RULES IN HEAVEN

A closer look at a set of regulations for air navigation service from a Resilience Engineering perspective

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Abstract

Air Traffic controllers are responsible for navigating aircraft and sustaining a safe and efficient traffic flow in a four-dimensional air space. They apply separation rules to keep aircraft apart from each other and their well-coordinated work and complete awareness of risks have made possible the combination of increased traffic intensity and strong safety records. Rules and procedures make up a significant part of the work and the locus of this study was to examine how the air traffic controllers, employed at the Swedish state enterprise LFV, perceive their current set of regulations. At each Traffic Service Unit operators are equipped with two operations manuals, and a particular focus was put on the design, use and management of the manuals.

Furthermore, this study involved two observation sessions in two Air Traffic Service Units and twelve interviews with operators and domain experts. With the aid of the theory of Resilience Engineering, four essential functions have been identified in order to account for the underlying and interconnected functions behind rule implementation: monitoring, learning, anticipation and responding. Thereafter, each function has been divided into sub-categories that all are aimed to describe in what ways, individual as organizational, current rule management supports the air traffic controllers.

Based on the results of this study, it can be concluded that there is need for a reorganization of the set of regulations at LFV, and that the maintenance of the operations manuals has been reduced because of constrained resources. An additional factor, which complicates the possibility to change the procedures, is that a major part of the content originates from international regulations. In addition, this thesis claims that safe and successful use of rules depends on more than the physical look and design of the operations manuals. Therefore, support of current set of regulations will be discussed in terms of document distribution, education, communication, purpose of procedures and approaches to rule following.
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## Terminology

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<tr>
<td>AIP</td>
<td>Aeronautical Information Publication</td>
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<tr>
<td>Dbh ANS</td>
<td>Operations Manual for Air Navigation Services</td>
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<td>ATS Dkb</td>
<td>Operations Manual for Air Traffic Services</td>
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<td>ATC</td>
<td>Air Traffic Control</td>
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<td>ATCO</td>
<td>Air Traffic Controller</td>
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<td>ATS Unit</td>
<td>Air Traffic Service Unit</td>
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<td>ATM</td>
<td>Air Traffic Management</td>
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<td>BFL</td>
<td>Ordinances for Air Navigation Services</td>
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<td>CAA</td>
<td>Swedish Transport Agency, Swedish Civil Aviation Authority</td>
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<td>CCC</td>
<td>Common Core Content</td>
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<td>DA</td>
<td>Operational deviation report</td>
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<td>EASA</td>
<td>European Aviation Safety Agency</td>
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<td>EPN</td>
<td>Entry Point North</td>
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<td>EU</td>
<td>European Union</td>
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<td>ICAO</td>
<td>International Civil Aviation Organization</td>
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<td>IFR</td>
<td>Instrument Flight Rules</td>
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<td>LFS</td>
<td>Ordinance</td>
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<td>NUAC</td>
<td>Nordic Unified Air Traffic Control</td>
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<td>OMA</td>
<td>Operational Message from Unit Management</td>
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<td>SERA</td>
<td>Standardised European Rules of the Air</td>
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<td>SUPP</td>
<td>Supplement</td>
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<td>SMS</td>
<td>Safety Management System</td>
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<td>TSFS</td>
<td>Ordinance</td>
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<td>QA</td>
<td>Quality deviation report</td>
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<td>VFR</td>
<td>Visual Flight Rules</td>
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<tr>
<td>Drifthandbok ANS</td>
<td>Driftavvikelse</td>
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<td>ATS Drifthandbok</td>
<td>Flygledningstjänst</td>
</tr>
<tr>
<td>Flygkontrolltjänst</td>
<td>Bestämmelser för Luftfart</td>
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<tr>
<td>Enhet för Flygtrafikledningsenhet</td>
<td>Operativt Meddelande från Luftfartstryelsen</td>
</tr>
<tr>
<td>Flygledningstjänst</td>
<td>Europeiska Unionen</td>
</tr>
<tr>
<td>Föreskrifter från före detta Luftfartsstyrelsen</td>
<td>Föreskrifter från Transportstyrelsen</td>
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<td>Kvalitetsavvikelse</td>
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1 Introduction

Aviation is a safety-critical domain often compared to complex socio-technical systems such as oil platforms and nuclear power plants. Aircraft transport hundreds of human lives at high speeds, rushing in four-dimensional space that never can be fully monitored. The margins are optimized and the smallest mistakes result in economical or human loss. Yet current air transport systems can show an impressive safety record. The statistics from 2009, taken from Aviation Safety Network (www.aviation-safety.net, 2011), report 30 airliner accidents with 757 people killed. The number of victims was the lowest in sixty years but also lower than the average number of the preceding ten years which was 802 victims.

Regarding the question of how flight safety can possibly match the critical conditions there is one answer, awareness of the potential for disaster and a well-coordinated and monitored air space, more precisely the service of Air Traffic Control. Air traffic controllers (ATCO’s) are concerned with the main task to ensure that the aircraft never exceed the separation restrictions, in order to organize a smooth traffic flow in the air and on the ground (Felici et al., 2008). Through calculations of permitted altitude and longitude, the controllers separate the aircraft vertically and horizontally. Operators are often geographically far away from the world they are expected to control and can only do so with the aid of technical devices that illustrate and communicate with the aircraft. Consequently, there are high demands on the distribution of work that ranges over time, space and organizations. A strict and standardized approach to the performance of actions is required to cope with such a dynamic reality and it is not a coincidence that Air Traffic Management is recognized for being a domain based on standards and procedures (Felici et al., 2008).

It is not only acknowledged that rules contribute to the control of system safety, but also that rules formulated in the wrong way or constituted for the wrong reasons may jeopardize safety in dangerous situations. The world that is monitored consists of an uncountable amount of factors that interact in unexpected ways and give rise to the unstoppable generation of unique situations. Despite the existence of an extensive set of regulations, many situations can never be fully covered by the procedures. There is a gap between procedures and practice that always will remain. Yet there is surprisingly little research on how this should be done in order to increase their purpose and to decrease the gap (Hale et al., 2003).
LFV, a Swedish provider of air navigation services has raised the question of whether their set of regulations is formulated in a well-functioning way and if it supports the work of the air traffic controllers. Administration and development of the set of regulations has undergone changes in the last years due to reorganization of the Swedish aviation authorities and cooperation with international aviation actors. This has, in combination with limited resources to regulate and monitor the set of regulations, led to a constant growth of the total collection of procedures.

1.1 Purpose

The purpose of this study is to explore how air traffic controllers employed by LFV experience the current set of regulations formulated in the operations manuals. The study aims at providing an analysis that from an organizational point of view seeks to describe in what ways the rule management has an effect on the actual implementation of procedures in practice. This is regarded as an exploratory study that will show if it is relevant to start a detailed and more extensive investigation of the problem area.

Observations and interviews focus on examining the following questions in order to meet the purpose of the study:
- How are the operation manuals administrated in terms of formulation, revisions and updates?
- How do the operators perceive the content and the structure of the operations manuals?
- In what ways does the organization support the operator’s application of rules?

1.2 Clarifications and Restrictions

The study has a qualitative approach and aims to, if results reveal issues with the current set of regulations, present samples of opinions and specific matters within the problem area. It is not of interest to map or account for all possible topics that may underlie these issues. With respect to time constraints and the extent of the thesis, the survey involves two of the sites for air navigation services that are run by LFV. The results based on observations and interviews can therefore not be generalized as opinions shared by all air traffic controllers or domain experts employed by LFV nor the organization as a whole.
2 Background

The organization, earlier called Luftfartsverket was shaped in 1978 thanks to the integration of civil- and military air traffic. The solution to combine the air navigation services was and still is rare in Europe. In April 2010 the organization was divided into two parts, namely the new LFV with the remaining mission to supply air navigation services, and the government company Swedavia that operates the Swedish state airports. LFV Group is today a state enterprise with sales that exceed SEK 2 billion. LFV, with its estimated 1400 employees, provides air navigation service to customers in more than 40 locations in Sweden and has its headquarter in Norrköping, Sweden. LFV is considered one of Europe’s leading actors in air navigation services with its primary target to provide a safe and cost-effective navigation which is strongly affected by the goals concerning minimization of environmental impact.

LFV operates air traffic service units in a number of different areas:

**Aerodrome Control Service** is the control where operators execute departures and receive approaching aircraft from the approach control. This also includes the responsibility to monitor the movement on the ground and to avoid conflicts between vehicles to and from the gate and runway. The duties are often divided among the operators when working in pairs. For instance, the ground controller has responsibility for the taxi management while the local controller handles the take-offs and landings.

**Approach Control Service** is concerned with the area around an airport and air traffic controllers manage the departing and arriving phase of each aircraft. After take-off, once an aircraft is separated from the next aircraft, it will be received from the aerodrome control. The air space is divided into sectors in which the operators organize the traffic via a radar screen. Aircraft that climb and leave a certain section will be handed over to the area control.
**Area control Service,** also called *en route* flight phase, deals with aircraft cruising in the upper air space. Area control operators guide the flights through sectors that often are adjacent to international territory. The size of each sector can be adjusted according to the number of operators in position and the intensity of traffic. When traffic requires duties are to be split among the operators, the planning controller monitors the sector and assists an executive controller with information while the executive controller coordinates the aircraft and guides them to and from adjacent sectors (Felici et al., 2008). The two Area Control Centers (ACC) are located close to Malmö Airport and Stockholm Arlanda Airport.

2.1 Safety

LFV takes yearly more than 600,000 flights through the Swedish air space and has the vision to be a leading supplier of tomorrow’s air navigation service in Europe. For LFV, safety has the highest priority and is defined as “the freedom from unacceptable risk”. A central part of the safety work is the concern for the human factor, and how human performance contributes to the performance of the entire system. The viewpoint also influences accident investigations where the function of the system is of great interest rather than the performance of a single operator. In order to identify risks and minimize them (as low as reasonably practicable and to an acceptable level) the work at LFV is manifested in a Safety management System (SMS) that will be summarized in the following four bullets: (www.lfv.se, 2010)

1. Organization and Safety Culture
   Every employer at LFV is responsible to contribute to the safety in everyday work. Also, the manager’s role is very important since they need to encourage and facilitate the growth of a safety culture and to provide the organization with resources and competence.

2. Proactive Safety – “Think Ahead”
   LFV is aiming to discover and minimize risks and weaknesses before they become problems. In practice this is realized through systematic risk assessment before introducing or changing systems; analyzing trends and problem areas; and international and national cooperation in order to develop and implement methods.
3. Continuous Improvement – “Lessons Learned”
Everyone within LFV has the obligation as well as the right to report any deviation from normal procedures. The occurrence reporting system (see 2.1.2) with a history of thirty years is witness of a well-established safety culture, since the number of reported incidents has increased. Through careful identification and analysis of the deviations, causes can be found and measures can be taken to prevent recurrence of the fault.

4. Monitoring
On a regular basis, LFV conducts safety audits to monitor the control system and ensure that it is reliable. With internal follow-ups of the air safety, LFV also makes sure that the goals are achieved.

2.2 Synergi and Trend Analysis

The occurrence reporting system Synergi used at LFV is divided into two channels that each concerns a specific kind of report. Operational work such as incidents, technological issues or uncertainties about the manual will be mediated through operational deviation reports (DA), while organizational issues, for instance work methodology and routines, or alternatively certification and documentations, are to be expressed through quality deviation reports (QA). The system is based on a digital platform and reached from the employee’s personal account on the intranet. The responsibility to evaluate a report once it has been sent away is laid on the chief of operations at each navigation site. Reports that require further investigation will be sent to Transportstyrelsen within 72 hours.

Some reports are examined with the aid of Trend Analysis (www.transportstyrelsen.se, 2010), a method developed in order to realize the cornerstones of the Safety Management System. LFV has a proactive approach that is manifested through three concepts: background, follow-up and development. It is based on the idea that investigations will be concerned with different types of events rather than a certain deviation report. Therefore, events are categorized according to the area in which they occurred and thereafter divided into the part of the system they may be related to. An example of such an area is so-called the runway incursions. Based on this categorization, investigators can reveal salient causes and formulate solutions.
2.3 Entry Point North

Air Traffic Controllers are educated at the Scandinavian training academy Entry Point North (EPN) located at Malmö Airport. The education is a collaboration between Naviair (Denmark), Avinor (Norway), and LFV. EPN is certified according to European guidelines and follows the Common Core Content (CCC). Eurocontrol constitutes the guidelines of CCC with the purpose to ensure that students obtain the same basics knowledge within air traffic services. Students are taught the international set of regulations collected in Documents and Annexes constituted by ICAO and the education is held in English. LFV is primarily involved with the latter part of the education that concerns certification and employment at a local navigation site within Sweden. During this latter phase the students are introduced to the national set of regulations; the content of the two operations manuals. Time reserved to study the national rules ranges from four to five weeks and depends on which air navigation service unit the students enter. After this introduction a period of authorization follows at the navigation site. The duration differs from four months to half a year and depends on the size of the navigation site as well as the student’s individual capacity to absorb the new environment. Also, the time of the year plays a significant role; the winter period is mostly concerned with regular traffic, while the control during the summer deals with less flights compared to the winter period.

