIP - Updated HARP

TOI-KK-01918 - Removal of Northern Runway Safeguarding Barriers HARP

TOI-PH-02318-Use of Stand 15B

TOI-ANS-00116 - DMAN – Runway Changes

TOI-ANS-03916 - Update to Taxiway Restrictions due to ongoing Juliet Works - Code E

TOI-ANS-03916 - Update to Taxiway Restrictions due to ongoing Juliet Works - Code E HARP

TOI-KK-02518 - VHF Radio Replacement Project - Reissue

TOI-KK-04318 - Conduct of Runway Inspections REISSUE

TOI-KK-05818 - Activation of Drone Command Procedures HARP

TOI-KK-02719 - Kilo crossing in controlled mode - REISSUE

TOI-ANS-01117 - Block 94 Restrictions due WIP - updated HARP

TOI-ANS-01117 - Block 94 Restrictions due WIP - updated

TOI-KK-05818 - Handling of Drone Incidents HARP

TOI-ANS-02817 - DMAN Live Trial In Network Mode

TOI-ANS-02817 - DMAN Live Trial In Network Mode HARP

TOI-KK-04018 - Block 46N-47N Rehab Works REISSUE HARP

TOI-ANS-02317 - Change to Lighting during Northern Runway Ops REISSUE

TOI-ANS-02317 - Change to Lighting during Northern Runway Ops REISSUE (HARP)

TOI-KK-03318 - Taxiway Quebec Realignment Enabling Works HARP

TOI-PH-00219-Turnhouse Apron Phase 21

HARP - TOI 00119

TOI-PH-01018 - Pushback Quick Reference

TOI-PH-01818 - Edinburgh Surveillance Radar System Changes from August 18 HARP
TOI-PH-01018 - Pushback Quick Reference HARP
TOI-PH-01118 - Downgrade of Stands 31-34 and Taxiway H HARP
TOI-PH-01718 - Model Flying at Kirknewton
TOI-PH-01918-Closure of H1.
TOI-PH-01518 - Code E Aircraft Operations HARP
TOI-PH-01218 - Stand 46C HARP
TOI-PH-00618 - UPDATE Gliding at Kirknewton HARP
TOI-PH-00818 - Downgrade of stands 31-34 and taxiway Hotel
HARP TOI 01918 Closure of H1 (1)
TOI-PH-00219-Turnhouse Apron Phase 2
TOI-PH-01318 Pushback Quick Reference HARP
TOI-PH-01218 - Stand 46C
TOI-PH-02118-Runway Rehabilitation Updated
TOI-PH-01618 - Airside Operations Relocation
TOI-PH-00418 - Edinburgh Surveillance Radar System Changes from March 18
TOI-PH-00818 - Downgrade of stands 31-34 and taxiway Hotel HARP
TOI-PH-02218-Inaccuracies in QFE and Samos
TOI-PH-00218 - Pushback Procedure Changes for Stands 1 & 6 (1)
TOI-PH-02018-Runway Rehabilitation Guidance HARP
TOI-PH-01318 Pushback Quick Reference 04-18
HARP for TOI-PH-00118, 00218, 00318, 00418 & SI-PH 00218
TOI-PH-01818 - Edinburgh Surveillance Radar System Changes from August 18
TOI-PH-00318 - Code E Aircraft Operations
TOI-PH-00918 - City of Edinburgh Security Enhancements HARP
TOI-PH-00518 - Kirknewton Gliding Operations 07-15 April 2018
TOI-PH-02018-Runway Rehabilitation Guidance
TOI-PH-02118-Runway Rehabilitation Updated HARP
TOI-PH-00218 - Pushback Procedure Changes for Stands 1 & 6
TOI 02218 HARP - Copy
TOI-PH-00718 - Kirknewton Gliding Operations 19th April -30th June 2018