2.4 Operations Manuals

Air traffic controllers employed at LFV are currently equipped with two operations manuals in which the set of regulations for air navigation services is formulated. As a part of the required certification in 2005, each unit of navigation services in Sweden needed to have an operations manual. It was discovered that the major part of the content was equal and LFV decided in agreement with Transportstyrelsen to design one common central manual for the whole territory. The operations manual for Air Navigation Services (Dhb ANS), henceforth addressed as the central manual, contains (like the name implies) those rules that concern the entire air space of Sweden. The binder initiates with a table of contents that accounts for the disposition of the manual, namely the six parts in which it is divided into. Each part in turn contains a certain number of chapters, whereas the first part accounts for each chapter’s content. Part Three which deals with the services of air traffic management, is the most extensive one whereupon another sublevel has been introduced called 18 sections that in-
stead are split into chapters. The table of contents is followed by an explanation of the concepts and abbreviations that figure in the manual. The explanation is organized in alphabetic order. Variations such as geographical aspects and traffic flow, that have to be taken into consideration when running the services, are caught by the operations manuals for Air Traffic Services (ATS Dhb), henceforth called the local operation manual. The local manual usually follows the same division of content as the central manual.

The operations manuals are updated several times each year because of the introduction, revision and elimination of regulations. The procedures are formulated in supplementing documents before they become official publications and enter the bindings in which the regulations are found. Changes regarding the central operation manual are called supplements (Supps) while changes in the local manuals that treat local restrictions, reminders, and methodological issues are named as Operational Message from Unit Management (OMA).

2.5 The Origin of Regulations

LFV maintains a high degree of cooperation with international organs, including the United Nations’ agency for international air navigation the International Civil Aviation Organization (ICAO), European Union (EU), EUROCONTROL and Nordic Unified Air Traffic Control (NUAC). Years of experience and international cooperation has resulted in an extensive set of regulations at LFV. Therefore, the structure of the current set depends partly on an international collaboration and partly on a historical reorganization of the Swedish aviation authorities.

The former LFV did initially hold the position as provider and regulator of the air traffic services in Sweden. Luftfartsinspektionen was theoretically independent and posed the role as regulator, but did at the same time belong to a part of LFV and served under the same executive. However, the construct did not respond to the European Union’s requirements regarding concurrence on the market and led to a separation of the responsibilities. Luftfartsstyrelsen was introduced as the regulator of LFV, which remained as the provider of navigation services. The by then existing set of rules was reviewed and moreover completely reformulated according to ordinances stated by Luftfartsstyrelsen. The ordinances propagated for a constitution of an operations manual for air traffic navigation services and were accompanied with strict and detailed guidelines: the regulations would be divided into six sections. A new operations manual was released in 2003 and, except for local variations, the structure has been kept since then.
In 2004, the EU formulated four fundamental regulations that still have a huge impact on the content of the set of regulations. They concerned: management of air navigation services within EU, use of air space, use of communication systems, and a flexible and shared use of military-and civil air space. In 2009, the former regulator was reorganized and renamed as Transportstyrelsen. The same year, EU introduced a demand of certification process that concerned each provider of navigation services. The certification was conducted by Transportstyrelsen, and former ordinances of the operations manual from Luftfartsstyrelsen were dropped. The new guidelines were less strict and requested an operations manual that would include all the procedures necessary for the performance of navigation services.

Today ICAO issues constitutions to all its members with the purpose of strengthening aviation cooperation between its countries. Standards and recommended practices are formulated in documents and annexes such as Doc 4444 and Annex 11. Member states like Sweden are obliged to follow the documents once they have signed the Chicago Convention. Additionally, this statement must be collected by the Swedish Aviation Ordinance (TSFS) in order to establish the juridical issue. This is done by Transportstyrelsen and also accounts for the Annexes that will be valid in Sweden, and for example, inserted into the Aeronautical Information Publication (AIP). With permission from ICAO it is possible to request variations from the Annexes. Variations from the standards are frequently requested by member states and have led to Eurocontrol’s establishment of Single European Sky. Single European Sky emphasizes a shared air space and straight air ways that will be used independently of na-
The previously mentioned cooperation has taken the regulation of rules to a European level, and the EU continuously releases regulations and directives. Regulations have an immediate effect and cannot be overridden by any Swedish law. Large parts of the regulations are European applications of ICAO’s documents and annexes. Directives are, on the other hand, less strict and give Transportstyrelsen a period of three years to realize and formulate them in TSFS. The extent of regulations is currently getting larger and replaces parts of the old Swedish regulations. National authorities are gradually getting less involved in the constitution of rules and the future role of Transportstyrelsen will be debated. For LFV, the ongoing cooperation with Naviair (Denmark) is the top priority in order to be an efficient Air Navigation Service Provider, and the creation of the Nordic Unified Air Traffic Control (NUAC) is a significant step where the need for harmonized and common documentation and streamlined ways of operate is a prerequisite. Moreover, the European Aviation Safety Agency (EASA) has a vision to provide the members of the EU with a common set of regulations: Standardized European Rules of the Air (SERA). Figure 1 illustrates the current structure of the rule management.
3 Theoretical Framework

The theoretical framework that will be presented is divided into three parts, each with a specific purpose. The first part aims at introducing the reader to system view that permeates the whole study. This is done with aid of theories of: Accident models, Complex Systems, Common Ground, Human Error and the theory of Sharp-and Blunt end. The second part accounts for the central concepts of the risk-and the safety approach known as Resilience Engineering. Ultimately general research about the use and formulation of procedures will be presented.

3.1 Accidents Models

Hollnagel (2004) divides the models into three main groups: sequential models, epidemiological models, and systemic models. According to the sequential models, an accident is the last outcome in a row of individual events that are perceived as normal. The sequence has initially been triggered by an unexpected event and the aim is to identify the cause-effect steps in (as the name indicates) chronological order. In the absence of parallel connections, the sequence of events can be represented graphically, and by doing so increases the chance to reveal hidden causes within the chain. The principle has been illustrated with the domino metaphor in which lined up domino blocks represent involved accident factors that contribute to the final outcome (the accident) by falling. Unless there are no barriers placed in between the blocks to stop the fall, a block will immediately affect the next coming block.

Epidemiological accident models take the sequential model to a higher level based on the idea of a disease and its ability to spread itself. The sequence of events is a combination of a certain amount of latent factors, such as a mistake caused by the user, environmental issues, barriers and latent conditions that occur in the very moment. The interaction of the factors may result in an accident in which the effects are measurable. The model seeks to find carriers of the latent factors and the errors that arise in the system. The Swiss Cheese metaphor developed by Reason (1997) is an example of the approach that intends to illustrate how a certain combination of holes in the barriers may result in unwanted events.
Unlike previous models, accidents according to the systemic model do not have a structural construction. They should instead be considered as normal events in a system. The approach focuses on the control over the system performance and analyses should be based on functions in the system rather than internal mechanisms. There will always remain variability within the systems and the model suggests a continuous control of it. Users of the model investigate accidents by searching after the occurrence of normal and abnormal conditions which through experience they know can lead to unwanted outcomes. An example of such a model is the Functional Resonance Analysis Method (FRAM) in which each function of a system is defined, and evaluated, and interconnected to the other functions.

3.2 Human Error

An ongoing debate within the field of human factors deals with the use and application of the concept of human error. The field has until recently been dominated with the well-established approach that human errors are intended actions incorrectly carried out by the operator which results in an accident or incident. Statistics from relevant domains such as transport and medicine tell us that 80-95% of the accidents are said to be caused by human errors. According to a categorization presented by Isaac & Ruitenberg (1999), human errors arise in two ways: either when making an incorrect action or when failing to act when it is required. Errors are the results of poor cognitive performance and caused by limited information processing including perception and decision-making. Hollnagel (1983) dismisses the use of the term and argues that it is neither an observable activity nor the result of an intention. Subtitles such as “accident caused by human errors”, often written in the newspapers do not provide us with any information about an accident which instead remains unexplained. The use of the word varies from time to time and refers to inexplicable errors that are assumed to be pure actions of the operator. The conclusion of this reasoning is that future accidents could never be prevented because of the simple fact that we cannot change human nature. Furthermore, it holds the operator responsible for a problem that might have occurred long before she or he entered the system. Analyses of unwanted outcomes should instead be derived from the study of mechanisms behind a normal action and focus on the potential mix of external and internal causes such as bad design or stress. Analysis in this direction would also allow us to examine the interaction between human performance variability and environmental limits rather than the characteristics of the operator.
In order to study the origin of events and accidents from a whole system view, the theory of sharp-and blunt end connects the epidemiological and systemic model together (Hollnagel 2004). As illustrated in Figure 2, the model describes the unavoidable relation and affection between different levels of an organization. The blunt end refers to people working in the higher levels of an organization such as management, whose main duties are to distribute resources. Operators, for instance pilots or doctors, are found in the sharp end, practicing in the environment where risks and accidents arise. The work conditions and performance of the operators are indirectly affected by the blunt end through earlier decisions and resources provided. It is not unusual that the operators at the sharp end are held responsible for accidents because of their presence in the situations where accidents take place. However the cause of an event can be traced to higher organizational levels where it may have arisen long before it reached the sharp end, through complex interconnections of multiple factors rather than simple cause-event explanations. In addition, the author sustains that none of the concepts are definite, but that each person’s blunt end is someone else’s sharp end.

Cook and Woods (1994) present three factors that affect the context in which performance at the sharp end takes place. Knowledge factors concern knowledge, obtained through training and practice, which is crucial to solve problems. Attentional dynamic factors deal with attention, focus, and the possibility to adjust the workload as a situation changes over time. Strategic factors are related to the operator’s ability to cope with conflicting goals, especially when there are uncertainty, pressure and limited resources. None of the factors are expected to be found in each operator, but are distributed over all practioners and artifacts in the workplace. Neither can they be separated since the performance of a system depends on their interrelations.
3.4 Complex Systems

The complexity of a system and the potential for a severe accident to arise from it can be defined through a classification based on the concepts coupling and interaction. Interaction refers to a connection that arises between functions and parts in a system and could be of either linear or complex kind. In linear interaction are the parts contribute to the system output, lined up in a predetermined sequence. The pattern makes the interaction predictable and gives the operator, in the event of failure, the possibility to identify the problem but also good opportunities to fix it, regardless of how many components exist in the line. Inexperienced personnel might perceive a system as linear while getting more involved with it, but have greater opportunity to reveal interactions that are unexpected (Perrow, 1984). Complex interactions are linked without intention and arise in unexpected sequences without having been designed into the system. Thus they are invisible and caused by loops and jumps between linear sequences. Components, so-called “common mode functions” with multiple purposes also contribute to the complexity of a system with unanticipated interactions that grow exponentially.

![Figure 3. The chart of interactions and couplings. Adapted from (Perrow, 1984)](image)

**Couplings** are connections that exist within a system or organization. A **tight** coupling means that no space is left between two parts that mutually affect each other if something happens to them. A **loose** coupling, on the other hand, refers to a slack between the parts, but should not be confused with an absolute lack of connection. What characterizes tightly coupled systems are restricted time limits that the processes depend upon and predetermined sequences of which the order never can be changed. There is also the inability to reach goals in other ways than the intended one and to replace operators or equipment with-
out a system shutdown. A tightly coupled system can recover itself if extensive buffers and redundancy have been designed into it.

In contrast loosely coupled systems allow for delays in the production, changes of sequence order, and other methods in order to sustain production and to substitute resources. Properties like these encourage flexible production and rely on the actors’ ability to perform work that is based on experience and interest. Therefore, they should not be confused with inefficiency or disorganization.

A conclusion, stated by EUROCONTROL (2009), is that Air Traffic Management, found in quadrant number two in Figure 3, will not be well-supported by existing accident models and is therefore considered as the area of interest for Resilience Engineering. The categorization, however, is neither absolute nor constant, systems are not completely complex or linear, nor are they unchangeable. Perrow (1984) writes that air traffic control management has gone from being a complex to a more linear system through successful organization and modern technology. In spite of increased density of traffic dependence between multiple functions has decreased thanks to successful division of the air space, introduction of standardized routes, and increased number of beacons. Technological devices such as radar and transponders have facilitated the work and decreased common-mode failures by providing the controllers with useful information that before had to be exchanged via radio contact. Perrow (1984) argues that the system is moderately tightly coupled. The three dimensional space makes it possible to redirect airplanes and cope with delays, a kind of recovery that loosely coupled systems can achieve, despite their strict limits. The domain is however stained with features of nonlinearity and tight coupling. The system contains a high amount of variables whose interactions cannot be completely prevented: substitution of personnel and equipment, feedback loops, and problems with isolation of functions.

3.5 Common Ground

Woods et al. (2005) define common ground as the knowledge, beliefs and assumptions that are obtained and shared among a lot of people within a specific context or domain. Common ground is often visible in conversations that are free from ambiguity and interpreted correctly and understood by the members, even though they are expressed in abbreviated form. The quality of common ground depends on the practitioners and their intentions for communication. Gestures such as simple nods may be sufficient as confirmation in a conversation between two persons that are chit-chatting, while agreements on a higher level require a more explicit and precise understanding. The mutual knowledge does not, however, imply that the participants share neither the same goals nor the same kind of thinking. Common ground should instead be considered as a communication process in order to test, update, and repair the understanding within a team. Mutual knowledge includes information and comprehension of
people’s different work conditions. All members do not only have different roles and duties that are aimed at diverse goals; moreover their ability to cope with time pressure, conflicting goals, and level of fatigue differs. The authors write that initial common ground treats conventions and earlier obtained knowledge that exists within the domain. Specific procedures and information about the members in terms of their knowledge and background are also included. Public events refer to the knowledge of the event history, and information that the members have obtained through previous experience which is essential in the present activity. Common ground can be supported through a various number of actions including structuring preparations and to constituting routines. Furthermore, Common ground varies over time and is never perfect but can be kept within acceptable limits through reminders and clarifications and control when it is being compromised. Other essential activities include: updating each other about changes, detecting the deviations that may contribute to a loss a common ground, and in case of loss to repairing the damage.

An example from the air traffic control domain illustrates how wrong assumptions about people’s knowledge can lead to common ground breakdown and unwanted outcomes. The case concerns a flight between Dallas and Miami that had to be redirected because of bad weather. The dispatcher, responsible for the flight, rerouted the flight in agreement with the captain of the aircraft, informed the air traffic control (ATC), and dropped the case convinced that the task was solved. The flight was moved from one sector to another within the air traffic control, but the receiving control was not, as the captain assumed, aware of the weather conditions and rejected the new plan. The involved parts thought that they all were striving towards the same goals with a common picture of the current situation, but did not make any attempts to confirm their assumptions about the other’s knowledge. As a consequence of this miscommunication, wrong actions were taken, and the circling aircraft run on low fuel and had to land immediately.
3.6 Resilience Engineering

The concept resilience has been used among many domains engineering, expressed as a material’s ability to recover itself after deformation (Woltjer et al., 2010). In line with this, Hollnagel and Woods (2006) suggest a broader approach that also includes the central concepts of foresight and coping. This paradigm for safety management intends to improve socio-technical system’s capacity to cope with complexity and varying conditions in a successful way.

The history of the accidents from Three Mile Island, Chernobyl and the space shuttle Challenger have revealed the need for human factor methods. Traditional accident models have a tendency to simplify interactions thus causing the inability to reveal the underlying multiple-factors and account for the performance found in socio-technological systems (EUROCONTROL, 2009). It is furthermore focused on the prevention of things that go wrong while Resilience Engineering seeks to complement existing methods with a focus on the things that go right. Hollnagel and Woods (2006) argue for a shift from theory of error to theory of action which encourages learning driven by the study of successful system performance rather than the evaluation of accidents and system failure. Adapting this thinking, safety can be regarded as the absence of events and the hallmark of functioning, although the occurrence of an event does not necessarily imply failed safety. In other words the increase of desired outcomes would automatically imply a decrease of unwanted outcomes. Moreover, safety should be considered as something that a system or an organization does through human performance rather than a core property.

Consequently we are left with the challenge of measuring safety in terms of its pure potential through careful monitoring rather than introduction of barriers and procedures (Hollnagel & Woods, 2006). Resilience Engineering expresses a necessity to permeate the whole organization with safety, including economy and business processes (Eurocontrol, 2009). Because of conflicting goals, trade-offs constitute a part of the performance that will concern either the blunt end in the meaning of management and system development or the operator work at the sharp end (Woltjer et al., 2010).

“Resilience is the intrinsic ability of a system to adjust its functioning prior to, during, following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions” (EUROCONTROL, 2009).
3.6.1 Threats

Control is independent of domain, threatened by conditions such as lack of time, resources, knowledge, and competence. Westrum (2006) argues that resilience is best achieved if the threats that challenge the system can be identified; he highlights three aspects of threats; predictability in terms of frequency, potential of disruption, and whether their origin is of external or internal character. Based on those features a division of three groups can be formed; regular threats occur so frequently that a standard response can be formulated to eliminate them, but this does not imply that the threat is less severe. An internal threat usually does not jeopardize the whole system function whereas the external one requires more extensive measurements. Irregular threats are often understood and triggered by the combination of many low-probability events. Unexpected threats are unpredictable in that they demand an approach that differs from the normal behavior of the system. In spite of this, basic abilities such as self-organization and monitoring will allow one to tell whether a system can recover itself effectively.

3.6.2 Performance Variability

Performance variability is a central part of resilience engineering and furthermore a natural and inevitable part of a system or an organization. Performance variability should be encouraged but still controlled rather than guarded against. Variability addresses the flexible behavior of people that adjust their performance in order to cope with limited resources and to meet the demands of a system. A system's performance varies and it is essential to understand its functioning in order to behave in an appropriate manner when control is lost. An increase of this flexible performance is, for instance, crucial when working with imperfect systems, procedures, and instructions that always will be insufficient and underspecified (Woltjer et al., 2010; EUROCONTROL, 2009). The challenge is to understand unanticipated variability by defining the boundaries in which the required performance takes part (Woltjer et al., 2010). Woods (2006) defines this as a competence envelope and holds that the awareness of its boundary and constantly changing demands can be met through monitoring and support of cognitive processes rather than the constitution of rules and procedures.

“The ways in which individual and collective performances are adjusted to match current demands and resources, in order to ensure that things go right” (EUROCONTROL, 2009).
3.6.3 The Four Cornerstones

Safety is achieved through the actions of a system and can, through control of the four cornerstones, be maintained in a system. The cornerstones express the abilities to adjust the functioning over time by considering the past and present, and suggest a set of requirements of practical performance that an organization needs to meet in order to regard itself as resilient. It is crucial to understand the importance of the interrelations and couplings between the four abilities and that they should never be studied in isolation from each other. However, it is important to determine the need of each ability in relation to the specific domain (Hollnagel 2010; Dekker et al., 2008).

Respond
The ability to address the actual is crucial for the survival of a system and requires the knowledge to handle and respond to regular and irregular disruptions that occur in the system. This can either be done through adjustments of the normal functioning or thorough preparation of predetermined responses. Abilities that underlie the action of response are detection and recognition of an unwanted outcome but also include a sensibility that indicates when and how to respond. An additional challenge is to fit this within a given time horizon and in relation to the resources available.

Monitor
Addressing the critical is to monitor the systems performance as well as the environment that surrounds it; this means to detect disturbances through so called leading indicators that have the potential to affect the current or future production of the system. A flexible monitoring is achieved through the identification of so-called “leading indicators” which are subtle signs that hint of upcoming events.

Anticipate
To address the potential is to predict future changes that may arise and affect the organization in both negative and positive ways. An important aspect of this ability is to adopt a wide approach of thinking that reaches outside the traditional boundaries that are often dominated by accident statistics and detection of known hazards and threats. Anticipate can easily be confused with monitoring but ranges over a long time and is concerned with the type of irregular threats, while monitoring deals with shorter time horizons and regular threats.
Learn
To address the factual is to use knowledge from past events in the right way. It must be stated not only how often learning will take place and if it is continuous or discrete, but also from what experiences that learning will be driven. Moreover it is necessary to make the distinction between what is easy and meaningful to learn from and not be blinded by statistical data of events. The events may be associated with success as well as failure but the essential part is to understand why an event did occur and to learn from the changes that were introduced afterwards. Unless no behavioral changes are made then there are reasons to suspect that nothing has been learnt. A third aspect is how learning should be manifested within an organization. It is a matter of balancing the responsibility of learning between the individual and institutionalized education.

3.6.4 The ETTO Principle

Hollnagel (2009) explains that the complex nature of the systems used today mean that we have to face situations with rapid changes that to a certain point never can be fully described. A mismatch between available time and resources leads to a growing uncertainty that in turn may result in risk taking. If a task is not formulated with respect to strict limits or if the amount of information is provided not is enough, there must be a compromise between what must be done and what should be done. Lack of time can rarely be changed, so what is left is a trade-off between time and resources spent on preparing for an action versus the time and resources spent on carrying it out. Every activity requires some kind of minimum information and efficiency, which people try to acquire, and this can be described and studied with the trade-off between thoroughness and efficiency. Efficiency is to meet the goals with as little investment and resources as possible. It is carried out unconsciously and is based on experience. Thoroughness, on the other hand, implies a certainty and requires all resources available in order to bring out the wanted outcome without any side-effects. Although a balance between the concepts is desired, it is more common that efficiency is chosen over thoroughness because of demands on high productivity. This may result in lost control because wrong actions are carried out or not handed out with respect to the conditions. Thoroughness can be reduced when high safety is required, but this may result in actions which are too late. The trade-off is a part of daily activity, and studies of the phenomena may help us to better understand how and why people act in certain ways.
3.7 Procedures

Rule management in relation to safety within organizations is a highly debated topic, and opinions differ strongly in manner of purpose, implementation, and required compliance. Participants of the discussion are grossly divided into two camps, whereas one withholds a scientific-rationalistic approach (Hale et al., 2003). Not following procedures is a threat to safety, or the other way around; safety is the result of people following procedures. The aviation domain is known for adopting this approach, and management does often prevent reoccurrence of accidents through change and introduction of new rules and procedures (Dekker 2001, 2003). The attitude is based on the following assumptions: procedures present the optimal way to carry out a task; reliance on a “if-then” structure; and the responsibility to invest in people’s knowledge of procedures and monitoring rule compliance lies on the organization, (Dekker 2001, 2003). Isaac and Ruitenberg (1999) claim that complex human-machine systems are in a need of procedures to maintain safety and efficiency, since human performance is variable and can lead to errors. The purpose of standardizing procedures is therefore to support the operator by reducing his or her variability.

The awareness of increasing complexity within socio-technological systems has led to the evolution of a contradictory stance: that safety can be achieved if people understand that procedures should be used with respect to specific conditions in a situation. According to this approach, procedures are resources for action, and pure application of procedures is not necessary to enhance safety or the most sufficient way to carry out an action (Dekker 2001, 2003). Instructions will always be incomplete and can at best account for a detailed accomplishment of a task in very simple situations (Suchman, 1987).

3.7.1 Procedures and Practice

By introducing the concept of plans and situated actions, Suchman (1987) emphasizes the flexibility of human intelligent action when facing the gap between a plan and the actual situation. The gap is a construct of material and social circumstances. The statement is as follows: human action performed in situ is based on experience to match current conditions rather than guided by the predetermined performance expressed in plans. The plan serves as an artifact of our reasoning about action and the action is the mean between the plan and circumstantial conditions. Therefore the initial plan is often abandoned at an early stage and undergoes a constant modification as the situation changes.
Cognitive science maintains that it is possible to overcome the vagueness of procedures with improved and more intelligible plans. Situated action states instead that this kind of insensitivity to context in representational schemes may constrain the possibilities of action. A plan should rather be regarded as a representation of action and that improvement should be realized through examination of what kind of resource the plan actually is. To judge the current situation is a difficult task that leaves an operator with two types of potential failures: to either fail to adapt or attempt adaptations that fail (Dekker, 2001, 2003). The former failure is caused by the people’s inability to interpret a rule with respect to the actual situation. It is a matter of rigid rule obedience that from this point of view is considered inefficient and unsafe (EURCONTROL, 2009). The latter failure regards those situations when operators deviate from regulations without having obtained enough knowledge about the new conditions. The failures can, however, be mastered through a supportive organization. Apart from regular monitoring and increased understanding of the gap, operators should be encouraged to develop the cognitive skills necessary for judging when adaptation is appropriate. Pritchett and Ockerman (2000) write that procedural failure can also be dealt with by controlling the grade of details, and to reduce them in situations when the user needs to rely on experience.

Earlier research proves that the need for procedures depends on the work tasks and experience of an operator (Lawton & Parker, 1999; Grote et al., 2009). A study by Law and Parker (1999) shows, for instance, that junior medical staff were in greater need of protocols while more experienced staff relied on information that was already in their heads. Furthermore, nurses and doctors applied the procedures in different ways. Hale and Swufte (1998) also observed a similar tendency within a railway company where different professions requested different amounts of specifications within the rules. In this case, there was a correlation between rule application and the responsibility of action.

3.7.2 Formulation of Procedures

Adequate application of procedures depends on the content, and the physical structure, and organization of rules (Pritchett & Ockerman 2000). The size of a rule set has significance and constant growth may be the result of supplements to “incomplete” rules (Hale & Swufte, 1998). Rules distributed over many volumes may also complicate update of the content and the risk to miss any of the parts increases. Furthermore, such a distribution has a tendency to confuse the reader when there is a need to jump between the steps of a procedure. It is a common problem for an element of a procedure to be related to a separate document, which causes the difficulty of combining different documents when working. The prescriptions of operations manuals, procedures, rules, and task planning often conflict with each other.
These kind of conflicts not only arise because of the different nature of the documents but also because they have been written by people with diverse perspectives from different organizations whose interests target separate parts of the organization (Carvalho et al., 2006; Lawton & Parker, 1999).

Also, textual content plays a role since comprehension of a procedure is based on the skill to read and translate the text into a representation of an action (Pritchett and Ockerman 2000). Comprehending and interpreting the language of the procedure makes up a large part of the overall understanding. A study conducted by Carvalho et al. (2006) revealed the necessity of understanding the meaning of a rule and that rules presented with reasons and explanations regarding the execution could facilitate decision making, especially in situations with conflicting rules. Lack of explanations put high demands on procedure users and the study showed that it required complex cognitive strategies in order to make sense of the rules they were left with. Yet results showed that operators succeeded to overcome these difficulties through close collaboration manifested in verbal exchange that included continuous feedback and shared knowledge.