TOI-PH-00718 - Kirknewton Gliding Operations 19th April -30th June 2018 HARP

TOI-PH-01718 - Model Flying at Kirknewton HARP

TOI-PH-00119 -Turnhouse Apron Phase 1

TOI-PH-00918 - City of Edinburgh Security Enhancements

TOI-PH-01118 - Downgrade of Stands 31-34 and Taxiway H

TOI-PH-00518 - Kirknewton Gliding Operations 07-15 April 2018 HARP

TOI-PH-01618 - Airside Operations Relocation HARP

TOI-PH-00618 - UPDATE Gliding at Kirknewton

TOI-PH-00118 - Pushback Quick Reference

TOI-PH-02318-Use of Stand 15B

TOI-PH-00119 -Turnhouse Apron Phase 2

TOI-PH-01418 - Downgrade of Stands 31-34 and Taxiway H

TDI-KK-00218 - Operation Tanglewood 2018

TDI-KK-00118 - Additional Post Incident Actions

SC-DF-904 (v1.1) - Digital Resolution Direction Finder Safety Case Part 4

SC-DF-901 (v1.1) - Digital Resolution Direction Finder Safety Case Part 1

SC-DF-902 (v1.1) - Digital Resolution Direction Finder Safety Case Part 2

SC-DF-903 (v1.0) - Digital Resolution Direction Finder Safety Case Part 3

SC-EF-001 (v1.1) - Electronic Flight Progress System Part 1

SC-EF-003 (v2.2) - Electronic Flight Progress System Part 3

SC-EF-004 (v1.1) - Electronic Flight Progress System Part 4

SC-EF-002 (v1.2) - Electronic Flight Progress System Part 2

SC-DM-004 (v1.0) - Distance Measuring Equipment Part 4

SC-DM-002 (v1.1) - Distance Measuring Equipment Part 2

SC-DM-003 (v1.0) - Distance Measuring Equipment Part 3

SC-DM-001 (v1.1) - Distance Measuring Equipment Part 1

SC-CA-904 (v1.0) - Omni-Crash Alarm Safety Case Part 4

SC-CA-902 (v1.0) - Omni-Crash Alarm Safety Case Part 2

SC-CA-901 (v1.1) - Omni-Crash Alarm Safety Case Part 1

SC-CA-903 (v1.0) - Omni-Crash Alarm Safety Case Part 3

SC-ND-904 (v1.1) - Non-Directional Beacon System Safety Case Part 4

SC-ND-902 (v1.1) - Non-Directional Beacon System Safety Case Part 2

SC-ND-901 (v1.1) - Non-Directional Beacon System Safety Case Part 1

SC-ND-903 (v1.1) - Non-Directional Beacon System Safety Case Part 3

SC-MT-903 (v1.0) - Master Time Source Safety Case Part 3

SC-MT-904 (v1.0) - Master Time Source Safety Case Part 4

SC-MT-902 (v1.0) - Master Time Source Safety Case Part 2