Grote et al. (2009) argue that a proper balance between standardized and flexible rules can push a high-risk organization towards the characteristics of such a loosely coupled system that has been defined by Perrow (1984). The decision latitude in turn depends of the uncertainty in the environment. This can be dealt with in two suggested ways: either to minimize or to cope with uncertainties. By minimizing the uncertainties, one reduces the operative degrees of freedom through automation and procedures. Coping with uncertainties means to use procedures as sources for action in order to support maximization of operative degrees of freedom. Through a categorization of rules, three different types of procedures can be identified and examined within an organization: goal rules, process rules, and action rules. Goal rules describe a goal in wide terms and do not specify any certain way in which the rule could be brought out or followed. Process rules intend to account for the processes necessary to achieve a goal and supply the user with a guidance of methods. Action rules are the most specified ones and provide the user with detailed information about how an action will be executed. The division of rules has in combination with earlier findings led to the following proposal: that rules are best applied when the user has taken part in the formulation. Formulation of rules can then be realized by the “right” person by letting each abstract level of rules respond to the levels found in the hierarchy of an organization. Goal rules should be constituted in the higher levels of an organization and translated into more concrete process rules on the levels below and finally obtain detailed descriptions when reaching the user. In addition, this successful implementation of procedures can be increased if the user takes part in the formulation (Grote et al., 2009). It is however common that the construction of rules is derived from the operators when established work practices become rules (Felici et al., 1998). The study conducted at Rome Airport revealed that operators gave all approaching aircraft the very same flight level because it appeared to be a convenient practice for pilots and controllers. This method of work ended up in the airport’s set of instructions as an established procedure.
4 Research Method

The purpose of this study is to account for administration and implementation of the set of regulations used at LFV. It can be described as a field study with a qualitative approach. A qualitative approach is appropriate in order to capture sociological aspects and interaction between people in the entire organization. With an ethnographic approach, data was obtained from documents provided by LFV, observations in the aerodrome, approach and area control, and interviews with air traffic controllers and domain experts responsible for the rule management.

4.1 Ethnographic Method

Analysis of the data is based on the basic ideas of Resilience Engineering and emphasizes the study of normal performance. Ethnographic methods are suitable for examining behavior in daily activities and fulfill this purpose (Cuvelier & Falzon, 2008; Cox et al., 2007). Additional interests in this study include the mismatch between work as imagined and practiced (Hughes et al., 1997) and the gap between implementation and procedures. Research has moreover proved that the approach is favorable in the examination of the domain of air traffic management (Cox et al., 1997; Sanne, 1999). Through studies in the London Air Traffic Control Center, details were discovered regarding the interaction and work between the operators that were undiscovered from task analyses conducted in the same setting (Hughes et al., 1995). Segelström et al. (2009) point out that the hallmarks of the method are difficult to unite within service design; to speak the local language and to participate in the studied setting. Nevertheless, they prove that the criteria can be met through appropriation of the ethnographic situation. Also, Hughes et al. (1994) showed that an ethnography can be modified according to the study of interest and proved that one should not be afraid of deviating from the classical view. The method is usually applied in small scale settings, but a study of a business Center conducted by Hughes et al. (1997) revealed that the approach also can be beneficial in the study of larger research sites such as whole organizations.
4.2 Data Collection

With respect to the main purpose to bring out pure opinions about the set of regulations, the data in this study is collected from interviews rather than observations. Furthermore, implementation of procedures deals with implicit information that is difficult to reveal through observations. The processes to collect and analyze the data have been performed side by side in order to focus and afterwards confirm detected features in the research context. The study was performed in two separated parts with an introduction moment regarded as an exploratory study in order to familiarize with the air traffic controllers and the environment in which they are operating. Without this knowledge and valuable access to the language and terminology used by the operators in the site of interest (Patton, 2002), it would have been very difficult to conduct this study. A further reason for this simultaneous data collection and analysis was to find out what kind of interview questions would bring out the most relevant and fruitful answers with respect to the questions of issue. Two different guides were initially formulated and tested on different respondents. The guides were thereafter revised and adjusted according to the new topics that were raised by the respondents.

4.2.1 Sampling

The administration and implementation of regulations permeates a whole organization, and it was necessary to reveal opinions from employees that represent different parts and levels of the organization LFV. Interviews were therefore performed with air traffic controllers and domain experts that are responsible for the formulation of the set of regulations at LFV. A couple of the informants held several roles within the organization and could account for the constitution of rules as well as the core implementation of them. The method of selection differed and some air traffic controllers were chosen by their supervisor, whereas others were chosen because of their pure availability, according the method of convenience sampling (Patton, 2002). It was also relevant to identify potential differences between novices and experienced operators, whereby newly examined students were included into the group of informants. The two airports that were visited during this study were predetermined by LFV.
4.2.2 Observations

The observations in this study were combined with an informal conversational interview, also known as an “unstructured interview”, which allowed the researcher to participate to a great extent as an so-called “onlooker” without getting involved in the actual performance, (Patton, 2002). The technique suited the study well since it enabled the researcher to generate questions spontaneously in the context of where the subjects were found (Patton, 2002). The study included two observations, whereby the introducing one was performed with an open-minded stance at a smaller airport. The questions asked concerned general knowledge in order to get an overall understanding of the work as an air traffic controller. First during the second observation conversations with the operators could be focused on regulation-related topics. Field notes were written down sporadically during the sessions, although with carefulness. There is a tendency to overgeneralize features in a field setting, and a clear distinction between descriptions and interpretations must be stressed in the field notes (Patton, 2002).

4.2.3 Interviews

In total, twelve interviews were conducted and performed in the normal environment of the respondents, the two air navigation sites that were visited. All informants were given both verbal and written information regarding their participation in the study such as anonymity requirements and their right to disrupt the interview. Permission to record the interview with an mp3-player was also requested before the session could begin. Two different interview guides were prepared and adjusted to the two groups of interviews, but the main structure was kept in both guides. Interview guide 1 (see Appendix A) aimed at revealing core opinions about the existing set of regulation and was used with the operators, while interviews with the domain experts were more focused on the core formulation of the rules and the participation in the formulation process (see interview guide 2 in Appendix B).

All interviews were performed according to the structured interview (Patton, 2002). Questions within the same topic were listed, but the order in which they were asked depended on the directions of each interview. The technique was chosen in order to let the respondents raise and reason about other relevant topics than those predetermined. An open-minded approach was crucial since the study aimed at revealing the respondents opinions and perceptions about the topic in general, rather than treating specific interests from the interviewer (Patton, 2002). The guide contained exclusively open-ended questions (Patton, 2002) and the respondents were free to answer in their desired way and not limited to predetermined answer alternatives. Few notes were taken because the technique requires a lot of attention on the informants in order to ensure that relevant topics were discussed during the interview.
The air traffic controllers had to dedicate their breaks and the interviews were automatically adjusted to the time available and were limited to a duration of 30 minutes. Because of a loss of data, follow-up interviews on phone were held with a subsample of the air traffic controllers to ensure that the information obtained during the interviews was completely understood. This interview technique is a suitable way to strengthen the quality of the data (Patton, 2002; Cox et al., 2007), and also provides the opportunity to dig deeper into relevant topics that have been raised. Follow-up interviews serve furthermore as an indication of the researcher’s genuine interest in the responses given by the informants, (Patton, 2002) and the informants that took part in the follow-up interviews showed a different understanding for the topic and could deliver fruitful answers the second time they were asked. Phone interviews were also conducted with the domain experts that were provided in advance with a summary of the topics that would be raised during the interview. The purpose was not only to compensate for the particular kind of interaction, which arises in face-to-face sessions, but was also aimed at giving the respondents time for preparation and the opportunity of reflection prior to the interviews. The interviews lasted 25-45 minutes.

4.2.4 Results and Analysis

Field notes taken during the observations were rewritten shortly after each visit in order to avoid what Patton (2002) calls memory reconstruction. Recorded data from the interviews were transcribed according to Linell’s (1994) definition of level three: a level that should be considered as a detailed documentation of recorded data. The transcribed material presented in Chapter 5 is structured according to the design of the interview guide. In order to describe trends and nuances at a more detailed level, parts of the data have been divided into subcategories. The results were furthermore analyzed with aid of the theoretical framework of procedures and Resilience Engineering.
5 Results

This is a study based on qualitative data and it is important to remember that results and analysis contain a grade of subjectivity. The information is based on the field researcher’s interpretations as well as the knowledge and opinions expressed by the respondents and should not be regarded as established facts. The interviews were not conducted strictly according to the interview guides because of the nature of the technique chosen that allow deviations from the predetermined order of questions. In order to follow every respondent’s sequence of answers and indirectly acquire a coherent picture of their statements, the quotes will be presented with an identification number of the related respondent. The interviews were held in Swedish and all quotes extracted from the study have been translated by the author.

In this chapter and the following chapter on the analysis (Chapter 6), the expressions “look up” and “use” will be referred to when the operators go and get the operations manuals and literally read the instructions found in them. The terms “application”, “implementation” and to “apply” will be used in a wider sense and refer to the general meaning of implementation of the regulations.

5.1 Use Rate of the Operations Manuals

In order to answer the research questions it was important to understand the main purpose of the operations manuals. The domain experts, that are responsible for the formulation of the manuals were asked to account for their expectations of the ways in which the operation manuals will be used. The operators were asked the same question, although a bit modified in order to find out how often they actually go and look up information in the manuals.

According to the answers given the air traffic controllers seem to use the two operations manuals in expected ways and few of them look up information in operational situations. As pointed out by operators and the domain experts the manuals serve as dictionaries, accessible in the environment when there is a need. The operators express that it feels safe and comfortable to know where to find them in case of uncertainty and go and look up information in the situations below. Usually a combination of situations gives rise to the need:
When there is uncertainty about how a rule is written
- When rules have undergone changes
- When detailed information is required
- When rare situations occur

All respondents stated that they apply the rules every day because of the fact that their job is based on the set of regulations and means that they do not go and look up something in the operations manuals often. Still, they claim that the use rate of the manual varies and depends on the work position and experience of the operator. Newly graduated operators and experienced operators state that students are in a bigger need of the manual while experienced operators rely on their experience by stating that problem solving is more than the pure set of rules. Interviews revealed also that operators in the area control might be more dedicated to procedures and look up in the manuals more often compared to operators in the aerodrome control. A possible and suggested reason for increased need of the manuals could be related to the higher grade of automation that is experienced to exist the area control.

5.1.1 The Central and the Local Manual

There is a clear difference between the use rate of the central and the local manual. Respondents talk about the central manual in terms of a set of basic rules that have been translated from the international documents and annexes constituted by ICAO. The knowledge “has been memorized in the spinal cord” and operators acknowledge that it would not be sufficient or convenient to look up information for each situation they face in position. Despite this they cannot say that the rules are practical and that it automatically implies that one can perform the work in an appropriate way. The procedures need complementing information such as the content of the local manual in combination with experience of the actual environment. Some of the operators claim that they almost never look in the central manual while others use it more often. Operators’ estimations of the use vary from every second to every fifth year.

“It is very rare that you look up something in the central operation manual since it concerns things that you should have learnt during the education, and that one is supposed to know. But of course there can be doubts about which rule to apply or how a rule is written, and then you have to look it up, but that is unusual. If you look something up ten times, then I would say that nine of these times it concerns the local manual.” (Respondent 6)

“If there has not been bad weather for a long time then you maybe need to check up the rules related to these conditions just to be sure even though you know it. But you check it up in order to not fail.” (Respondent 9)
The local manual is perceived as the one that concerns the “real work” of the operators, and the respondents, refer to it as an “application of the central manual”. According to the respondents it accounts for the way in which actions actually should be carried out. The use rate is still low although noticeably higher than the rate of the central manual and involves mostly detailed information such as numerical values. The information is used in rare or less frequent situations and was therefore explained to be hard to memorize. Examples of those situations are the strength levels of runway lights in relation to weather, phraseology, local restrictions that treat the separations of aircraft, or local regulations regarding adjacent flight sections. When changes have been made the operators look in the manual more often.

5.2 Management and Formulation of the Regulations

The domain experts concerned with formulation of the central manual at LFV say that the management of the manuals can be perceived as complicated and that the distribution of responsibility and administration is not always clear. The chief of operations at each air traffic service unit is responsible for the administration of the local operation manual and the domain experts are only involved with a few administrative issues that do not cover any regulation nor control of the content in the local manuals. Instead, the central manual is the main concern for the domain experts. Responsibility for the central manual is, however, primarily laid on the operations manager and then on the process owner that provide the domain experts with general guidelines regarding the administration of the operations manual. There is trust that the work will be done correctly and therefore no need for circumstantial control.

The formulation of the set of regulations at LFV has been influenced by historical reorganization and international cooperation. Directions issued by Transportstyrelsen in its earlier form during the period of certifications are still evident in the structure of the manual and can only be renewed gradually because of constrained resources. The domain experts express that they are found in a middle of a chain within an organization that from this point of view also ranges outside Sweden. They have to defend international constitutions and at the same time meet national demands and proposals of improvement. From above, the work of the domain experts is affected by ICAO, the European Union, Eurocontrol, and Transportstyrelsen that continuously execute referrals and guidelines. The domain experts state that the major part of the work are regulations executed by Transportstyrelsen but that they do not have any authority to ease them or realize changes. What they can do is to specify the content with respect to environmental conditions and by doing so add more strict interpretations of the content. In addition to work methods, proposals
from operator involve interpretations of the procedures that can be solved by the domain experts without consulting Transportstyrelsen. An example are the regulations from the ICAO that often are translated into a more readable text in order to avoid too difficult and juridical texts. The flip side of the coin is, however, that the translation has given rise to wider interpretations.

The domain experts monitor the international actors on the market. Opportunities to change on the international level are manifested through Eurocontrol. Together with Transportstyrelsen, the domain experts participate three times a year in a working group that contains providers and regulators from the member states. In the working group, no decisions are taken, but the proposals can be forwarded to ICAO.

One formulation issue that was mentioned during the interview is the purchase of technical devices within LFV. The domain experts perceive that new systems are bought with respect to financial aspects rather than existing regulations. There is a lot of work to match the systems to the European standards of communication between systems that are left to the domain experts. In addition, one of the domain experts said that in general they have seen difficulties with realizing verbal rule-related agreements that have been established during meetings. Written agreements have greater effect but are more circumstantial and take more time to register.

Despite limited possibilities to affect the domain experts perceive this regulation as positive and explain that it is a good support whenever they have to refuse new work methods and rule-related changes that are proposed by the operators. The domain experts believe still that in spite of limited resources they can provide the air traffic controllers with good conditions. They also think that the operators respect the set of regulations and trust the work they commit.

5.2.1 Update of the Operations Manuals

The central manual is updated and republished two times a year in the spring and in the autumn. The update concerns the following changes;

- Editing issues caused by the reorganization in Sweden, such as old names that figures in the rules. Also, there is input from the students that discover language errors when practicing the set of rules.
- Reformulation of texts that have been made evident through deviations reports.
- Introduction of equipment that requires changes in the work.

Changes are announced four weeks in advance on the intranet and then printed in a physical (paper) version and sent to the local service units. The same process values for supplements (SUPP) that are inserted into the central manual to cover up changes that occur between the yearly updates. The responsibility to
stay updated with the content of the manual is double. It is principally laid on
the individual operator, but assumes that the executive of each navigations unit
has made the information accessible. The same person is also responsible for lo-
cal changes, Operational Message from Unit Management (OMA). Besides rule
reformulations, OMA contains information about methodology and temporary
conditions such as temporary military exercises. In addition so-called “periodical
updates” are held, and the chief of operations gathers the operators in order
to discuss different areas of the navigation in order, refresh knowledge and to
maintain their authorization.

Updates are being announced differently depending on the air traffic service
unit unless it is a matter of major changes. Smaller ATS units have declared a “I
have taken part” as a binding in which the operators leave a signature to note
when they have read the new changes. Some units have briefing meetings be-
fore the shifts, in which changes are announced, while others rely on the in-
tranet, so-called “self-briefing”. During the interviews some respondents have said
that they prefer to be informed in verbal ways. They think that discussions fa-
cilitate the application of a rule since the underlying reasons can be understood
more easily. For instance one service unit has four meetings each year and
changes are announced a month before they are put into practice.

5.2.2 Opinions of the Updates

The following opinions concerning the changes of the operations manuals were
revealed during the interviews:
- The set of regulations undergoes changes too often
- Some changes are unnecessary
- The structure of the set of regulations is disturbed because of the changes

“The changes end up in a binding on the side, haha, there is an indication if there is a
change in the local one then you have to look up this OMA, deals with local issues, and
then you have to look it up in another binding and read it [...] You want to avoid a
loose-leaf system, and you want to have it all in one and the same place but I also
understand that they cannot change the manuals each time there is a new OMA.”
(Respondent 4)

Operators perceive that the time of announcement of the changes is enough, but
that small changes are difficult to absorb and moreover occur too frequently. It
is often a question of phraseology modifications that by the operators are not
always perceived to be necessary. In addition, they mean that it is difficult to
relearn phraseology that has been established and memorized for many years.
Although the respondents admit that the reality of an air traffic controller is
known for being changeable, they claim that changes sometimes makes the
work more complicated. For instance, new phrases are often too similar to
already existing phrases and the risk for misinterpretations increases, thus
requiring communication with colleagues, other air traffic controllers, and
pilots. Therefore, the old phraseology might be applied when communicating
with known pilots in order to work sufficiently.
Changes that are retaken and replaced by old phrases complicates the communication even more and some operators point out that this kind of confusion leads to decreased trust for the set of regulations. Some operators question why a more careful analysis has not been done before changes are introduced in the first place and experience that changes can be done without considering the way in which the rules actually will be practiced or perceived by the user. They think that different size and conditions at all navigation units have to be considered and one should be very restrictive with making too big changes in the central manual. A suggested way to cope with this problem is to involve all actors that will be affected, which includes airport staff as well as flight operators. This reasoning was based on the opinion that the existing set of rules today is better thanks to the inclusion of more employees with experience of operative duties when modifying the set of regulations.

Some of the operators mentioned furthermore that rules sometimes are modified right after the occurrence of an event and perceive that remedial actions many times have been done too fast without considering the real cause of the incident. They claim that there is a tendency to blame rules instead of taking responsibility and to investigate the action that was carried out. They think that there are a lot of reasons behind the occurrence of an incident and that the pure rule does not necessarily have to be wrong. Often it is a matter of an inappropriate way to apply a rule, for example wrong phraseology.

Changes are by the operators also perceived to contribute to a less definite structure of the manuals since the content is distributed over different documents. One document can refer to another document found in a separate binding located far away from the paper that initially indicated the change. Operators understand that updates cannot be done too often because of work and resources, but wish that the current loose-leaf system could be avoided to a higher extent.

5.3 Content of the Operations Manuals

The results below account for opinions raised about the content of the central and local operation manuals as well as findings from extracts in the environment of the operators.

5.3.1 The Central Manual

The current central operation manual consists of a mix of documents. Some of the procedures remain from the old set of Swedish regulations while others originate from the ICAO documents, the EU and Eurocontrol. The structure of the central operation manual is generally perceived as old-fashioned by the operators, and the domain experts explain that the structure originates from the time of certification.
"The first impression when I open up the book is where do I start to look?"

(Respondent 6)

Operators generally perceive that it is difficult to search in the current central manual because of the structure of sections and note that unless it is known in which section the answer may be found, one has to look in the whole book. At request of a proper index a searchable software version of the manual has been introduced. Moreover, it has been discussed whether the physical manual could be completely removed and replaced by the software version, but the dependence of a computer is however seen as a disadvantage. Watch supervisors claim that they look up information in the software version but asked operators search not in the file very often.

Operators that had experienced the reorganization of one local manual think that everything is written in black and white in the central manual and that there is no support for the eye to easily skim through the content. During the education, students practice to look up things in the manual and the respondents that had graduated recently perceived it as difficult in the beginning. This is in agreement with experienced operators who claim that they work with it more frequently and are in general better at searching in the manual compared to experienced operators who think they know the local manual better.

The domain experts perceive that it is difficult to balance the redundancy of rules in the manual and strive to present the rules only once, in order to facilitate the update. They claimed that it is easy to forget to change a rule if it is located in many places. This is an aspect that needs to be considered at the local navigation units where the content of the two manuals sometimes is mixed in order to reduce the amount of bindings. Redundancy in turn is a result of closely associated rules that range over different situations and need to be placed with the related rules. The domain experts sustained that such opinions always are subjective and therefore hard to realize which explains why there still exists a degree of redundancy in the manual. The software version of the manual has been suggested as a solution to this issue but is not used in position.

The majority of the operators are unable to answer whether the central manual contains any unnecessary parts or if there is any information missing. Although all of them assumed that manuals include mostly relevant parts in spite of the fact that they are considered to be too large. When discussing the size of the regulations one of the domain experts maintained that it was a good idea to collect all documents in one place, for example military restrictions that before were placed in a separate collection. Today they think it would be more convenient to adjust the manuals to different working duties. With the entrance of NUAC there may be reasons to introduce a separate manual that only concerns aerodrome control. An alternative option could be to leave some space in the central manual and to insert necessary local variations. There are also many parts that principally concern management that possibly could be extracted in
order to seize the growth. This option was presented to the operators during the interview and many of them agreed, but feared that it also would limit the generality of the rules and point out that the current manual already is too specific.

Misunderstanding and lack of comprehension of a rule because of the language used is not perceived as a major problem, but it does occur. An example is the different meaning behind the two concepts should [bör] and shall [skall]. Students are taught to make this crucial distinction between the concepts during the education but there are still moments in which the words can be confused. In those situations of uncertainty the operators apply the interpretation of shall. The domain experts also mentioned that so-called “s-marked rules, rules that deal with national Swedish variations, seem to be problematic to the air traffic controllers.

5.3.2 The Local Manual

The local operations manuals are administrated and structured in different ways depending on the air traffic service unit. Most work places organize the manual in the exact same way as the central manual in order to not get confused. It is appreciated and operators are pleased with the division of different areas. However, a new manual introduced in one site has instead been structured according to a color coding system. The reorganization of the manual has been very successful and those operators that have experienced the new manual request a similar division of the current central manual.

“They deal with different parts, so you use them both at the same time, and of course you cannot put everything in the local one since that would mean that it would grow to the size of the central manual, and that would be bad. I think they complement each other pretty well. It happens that you have to look up facts in the central manual too, but it takes a lot more time before you find where it is written. It can be hidden on a page where you did not expect to find it at all, so sometimes you have to scrutinize more or less the whole binding - not properly, but you have to look carefully.”

(Respondent 4)

The domain experts maintain that the quality shifts between the manuals and that some are very detailed and well-updated while other manuals have been made less extensive due to the fact that employees rely on the information they have in their heads. The underlying reason to such reorganization is that operators find it inconvenient to work with two manuals and prefer to remove large parts of the central manuals to the local operation manual. The domain experts think that it requires high demands on the local staff responsible for the manual
that have to follow the development of the central manual carefully in order to update the local manual. They experience that the update not has been optimal.

5.3.3 Extracts from the Operations Manuals

In the visited ATS unit, operators look up information in additional quick reference guides, tables and checklists. The extracts are copied from the two operations manuals, the SMS handbook and the AIP. The content is furthermore located centrally in the environment around the position. Respondents claim that the content of the quick reference guides is regarded as the “most frequently used parts of the less frequently used parts” of the operation manuals, and in other words not used so often that it had been memorized. Examples of the extracts are local standard routes, phraseology, and definitions and codes for the weather report system. Also, guidance for emergency situations has been placed in the quick reference guides since there is no time to look it up in a real situation. The checklists account for guidance regarding opening and closure of the work site and the process of a handoff, while the tables contain abbreviation summaries such as the permitted strength of runaway lights. An example of the distribution of extracts in one workplace is illustrated in Figure 4.

Figure 4. The distribution of extracts found in one of the visited aerodrome controls.
5.4 Changes in a Longer Perspective

The domain experts believe that the total historical reorganization of the Swedish civilian aviation authorities in combination with increased international collaboration and harmonization has had an effect on the set of regulations at LFV. Moreover, the air traffic controllers perceive that the changes discussed below have contributed to different work conditions in both negative and positive ways.

5.4.1 Extent of the Set of Regulations

In general, the operators perceive that there is a constant growth of the manuals that makes the manuals less convenient to work with and emphasize in agreement with the domain experts the need for a proper review. Experienced operators noted that the procedures used to fit in one document, while today scarcely two bindings are enough to capture the whole content. This is perceived as a surprising fact and the operators explained that their work duties have not changed remarkably. According to the domain experts the answer to the question is the insertion of parts concerning military aviation and management-related rules. Some respondents think that the external distribution of the procedures in a different document is rather confusing today. Rules from different resources have led to a disjointed set of regulations and they perceive that it is sometimes hard to know which one that values. Operators also mentioned that changes to rules contributes to a separation of documents even though the modifications are perceived to be less today compared to three to four years ago. They believe that the involvement of operative personnel when making the changes might be the answer.

Experienced operators maintain that they used to work with two manuals at most, and there were no difficulties in finding the requested information. Today students can refer to different documents that contain different information about one and same the issue. It also happens that students use search engines on the Internet in order to obtain information. The new resource of knowledge, however, does not concern important information such as separations and is for example used when there is uncertainty about abbreviations of flight operators.

Regarding the textual content of the procedures, respondents have expressed different opinions and some said that the rules today encourage more interpretation, while others think that standards and directions brought from abroad have led to a more stiff and detailed set of regulations. They think that the procedures contain a higher grade of work methodology and amount of automa-
tion. On the other hand, they believe that the language has been modernized and contributes to more legible manuals.

The “standardization” the respondents refer to concerns also use of English as the language of communication and is perceived by the operators as easy for the working with foreign pilots. Even though contact with local sport pilots is often held in Swedish the operators perceive no problems with the switch between the languages. Standardization is in general perceived as positive and respondents believe that it has contributed to a simplified work. In addition, informants perceive that the amount of national variations have decreased, but some of them question the fact that Transportstyrelsen is involved with the formulation of regulations and believe that international collaboration slows down the process of rule modification.

5.4.2 Education

The major part of the education at EPN for air traffic controllers deals with Document 4444, and the students are given four to five weeks to study the national set of regulations. Respondents maintain that there is, compared to the old education, a difference in the amount of knowledge of the national rules that the students bring to the air traffic service units. Informants define the knowledge as insufficient, and some point out that it is also unknown whether and how it will be memorized in a long-term perspective. Furthermore, they said that students obtain various level of knowledge and that some are well-prepared while others show lack of knowledge regarding the national set of rules. Before international and national rules were taught simultaneously in the contemporary manner, the national rules were introduced at the beginning of the education. Operators educated according to this old system think that they have memorized the manual graphically and note that they could vividly remember the look of the pages. In spite of the fact that the central manual has a lot in common with the international document there are still national variations that have to be studied. Students familiarize themselves with the structure of the manual by practicing how to look up information in it.