SC-MT-901 (v1.1) - Master Time Source System Part 1

SC-VC-902 (v1.1) - Voice Communications System Part 2

SC-VC-901 (v1.1) - Voice Communications System Part 1

SC-VC-903 (v1.1) - Voice Communications System Part 3

SC-VC-904 (v1.1) - Voice Communications System Part 4

SC-RE-904 (v1.0) - Recording Systems Safety Case Part 4

SC-RE-902 (v1.1) - Recording Systems Safety Case Part 2

SC-RE-901 (v1.0) - Recording Systems Safety Case Part 1

SC-RE-903 (v1.0) - Recording Systems Safety Case Part 3

SC-VC-003 (v1.2) - Voice Communications System Part 3

SC-VC-002 (v1.2) - Voice Communications System Part 2

SC-VC-001 (v1.2) - Voice Communications System Part 1

SC-VC-004 (v1.1) - Voice Communications System Part 4

SC-IL-902 (v2.0) - Instrument Landing System Part 2

SC-IL-903 (v2.0) - Instrument Landing System Part 3

SC-IL-901 (v2.0) - Instrument Landing System Part 1

SC-IL-904 (v2.0) - Instrument Landing System Part 4

SC-MET-902 (v1.1) - Meteorological System Safety Case Part 2

SC-MET-903 (v1.1) - Meteorological System Safety Case Part 3

SC-MET-901 (v1.1) - Meteorological System Safety Case Part 1

SC-MET-904 (v1.1) - Meteorological System Safety Case Part 4

SC-GS-904 (v1.0) - Ground Surveillance System Safety Case Part 4

SC-GS-901 (v1.1) Ground Surveillance System Part 1

SC-GS-903 (v1.0) - Ground Surveillance System Safety Case Part 3

SC-GS-902 (v1.1) -Ground Surveillance System Part 2

SC-SU-003 (v1.0) - Surveillance Part 3

SC-SU-001 (v1.2) - Surveillance Part 1

SC-SU-004 (v1.0) - Surveillance Part 4

SC-SU-002 (v1.2) - Surveillance Part 2

SC-DF-904 (v1.1) - Digital Resolution Direction Finder Safety Case Part 4

SC-DF-901 (v1.1) - Digital Resolution Direction Finder Safety Case Part 1

SC-DF-902 (v1.1) - Digital Resolution Direction Finder Safety Case Part 2

SC-DF-903 (v1.0) - Digital Resolution Direction Finder Safety Case Part 3

SC-EF-001 (v1.1) - Electronic Flight Progress System Part 1

SC-EF-003 (v2.2) - Electronic Flight Progress System Part 3

SC-EF-004 (v1.1) - Electronic Flight Progress System Part 4

SC-EF-002 (v1.2) - Electronic Flight Progress System Part 2