"It was not like I had to learn it all over again but you had to learn it again, but you had the basics and there were only some implementations and separations that did not exist before, and these of course you had to learn. They have thought about it since you are provided with education...we got four weeks of schooling in the Swedish rules and I think it is a little short. It was enough to know it but you are not certain about it, it was when I got here that I really got time to study them, and since then I know them very well, better than the international rules. After all, it feels more relevant to learn them since they are the rules that you work with. The international ones are good for basic knowledge but I don’t work in line with to them. So yes, there was a bit of gap, yes.” (Respondent 10)
Some respondents said that the number of students that graduate and pass the period of authorization has increased but admit at the same time that the education has led to changed conditions. First, before the issue with the short time period was fully recognized it was hard for the operators who received students to know what parts of the knowledge the students actually had obtained or more precisely whether there actually was a lack of some parts. Second, a large part of the education has been removed from the ATS unit and requires more engagement and support from the instructing operators. By doing this, work is laid on the students, who have the responsibility to learn the two manuals by themselves during the period of authorization. Breaks are often dedicated to this study. Third, rules are more often discussed at the air traffic service units since the students need to make sense of the rules. Discussions are being raised both in position and when the students are about to write tests. The tests focus on national rules, but students tend to refer to the international rules they have been taught. It is also a matter of language knowledge and students need to learn the Swedish phraseology since many national pilots choose the mother tongue when communicating with the air traffic controllers. The length of the period of authorization may differ from four months to half a year and depends on the size of the site of navigation as well as students individual capacity to absorb the new environment. The time reserved for the national set of regulations has been prolonged, but some respondents suggest that less variations from the international rules could be one way to cope with a perceived gap between education and work in an ATS unit.

5.5 Rule Management at LFV

To collaborate at the European level and to sign international agreements is important, but this means a changed distribution of responsibility. Every individual operator employed at LFV is responsible for the set of regulations as a provider, while the chief of operations at the ATS unit has the juridical responsibility. The domain experts think that the intermediate links and executives between the steps are not completely clear and add that changes and own initiatives cannot be made as easily as before.

One of the domain experts perceived that the set of regulations is discussed in different parts of the organization that are not always linked with each other but that the priority of the set of regulations is relatively low on the management level today. The importance of rule administration is acknowledged but has not led to increased resources. As a consequence of lost manpower the domain experts, can today only deal with the most prioritized work. The group consists of three employees, but only one of them works full time. The other two work half-time, a fact that leads to limited availability. Before, the group consisted of three more members: full time pensioners with valuable and irreplaceable knowledge of the domain. The domain experts said that no planning
can be made and that it is rather a question of keeping the work “on the surface” and to take one day at the time and mention two reasons that may explain the tight situation. First, it is unclear how the future rule management will be with respect to the international set of regulations, realized, for example, through the Swedish-Danish collaboration NUAC. Second, those who work with the set of regulations have always been a driven group, capable of carrying out their task in a good manner despite limited resources. As a result, they have high expectations that they can continue to work this way.

Previously the domain experts had an open telephone line on which the operator could call directly to ask questions, basically 24 hours a day. Apart from the recently mentioned report system they can also be reached via a digital mailbox. Before, responses could be carried out quickly, but now one whole day each second week is dedicated to responding to mails.

5.5.1 Participation in Rule Management

The air traffic controllers at LFV express that they are very committed to their work and eager to solve every uncertainty regarding the procedures. The discussions often start in position and in the staff coffee room. A couple of the informants mentioned that they are obliged to deliver opinions and proposals of improvements because of the fact that they are the only ones who actually can say how the work is supposed to be done. In general, operators think that they have different possibilities to affect the content of each manual and perceive that modifications of the local manual are easier with respect to the central manual. The difference has to do mainly with two reasons which are both related to the distance to people involved in the formulation process.

Opinions concerning the local manual can at some service units be mediated directly to the chief of operations. To achieve changes in the central manual is in general experienced as complicated and requires more effort and leads to a longer and slower process. The central manual is considered as a “translation” or “book of law” from the international documents in the sense that the content is not negotiable and some operators define it as a question of rule interpretation.

“I don’t perceive that we have the same possibilities to affect the central manual it is not convenient and you have to put a lot of effort to contact concerned staff, while I can grab a colleague at the office here and verbally express my opinion about the local manual, I think it is easier.” (Respondent 6)

Some informants believe that rule-related discussions should involve all actors in the chain that will be concerned with the changes. A lot of the changes concern not only safety but also environmental and financial aspects that have to be taken under consideration. Some respondent suggest that the character of each case should decide who will participate. If it is for instance, a matter of runway reconstruction, then management from the airport in question should take part.
The operators also have possibilities to affect their methods of work but say that the process to realize changes is long and slow. Examples of interventions that have been proposed by the operators in order to create changes are a white board with adjacent sections and the insertion of beacons. These changes are currently inserted as documents into the local manual but were initially verbal agreements. The introduction of the white board did initially contradict the consisting set of regulations, but the operative executives were able to validate the proposals through negotiations. The invention was initially used in one of the work teams but is nowadays established and used by more teams.

5.5.2 Communication Between the Employees

The education used to contain obligatory sessions in which the students had to practice both aerodrome control and area control in order to create an overall understanding of the work of an air traffic controller. Today neither students nor experienced staff are equipped with such information that they think is crucial for the collaboration. Respondents also think that cooperation between air traffic controllers and pilots would be more sufficient if there was a higher amount of understanding for each others work duties. During the interviews, a specific situation was mentioned in which lacking knowledge about each other work duties was highlighted as a contributing cause to the occurrence of the particular problem. Also, the domain experts express a wish to be more understood and suggests the intranet as the appropriate channel by pointing out that other information on the intranet has successfully been published in this way. The domain experts perceive that operators know little about the work that they do commit or how they can be contacted for proposals of improvements. In order to provide airports and staff with better insight of their work, the domain experts hope that this overall picture of the organization of rules would increase comprehension and make people see why procedures sometimes cannot be changed. The wish is clearly outspoken and the technique is there but has not been realized because of lack of resources.

5.5.3 The Occurrence Reporting System

According to the domain experts, the reporting system Synergi works well. To write a report is the most structured way to bring out pure opinions, errors, or missing information in operations manuals and by doing so no reports can be thrown away or ignored by any executive. There are, however, situations in which it might be hard to choose the appropriate channel, but one of the domain experts said that operational deviation report (DA) is preferable, because it is the fastest way of mediation. The responsibility for the quality deviation report (QA) is rather vague.
The process of a report that has been sent in is as follows: when a report is received it is up to the executive in each navigation site to decide whether the report demands remedial actions. It is a great responsibility to ensure the safety and to investigate the problem and includes also the authority to suspend an air traffic controller if misconduct has occurred. Within a couple of hours, a decision will be taken and a copy will be sent to Transportstyrelsen. A report can also be sent to an administrator at the headquarter or result in an OMA. When a report regards the set of regulations the domain experts are the ones to examine related procedures and leave an answer to the one that initially had written the report. The domain experts underline the importance of a clear and united answers and consult experts when there is a need and perceive that operators accept the answers they are given.

Among the operators, opinions regarding the occurrence system are divergent. Some operators associate the system with a relaxed attitude to rules and believe that the individual never gets the blame or is personally linked to a report. Other operators think that DA is easy to use from a technical point of view but that it is too “serious and complicated”. Some of them said that they sometimes avoid it because it is inconvenient, and mentions that a former system, a mailbox to which it was possible to propose improvements through hand-written notes, was better. Operators at one site saw the report system as channel to achieve changes, although in a rather long-term perspective. They think that a change can be realized if more than one operator point out the same issues, but a change is not perceived to be “one call away” and perceive that the speed of the response is correlated to the grade of severity of the rule or the situation in which the implementation of the rule is concerned. Answers from the headquarter are perceived to be handed out very quickly if the case is severe and the operators said that they generally receive positive and constructing feedback when they hand in reports.

5.6 Application of Rules

In this part, the words “apply” and “implement” will be used in order to explain how the procedures are practiced.

One of the domain experts said that within LFV there are two attitudes; one approach supports detail-oriented rules that account for each possible situation and that moreover have to be applied rigidly, whereas the other one calls for general rules with room for interpretations. Informants that were questioned were united upon the fact that rules are never complete and that no situations can be fully specified. They think in general that the procedures in the manuals are stiff and do not correspond to the way the work is performed in position. They point out that the situations they face involve too many aspects and therefore require a large amount of common sense and experience to solve.
need of interpretations differs between the units of navigation but also on the experience of the operator. Interviews revealed that operators employed at smaller airports seem to apply procedures based on a higher amount of interpretation. They also think that experienced air traffic controllers are more used to applying less specific procedures compared to students.

A clause in the set of regulations permits the operators to base their interpretation of some procedures on common sense, but the operators still think that many procedures in both of the manuals contain a too much specification that instead should be expressed in wider terms in order to support the decision making. The domain experts claim at the same time that phraseology may provide a grade of interpretation while separations never should permit this. Some operators perceive that the local manual encourages a higher grade of interpretation. One of the domain experts explained that not all changes have been inserted into the manual, and some service units rely on mutual experience rather than written rules. Even though operators find this as a convenient way to work, the domain experts underline the importance of written instructions, especially in the case of investigations. Some of the asked operators think that background knowledge serves to facilitate decision making and explain that a “fuzzy” rule that is not understood in the worst case can be avoided and not applied at all. Few rules are accompanied with this kind of explanation and operators think this would be helpful in the local manual. Furthermore, they believe that the purpose of the procedures in the central manual is obvious and decreases the need for explanations.

5.6.1 In Case of Uncertainties

Operators perceive that they can solve all situations and that it is very rare to end up with an “impossible” situation. They believe that there are too many variables that have to mismatch and equipment that has to break down before such a scenario would occur. One of them refers to a “toolkit” of options from which they can tailor a plan for action for each new and unique case. However situations cannot be solved in optimal ways or in the same way and there are as many solutions as there are air traffic controllers. Furthermore, they explain how important it is to always be aware of the possibility that the current situation can develop in other ways than those expected. It is therefore crucial to be able to abandon old plans and immediately deliver a new solution that is adjusted to the changed conditions. To think ahead and to count in possible intentions that the pilot may have in mind is also a part of this estimation.

Operators emphasize the importance of a set of regulations that can also support those situations that cannot be fully described in a procedure. However, they do not perceive that the current set always provides them with this support and describe the following ways to cope with an event in which a grade of uncertainty arises. Often operators work in teams of two or more air
traffic controllers and there is the opportunity to consult present colleagues. A manual is brought to the position, and the concerned procedure is read by the team. When a decision cannot be supported by a procedure, the operators seek information and update themselves with current conditions, perhaps more than usually. They mean that it is very important to have an overall comprehension of each situation and that all relevant forces that are involved. Also, the use of technical devices is crucial, and some operators mention the great support they receive from a new radar system. With aid of estimations of flight routes, planning is facilitated. Other crucial knowledge that cannot be found within the procedures is what the operators addressed as “system understanding”. It refers to background information that has been obtained through work experience and verbal communication with involved colleagues. The knowledge ranges also outside of LFV and has been established with air traffic controllers and flight operators in adjacent nations. The domain experts say, however, that the kind of implicit knowledge established through local agreements often remains unwritten and may therefore collide with existing regulations.

According to the air traffic controllers, the abilities of “common sense” and “creativity” are necessary to apply obtained information and to adopt current conditions in appropriate ways to solve a situation. Common sense is developed through experience in the work place and has initially been practiced during the education. Operators cannot account for how it is actually obtained or whether it can be improved. They think that the selection to the education and the training at EPN ensures that people with the right “thinking” enter the workplaces when graduating. Executives in one site are, however, convinced of the fact that creativity can be improved and supported continuously through discussions and practice.

Operators experience an established safety-think within the organization and believe that it was instilled on the very first day of the education and then followed up through seminars, training, and shared experience from other navigations sites. Safety always has a high priority according to the respondents that claim that they would deviate from a rule if the alternative to follow it would lead to an unsafe situation. At the same time, they underline the importance of knowing from which rule and why an operator makes a variation. No one can make up their own solutions, and it is essential to have support from a rule in the sense that the action was carried out according to the given guidelines, especially if a situation would have an unwanted outcome. Operators maintain that important rules are never broken, and one of them explains how rules can be divided into two subgroups in order to make this distinction. Efficiency rules contain room for interpretations and can therefore be adjusted for each situation, while safety rules accounts for separations and need to be followed rigidly.
Operators say that there are “exceptions” that allows rules to be overridden and that the first rule should be considered as complemented rather than broken. An example is a rule that initially says that only one aircraft at a time can enter the runway. To this there is an exception that permits the operators to have two aircrafts on the runway given that they belong to the same classification of aircraft and that weather conditions are good. In addition, some operators explain that the weight of visual impressions is important when guiding the aircraft and say that if one really can see that a collision will never occur they may keep a shorter distance than permitted between the vehicles. Operators think that it is necessary to act even if there is uncertainty about how a situation can be solved and that they can, in case of uncertainty about the chosen solution or the acting in general, send a report to the occurrence reporting system in order to account for the situation. One of the operators maintains that no action can break the basic rule: to avoid collisions between two aircraft.
6 Analysis

The analysis is divided into two parts. The first part accounts for the global context in which LFV is found. The purpose is to explain that and how the set of regulations at LFV is affected by international cooperation. The second part focuses on describing and defining the underlying functions of rule application.