SC-DM-004 (v1.0) - Distance Measuring Equipment Part 4

SC-DM-002 (v1.1) - Distance Measuring Equipment Part 2

SC-DM-003 (v1.0) - Distance Measuring Equipment Part 3

SC-DM-001 (v1.1) - Distance Measuring Equipment Part 1

SC-FD-004 (v1.1) - Flight Data Management System Part 4

SC-FD-001 (v1.0) - Flight Data Management System Part 1

SC-FD-003 (v1.0) - Flight Data Management System Part 3

SC-FD-002 (v1.1) - Flight Data Management System Part 2

SC-LC-901 (v1.0) - Landing Clearance Indicator System Safety Case Part 1

SC-LC-904 (v1.0) - Landing Clearance Indicator System Safety Case Part 4

SC-LC-902 (v1.0) - Landing Cleance Indication System Safety Case Part 2

SC-LC-903 (v1.0) - Landing Cleance Indication System Safety Case Part 3

SC-SM-001 (v1.0) - Semi-Automatic meteorological observing system Part 1

SC-SM-002 (v1.1) - Semi-Automatic meteorological observing system Part 2

SC-SM-003 (v1.0) - Semi-Automatic meteorological observing system Part 3

SC-SM-004 (v1.0) - Semi-Automatic meteorological observing system Part 4

SC-MT-003 (v1.0) - Master Time Source Part 3

SC-MT-001 (v1.0) - Master Time Source Part 1

SC-MT-002 (v1.0) - Master Time Source Part 2

SC-MT-004 (v1.0) - Master Time Source Part 4

SC-IL-002 (v1.2) - Instrument Landing System Part 2

SC-IL-003 (v1.0) - Instrument Landing System Part 3

SC-IL-001 (v1.2) - Instrument Landing System Part 1

SC-IL-004 (v1.2) - Instrument Landing System Part 4

SC-EF-902 (v1.0) - Electronic Flight Progress System Safety Case Part 2

SC-EF-903 (v1.0) - Electronic Flight Progress System Safety Case Part 3

SC-EF-904 (v1.1) - Electronic Flight Progress System Safety Case Part 4

SC-EF-901 (v1.0) - Electronic Flight Progress System Safety Case Part 1

SC-RM-902 (v1.0) - Airport Remote Monitoring System Safety Case Part 2

SC-RM-901 (v1.0) - Airport Remote Monitoring System Safety Case Part 1

SC-RM-903 (v1.0) - Airport Remote Monitoring System Safety Case Part 3

SC-RM-904 (v1.0) - Airport Remote Monitoring System Safety Case Part 4

SC-IR-004 (v1.1) - Instrumented Runway Visual Range Part 4

SC-IR-002 (v1.1) - Instrumented Runway Visual Range Part 2