6.1 Rule Management Driven by Standards

This section applies theories of Grote et al. (2009) and Perrow (1984) on issues of management of rule formulation (see 2.5). Perrow (1984) writes that up until 1984, air traffic management had gone from being a strict, complex system to a more linear system. Standardized procedures in combination with technological devices are used in order to increase safety in high-risk organizations and the global network in which LFV takes part. The standards and recommendations of ICAO, the EU and Eurocontrol are examples of means that bring structure to the global air space.

The central and the local manuals are the final products of a long chain of modification, in which procedures are being specified gradually as they get closer to the air traffic service units and the operator. Following the rule categorization of Grote et al. (2009), three subset of rules can here be traced through the transition of procedures that ranges from the actors in the top layers of the rule management to the watcher in each air traffic service unit (see 2.5). Documents from ICAO, and directives and directives from the European organs are here labeled as goal rules that furthermore will be distinguished from each other. Rules that target the European air space account for European conditions and are therefore more specific. Goal rules found in the documents of ICAO are instead general and are valid for the global air space. The same process applies for Sweden where Transportstyrelsen and the domain experts at LFV are responsible for transforming the goal rules into process rules by adding national variations, thus upgrading the rules to a higher level of specification.

Furthermore, the content of the central and local manuals differs due to the level of specification. The central manual contains a higher level of process rules (ibid). This means that the rules still remain on a relatively general level since they account for the whole Swedish airspace. The local manual, however, contains a lower level of process rules adjusted to the local conditions. Therefore, the content is more specified compared to the procedures in the central manual.
It is important to notice that this division into goal, process, and action rules is not absolute. It should rather be regarded as a simplification made in order to identify levels within the rule sets that will have to be considered when discussing the core application of rules.

6.1.1 The Distribution of Decisions and Responsibility

Grote et al. (2009) suggest that the hierarchy of rules should respond to the levels of an organization, and that application and formulation of rules should take place at the same level. In combination with the theory of the sharp and blunt end (Hollnagel, 2004), the rule development (see 2.5), and the results on management and formulation of the regulations (see 5.2), one can see from communication at LFV (5.5) that this not is the case within the rule management system of interest. The operations manuals at LFV are the results of decisions that have been taken at higher levels compared to where they are applied. Following Grote et al. (2009) rigidly, there is a mismatch between the distribution of decisions and the responsibility of the implementation of rules. This must be considered when discussing the responsibility of implementation and formulation of rules at LFV.

“The central manual lives its own life and should more be like a translation of the international standards” (Respondent 5)

During the period when LFV served as a regulation and provider for the management of rules, this was consistent with the idea of Grote et al. (2009). In those days, LFV worked out and applied their own rules. Today, the previously mentioned rule transition constrains the possibility of change and to replace the responsibility despite the gradual specifications of rules (described in 6.1). Decisions are taken and established by ICAO and the European aviation actors at the blunt end before they reach the operator at the sharp end (see Figure 5). As stated by Hollnagel (2004), each person’s blunt end is someone else’s sharp end. Here in this study, two sharp ends that are of relevance for the implementation of rules have been defined. First, the domain experts at LFV work with a set of regulations that has been formulated at the higher levels within the entire organization either by international actors or Transportstyrelsen. When there is need to reformulate or to add procedures to the content of the central manual, the experts always have to make sure that the changes do not contradict any of the already existing procedures. By working with a set of partly predefined procedures, the experts cannot be blamed for not being able to realize all changes that are requested. In the same way, the work of the air traffic controllers is affected by prewritten procedures. The procedures are written with respect to the resources and information that was available in the time and context in which they were formulated. The specific context in which they will be used can, however, not always be included and leaves the operator with the challenge to a match the procedures to the current situations they face. As described in Figure
5, the operator’s implementation of rules will be dependent and to some extent constrained by and earlier decisions. The responsibility ranges over larger parts of the organization rather than just the individual operator, and this fact needs to be taken into account when investigating failure or unwanted events.

Figure 5. The Sharp and Blunt end applied on the Rule Management

6.1.2  Impossibilities and Possibilities to Affect

The need of the operator’s contributions to the set of regulations at LFV will be discussed in this section from two points of view. According to both the structure explained above (see 6.1) and results on management and formulation of the regulations (see 5.2 and 5.5.1) one can see and suspect why the content of the central manual is more difficult to change with respect to the local manual. The central manual contains what have been labeled here as the higher level of process rules. Large parts of the rules are derived from international documents and limit the possibilities for being affected.

The statement of Grote et al. (2009) that formulation of rules influenced by the users is beneficial for the overall rule application is confirmed among the operators at LFV. For example, the operators think that the set of regulations has been improved during the years, thanks to the inclusion of operators within rule formulation. A successful reorganization of a local manual is another concrete proof of this. Operators can also affect the set of regulations by introducing new methods. Felici et al. (1998) write that it is not unusual that the operators themselves work out procedures, and by doing so, the operators at LFV use their in-
terventions as means of participation. However, this participation is limited by what is perceived to be long and slow processes. Furthermore, different methods have been mentioned during the interviews and among these are the report occurrence system and verbal contact which are highlighted as channels for rule-related proposals. In turn, this may explain that the varying grade of participation of ATCO in rule implementation activities between the different air traffic services units.

From another perspective it is also important to understand that the operator’s participation is not always needed at the higher levels. Goal rules that are constituted with respect to overall goals (as the name implies) and the operator’s specific knowledge may not always be relevant in these discussions. The fact that the domain experts sometimes find support in the whole hierarchy of rule formulation when denying the proposals that sometimes are unrealistic show that there is too little acceptance or knowledge among the operators about the complex transition of rules. LFV should think of informing the operators about the structure of the total rule formulation and all involved actors, international as well as national. By doing so it will be easier to understand what parts of the regulations that are negotiable. Furthermore LFV should consider to mediate the exact ways in which the proposals can be communicated by the operators. If it is difficult to establish precise channels for this purpose, one possible way could be to gather operators in continuous workshops or seminars.

6.2 Functions of Rule Application

The response to potential threats means a quick shift from a state of normal functioning to a state of so called readiness (Dekker et al., 2008) and is for an air traffic controller based on the application of procedures. Following Cook and Woods (1994), the performance of an operator at the sharp end is based on certain factors provided by the organization. In this study the factors have been addressed as the abilities of resilience: to monitor, to anticipate, to learn and to respond. Together they found a base for the final response of an ATCO defined here as the control of the air space achieved through rule implementation. Furthermore, the abilities have been added to the figure of the relation blunt and the sharp in order to get on overall picture of the conditions that affect the work of the operators at LFV, see Figure 7.

There is a dynamic interplay between the abilities that makes them hard to separate. The same applies for the functions into which the abilities will be divided into in this analysis. The result of such a close interconnection is the dependency that arises between the abilities and the functions. These connections have many similarities with the tight coupling described by Perrow (1984). The consequence of such couplings is the potential for chain reactions; dysfunctions in one ability may disturb and have immediate effects on another ability or
function. Precise connections and relations between the abilities cannot be defined in this study, but the following example illustrates a possible dependency structure and aims at pointing out the need to support all the underlying abilities and functions.

In order to execute a response, an operator needs to know how to read and how to interpret the rule with respect to the context. As Hollnagel (2010) explains, learning grounds the response through supplementing with knowledge and it is moreover important that the learning is performed in the right way. An operator learns how to interpret a rule, but a correct application of it can easily be disturbed if the ability of monitor is under-supported and the rule is not accessible or is difficult to understand. The latter issue deals in turn with the overall attitude to rule following and the grade of permitted interpretation of rules than can be expressed through the level of specifications. Since a great part of the work of the operators concerns planning and to combine rule-related knowledge with experience, a response is indirectly based on the ability to anticipate.

Furthermore, many of the functions are of a multi-functional character, which Perrow (1984) calls “common mode functions”. The occurrence reporting system Synergi (see 5.5.3) is an example of such a dependency to other functions. First, there is the principal function of the system, a channel in which deviation reports and quality deviations reports are sent. A second function is for communication in order to teach and to support operators with interpretations of the content in the manuals. Third, it serves as a mean of participation and to affect the content of the rules. Fourth, the process of investigations that captures the reports mirrors in turn the organization’s attitude to rule implementation and safety.
6.2.1   To Learn

For an air traffic controller, the function of learning is a fundamental part of the rule application. In order to use obtained knowledge when implementing rules, the function of learning must consist of more aspects than the core absorption of knowledge. In this study the following functions have been identified as crucial: the form of education, the origin of the knowledge that will be learnt, and how the knowledge is maintained and shared among the operators as a group.

6.2.1.1.   Organizational and Individual Learning

Learning within a system or a company can be manifested in organizational and individual ways (Dekker et al., 2008). The results on the education for operational air traffic controllers (see 5.4.2) point to the fact that not enough study time for the national regulations affects the balance of different kinds of learning. This has seemed to complicate the transition between education and the air traffic service units.

“The transition from education to reality has been handled in different ways. Some students can deal with it very well while, others show lack of knowledge and are less informed […] There are a lot of discussions because the students have learnt the international rules in another way than we did” (Respondent 4)

Compared to a former structure of education, a lot of work is laid on the students today. The students have the responsibility to learn the two manuals by themselves during the period of authorization, and learning has gone from being organizational to individual. Even though the process rules in the manuals at LFV are based on the goals rules from the international documents, national variations and specifications must be studied. In addition, the studies include the Swedish phraseology that must be applied when guiding national pilots.

By removing a large part of the education to the workplaces, a higher amount of engagement and support is required from colleagues and instructing operators. They have to guide and explain more to those students that still are influenced by the international set of regulations which in turn encourages discussion. To discuss the procedure helps the operators to make sense of their work, even those that are experienced. However, the work in position is often stressful due to the time reserved and the discussions may tend to decrease the time of decision-making even more. Therefore it does seem relevant to examine the locus of teaching in position.
To teach the documents of ICAO is the not a problem such as. What LFV needs to consider is rather were the responsibility for teaching the national rules will be and when this learning should take place? Despite the fact that support from colleagues is crucial and makes an important part of the period of authority at the air traffic service units one question remain, how much of the work in position that should be dedicated to teaching, could the compensation be provided to the students in other ways a part from the breaks?

6.2.1.2. Updates as a Function of Relearning

Learning should be continuous and driven by a plan or strategy (Dekker et al., 2008) and is at LFV realized through updates of the manuals (see 5.2.1 and 5.2.2). It is important that learning is derived from the right experience (Dekker et al., 2008), but this is not always the case at LFV. Oftentimes learning seems to be driven by a history of unwanted events.

“There are a lot of changes that occur to often and are annoying to us operators and they are not always explained well and seem unmotivated [...] moreover they are changed back again...” (Respondent 3)

A tendency described by (Hale et al., 2003; Carvalho et al., 2006; Dekker, 2003; Sanne, 1999) to derive supplements, make changes and to modify rules after the occurrence of an incident is present at LFV. Changes are perceived by the operators to be made too fast and sometimes without considering the real cause of an event despite the process of investigation. Here it seems that the content of a procedure gets the blame instead of questioning how the rule was implemented in the first place. If changes are based on wrong conclusions about the cause of an event that has occurred, then learning could based on the wrong experience.

As stated by Dekker (2001, 2003), changes based on misleading conclusions do not guarantee increased rule compliance nor prevention of future events. This is evident at LFV where the changes seem to confuse the operators, especially in those cases when changes are retaken. A contributing consequence of this is a slight tendency of decreased trust in the set of regulations. The risk for misinterpretations grows and more specific forms of communication with colleagues as pilots are required. An example mentioned by some operators proves that adoption of new phraseology might even be dismissed because of inconvenience. In this particular situation the communication with known pilots continued without using the new lines, while contact with unknown pilots needed to be more correct and in line with the new phraseology.
A major challenge when adapting the safety approach of Hollnagel (2006), is to measure safety when it is shown in the absence of errors. Operators at LFV point out that they often get feedback and positive confirmation of their performance when sending in a report about a particular event. Therefore these reports could be used for the purpose of learning from normal actions and successful performance. In combination with an even more careful examination of the reports with unwanted outcomes, this would allow for a meaningful learning experience.

6.2.1.3. Common Ground

The concept of common ground permeates the work of an air traffic controller since the coordination of air traffic requires a high grade of teamwork. Results on communication between the employees at LFV (see 5.2, 5.4.2 and 5.5.2), however, show signs of lack of shared knowledge that will be discussed from three points of view: between the staff in the same control, between the controls, but also between different actors within the organization as a whole.

Because of tight traffic flow there is not much time for explanations and operators must receive and hand-over aircraft to other air traffic controllers with the assumption that their colleagues know how to continue the guiding. The changed form of education seems to be one reason for decreased insight in the different controls. A situation highlighted by some of the informants shows that the lacking knowledge partly deals with the different work conditions of the colleagues and their way to apply the procedures. Aside from the need of extended communication, the core element of guiding aircraft was disturbed because of misinterpretations. This particular case exemplifies also how bad communication can give rise to tensions between the operators. In a longer perspective, a mismatch of knowledge can contribute to a more severe segregation of staff and, in the worst-case scenario, contribute to loss of trust and confidence for each other.

"Often you thought that a student had it under control but then there was a situation in which you realized that they did not know how do it at all, and of course one had to give them a hand and to solve the situation together."

(Respondent 10)

The second area treats different bases of knowledge. Initial common ground is a kind of knowledge that can be expressed in procedures (Woods et al., 2005) and is embodied in the set of regulations at LFV. The set of regulations collects the kind of information that is aimed at establishing an understanding between the operators. The students are taught the international documents for this purpose, but their knowledge is not directly applicable when entering the workplaces where the work is focused on the national rules.
Apart from the fact that students don’t have the same knowledge as their colleagues, this discussion also deals with a meta-level perspective of knowledge: to know whether an operator has the same base of knowledge or not. This was the reality for some operators before it was acknowledged, that some students not were equipped with the same information. The colleagues could not presume what knowledge or to which extent the students had absorbed the national procedures.