SC-IR-003 (v1.1) - Instrumented Runway Visual Range Part 3

SC-IR-001 (v1.1) - Instrumented Runway Visual Range Part 1

SC-AD-003 (v1.0) - Airport Display Information System Part 3

SC-AD-002 (v1.0) - Airport Display Information System Part 2

SC-AD-004 (v1.0) - Airport Display Information System Part 4

SC-AD-001 (v1.0) - Airport Display Information System Part 1

SC-CA-002 (v1.0) - Omnicrash and Emergency Bridge Part 2

SC-CA-001 (v1.0) - Omnicrash and Emergency Bridge Part 1

SC-CA-003 (v1.0) - Omnicrash and Emergency Bridge Part 3

SC-CA-004 (v1.0) - Omnicrash and Emergency Bridge Part 4

SC-AS-901 (v1.1) - Approach Radar Surveillance Part 1

SC-AS-904 (v1.1) - Approach Radar Surveillance Part 4

SC-AS-902 (v1.1) - Approach Radar Surveillance Part 2

SC-AS-903 (v1.1) - Approach Radar Surveillance Part 3

SC-CA-904 (v1.0) - Omni-Crash Alarm Safety Case Part 4

SC-CA-902 (v1.0) - Omni-Crash Alarm Safety Case Part 2

SC-CA-901 (v1.1) - Omni-Crash Alarm Safety Case Part 1

SC-CA-903 (v1.0) - Omni-Crash Alarm Safety Case Part 3

SC-SW-004 (v1.2) - Surface Wind Part 4

SC-SW-001 (v1.2) - Surface Wind Part 1

SC-SW-003 (v1.0) - Surface Wind Part 3

SC-SW-002 (v1.2) - Surface Wind Part 2

SC-AG-003 (v1.0) - Aeronautical Ground Lighting Part 3

SC-AG-001 (v1.0) - Aeronautical Ground Lighting Part 1

SC-AG-004 (v1.0) - Aeronautical Ground Lighting Part 4

SC-AG-002 (v1.0) - Aeronautical Ground Lighting Part 2

SC-RE-001 (v1.1) - Recording System Part 1

SC-RE-002 (v1.1) - Recording System Part 2

SC-RE-004 (v1.1) - Recording System Part 4

SC-RE-003 (v1.0) - Recording System Part 3

B. Additional Sociodemographic data

- Age area of participants

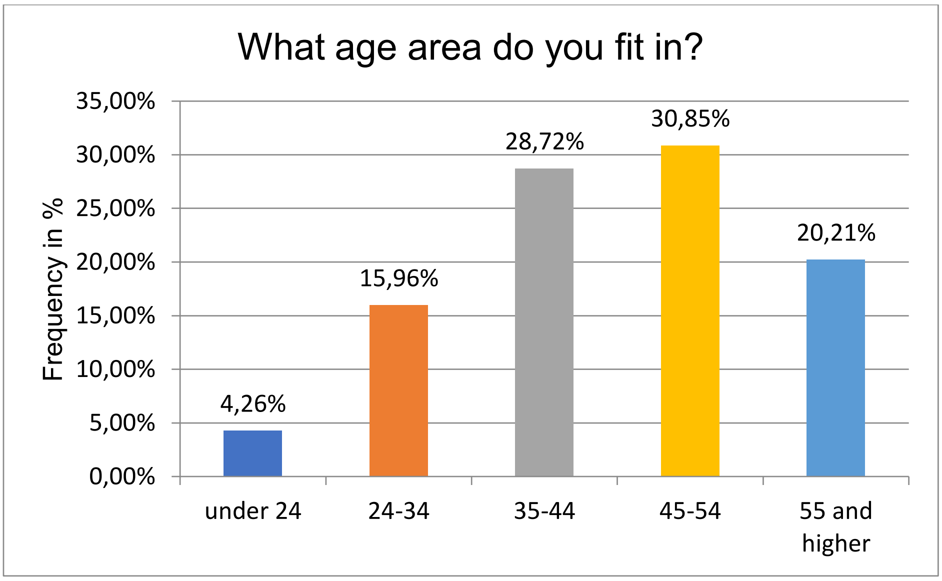

Figure 48: Participants' Age, Source: own research

- Country of work

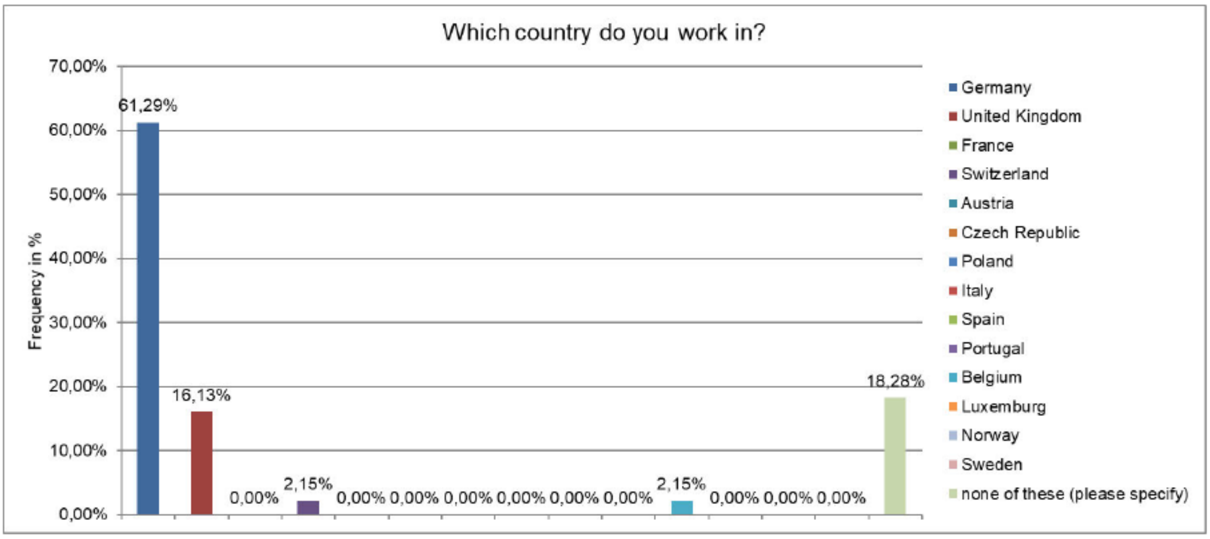

Figure 49: Participants' Working Country, Source: own research

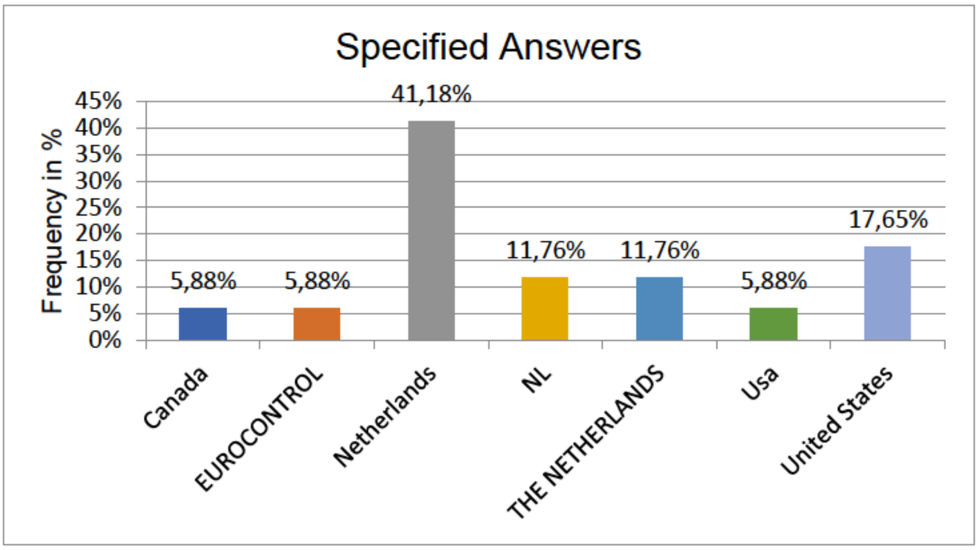

Figure 50: Specified Answers Working Country, Source: own research

- Question on further information

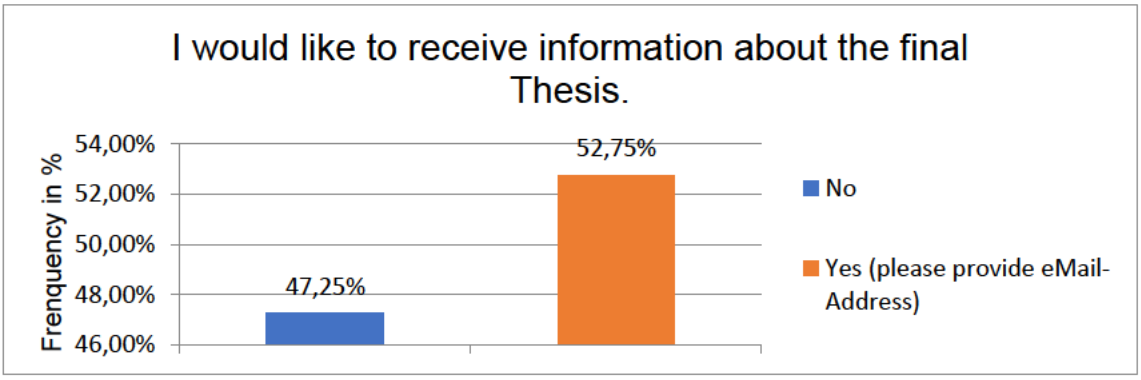

Figure 51: Participants' Interest in the Final Thesis, Source: own research