The third aspect involves knowledge that concerns the understanding of the rule management within the overall organization, discussed regarding possibilities to change (see 6.1.2). The domain experts’ wish to be more visible is clearly motivated and parts of the work that they commit seem to be unknown to the operators. One example is the mailbox to which proposals of improvements can be sent, which never had been mentioned by the operators when discussing communication means during the interviews. An insight into the work of the rule management of the domain experts would provide staff at LFV with information that in the long run could gain the core rule implementation.

LFV should consider exposing their employees to each other’s work. By understanding the different sub-goals of the system, the effort to achieve the main goal would be better supported. From a resource-oriented point of view, common ground could also increase the substitutability of manpower, which according to Perrow (1984), is one of the disadvantages in linear systems. Through shared knowledge, it would be possible to cope with a sudden loss of air traffic controllers by replacing one operator with another.

6.2.2 To Monitor

Monitoring refers to the collection of information that becomes the foundation for the shift between the state of normal operation and the state of readiness Dekker et al. (2008). An appropriate response is based on the evaluation of the information provided. The distribution and structure of the set of regulations are crucial parts of the implementation (Pritchett & Ockerman, 2000). For an operator, monitoring involves the task to identify indicators that signal about an upcoming situation and to look up the information that is required in the operations manuals.

6.2.2.1. Extent of the Set of Regulations

The crucial subtask of monitoring “to know what to look for” (Dekker et al., 2008), is not the main problem for the operators but is indirectly disturbed due to the location of the set of regulations. Results on the formulation of the central manual and the extent of the total set of regulations (5.2, 5.3.1 and 5.4.1) show that the placement of information is not always known and that there is need for a proper renewal of the central manual.
This would, however, require a lot of work and has so far been impossible due to limited resources which, as stated by Dekker et al. (2008), makes monitoring a matter of investments in money and time.

"We are under pressure and the work is committed with artificial respiration today." (Respondent 11)

The domain experts at LFV have to cope with a mismatch between available time and resources and the work that will have to be achieved. They deal with the kind of trade-off that Hollnagel (2009) describes as the compromise between what must be done and what should be done. The work with the regulations is driven by the former expression must due to time available and a loss of manpower. The domain experts plan and perform their work on a daily basis while they seek to meet the goals with as little investment and resources as possible. The work is not done continuously as preferred by the domain experts, and only the most urgent issues can be taken care of. For example updates can only be realized when a rule-related issue has been detected, and the many ideas regarding reorganization of the set of regulations are laid on ice.

It is clear that the implementation of procedures is affected by the structure of the set of regulations. Low priority of its reorganization can, in the long run be considerate, as a threat of decreased safety. In financial terms it might seem unnecessary to spend money on a rule management that does not show any tendencies of being dysfunctional. However, the right or the wrong situation might uncover some of the latent weaknesses with the set of regulations and lead to failure which would mean higher costs and, even worse, a loss of human lives. The search for a procedure that is not placed where it is expected to be found is an obstacle that may disturb and jeopardize the work of an air traffic controller.

6.2.2.2. Purpose and Use of the Manuals

Results on the use of the operations manuals (see 5.1 and 5.1.1) show that the manuals should serve as dictionaries. However, when used in practice, the results show that the operations manuals support the operators differently. In combination with results on the extracts from the manuals (see 5.3.3), this gives a slight indication of diverse use goals with the operations manuals.

Lawton and Parker (1999) argue that the structure of a set of regulations and the different parts it consists of can confuse the user’s perception about the expected purpose. That there is a different use rate between the local and the central manual at LFV may be a result of different organization of the content, but of course, also the content itself. The central manual, with a higher level of process rules, is more general and may therefore be expected to be memorized, while the local manual contains the lower level of process rules and is more specific, so it is allowed to be used to a higher extent.
Moreover, extracts from the both manuals indicate that there is a need to look up the detailed parts relatively often. In combination with the differences of the manuals, it seems that the purpose of the manuals changes as the procedures get more specific.

In line with the study of (Lawton & Parker, 1999), where novices are more dependent on procedures compared to experts, the students at LFV look up information more often than the experienced operators. It might sound like natural phenomena, but the point is that an increasing use of the operations might be a result of less education in the national rules. This would mean that the need of a well-organized set of regulations and access to the manuals is even more important. In this way, the operations manuals can serve as compensation for a low grade of knowledge.

The aim is not to question the current purpose with the operations manuals or to doubt the operator’s perception of the expected use. It is rather a matter of highlighting the possibility that different collections of procedures might have different purposes and different meaning depending on the user’s experience and main duties. An idea to separate the content of the operations manuals mentioned by the domain experts indicates that LFV is already aware of differences between the aerodrome and area-controls. Potential differences between the other controls and between students and experienced operators could be examined further in order to adjust the structure of the operations manuals in preferable ways.

6.2.3 To Anticipate

Anticipation is the ability to look for the potential and to make a model of future states (Dekker et al., 2008). Results on the application of rules (see 5.6 and 5.6.1) show that for an air traffic controller, the ability to anticipate is a profound function of planning. The task to foresee future states in the traffic flow of aircraft makes up part of the ability to respond. To estimate the trajectory of the aircraft is, for instance, one task that requires a high amount of anticipation, and operators need to shift between information resources in order to succeed. The first resource deals with explicit information that can be applied immediately. One example is the separation tables and technological devices that are used in order to structure a linearity of the traffic and to make it as predictable as possible. The radar screen with built in functions, plots the estimated route of an aircraft, and by doing so, provides the operator with information about the future.

At the same time the operators have to cope with the main task of anticipation: imagining. This is to see “on the side” of the expected trajectory and to think of the possible reasons why the aircraft would deviate from the route. The imagination is based on experience, and an operator has to consider the intentions of
the pilot of the concerned aircraft. Examples of useful experiences are knowledge about the local conditions, such as weather or geography, but also includes surrounding aircraft and time table.

Suchman (1987) writes that part of planning deals with the capacity to abandon plans as the conditions change. For air traffic controllers, it is crucial to see the need of a switch between different plans. To not be aware of this and to not replace an old plan with a new strategy is considered as unsafe acting. Therefore, operators are prepared with a buffer of back-up plans that can be adjusted according to the new conditions. The more experienced the operator gets, the earlier her or she can detect the indicators that said if a plan will have to be substituted or not.

Today, focus is laid on minimizing risk before something becomes serious through analyzing the problem areas, which is a part of the Proactive safety element of the Safety Management System at LFV. In order to support the operators with the ability to anticipate, this proactive approach could involve discussions of how training to handle the unexpected could be realized. The pure definition of unpredictable situations states that it is hard to be prepared and to set up training sessions for a threat that barely is imaginable. Still, some extent of training in simulators could serve as support to the operators and support creative thinking.

6.2.4 To Respond

A response is defined by (Dekker et al., 2008) as a desired change, and for an ATC some of these responses are to be found as predefined events in the central and local manuals. According to the division of threats (Westrum, 2006) and results of the application of rules (see 5.6 and 5.6.1) these events will hereby be named as regular threats. However, this section is most concerned with so-called “irregular” and “unexpected” threats. They are unlike regular threats in that they are not possible to predict or to describe in a set of regulations and therefore require the existence of performance variability (Woltjer et al., 2010; EUROCONTROL, 2009).

6.2.4.1. The Competence Envelope

Performance variability must, however, always be controlled and the operators are aided by the competence envelope, which according to Woods (2006), indicates the grade of permitted acting. Described in metaphorical terms, the boundaries of the envelope can be regarded as the result of a balance between the two approaches to rule following presented by Dekker (2001, 2003). Apart from the attitude to rule application, the boundaries also seem to be defined for
each specific situation with respect to the local conditions and the character of the procedure.

“It is not just black and white, there are a lot of situations that haven’t been described in the manuals. You can break the rules but you must be able to account for it afterwards and to motivate the reasoning behind your actions. It is important to have a rule to lean on.” (Respondent 11)

There is a general belief that the occurrence of events and accidents are considered to be results of bad adaption of the context. The operators adapt the conditions in the environment and match the rules according to these observations. In this way, procedures are implemented as what (Suchman, 1987) defines as resources for action. As described in section 6.2.3 when discussing the ability of anticipate, this means that the operators combine technological resources and experience in order to fill the gap between an incomplete procedure and the current situation. An example of such an adoption has been mentioned during the interviews. In this specific situation the pilot and the air traffic controller established agreements together with respect to the context and local conditions in the sector that was monitored. The written procedures were replaced with a new suggested route for the aircraft which was considerate more safe and sufficient than the standard route.

The adaption of the environment sometimes is so important that an operator can choose to not apply a certain procedure at all, if it shows that following the procedure can lead to an unsafe situation. The incapacity to match a rule to a situation has by the respondents been explained as a result of too little flexibility in the rules or lack of explanations. Their request of more general rules supports the hypothesis of Grote et al. (2009); flexible use of rules requires flexible rules. However, it is not clear what kind of flexibility that is requested. In the article of Grote et al. (2009), standardized procedures are recognized for reducing the degrees of freedom, and are defined as the opposite to flexible rules. Based on the origin of international set of regulations, the recently mentioned kind of standardized procedures exists at LFV. Considering the operators way to address some procedures there seems to exist also another perception of standardized rules. For example, the documents of ICAO and the central manual are, by the operators, spoken about in terms of “basic rules”, and may therefore have the opposite function. The content of the central manual is from this point of view more standardized than the content of the local manual. In turn, this would mean that the content of the central manual is less specific and permits a higher grade of interpretation.

The work of the operators is a handicraft based on experience rather than procedures, but there are still signs of a rigid approach to rule following. The operators must be aware of what kind of deviations they do and make sure that they are well-motivated. The juridical weight of a rule is taken seriously and there are those procedures that cannot be applied in a flexible way. However, the awareness of investigations might support a reasoning that may hinder the
adaption of the context. For example, some operators have highlighted the importance of working in line with the procedures in case of failure. The same operators argued that if one follows the procedure, one will not be completely responsible for an occurrence of an unwanted outcome.

There is an established awareness of safety among the operators, and a balance between the two ways of rule interpretation is often based on common sense. What LFV can do in order to support this interpretation of rules is to further examine the operator’s need of flexibility and explanations of rules. An additional support would be to encourage the adaption of context, for instance, through discussions and training or simulations.
7 Discussion

This chapter presents reflections and lessons learned from this study. The discussion treats the main parts of the thesis; the theoretical framework, the research method and the results and analysis.

7.1 Theoretical Framework

The theoretical framework is divided into three parts. The first part consisting of the theories of Accident models and Human Error aims at providing the reader with an introduction of the complex features of a socio-technical system. A second purpose was to highlight the essence of Resilience Engineering by presenting the traditional theories and their characteristics and constraints.

The second part treats the framework of Perrow (1984) and Grote et al. (2009). The purpose was to explain the global context in which LFV is found and to account for the origin and the content of the operations manuals and their dependency to the international documents. The idea of defining the rules was initially good and aimed at creating a vocabulary for discussion of the transformation of rules but could have been used more sufficiently if the collected data would have contained more detailed descriptions about the content of the rules. By applying the theory of Perrow (1984), the intention was to demonstrate the main functions with the international standardization of the traffic in the air space. In addition, the theory of the blunt and sharp end (Hollnagel, 2004) was used to explain the change of responsibility that comes with standardization in organizations that involve many actors and ranges over several levels. An alternative way of presenting the data could have been to apply the schematic model of the necessary steps of rule management made by Hale et al. (2003). By mapping the model to the rule formulation in this study, missing steps and weaknesses in the steps could have been detected. However, a disadvantage is that the model seems to be most suitable for describing the management within one and the same organization. Adequate application of the model would therefore require modifications with respect to the rule management that involves several organizations in this study.

The third part of the theoretical background was aimed at accounting for the functions behind rule implementation, and the four cornerstones of Resilience Engineering seemed suitable for describing the work of an air traffic controller. As acknowledged by Hollnagel (2010), it has been difficult to separate the abilities from each other due to the close connections and to define the abilities and
functions in a consistent manner. For example, the abilities to anticipate and respond are vaguely defined through the tasks of an ATCO. They include the functions of “experience” and creativity while the abilities to learn and to monitor have been discussed as organizational means: the education and the location of the operations manuals. The location of the functions is furthermore subjective and it is possible that someone else would have distributed them in a different way. Moreover, the inclusion of the education has led to a slight modification of the ability to learn that originally defined by of Dekker et al. (2008) emphasizes learning as driven by earlier experience.

The functions of the purpose and the distribution of the procedures at LFV were furthermore explained with aid of the studies of Lawton & Parker (1999) and Pritchett and Ockerman (2000). The theory of the former authors could, however, have been used to a higher extent in order to capture an operator’s overall experience of the operations manuals. The theories of Dekker (2001, 2003) and Suchman (1987) were used in order to account for the complex discussion of attitudes to rule implementation. An optional way to describe rule application could have been with aid of the concept of “Professional vision” by Goodwin (1994) that describes how experience separates a novice from an expert through absorption of information. According to the theory, an expert sees different features of an object or situation compared to a novice, based on this distinction experts can make faster decisions.

When analyzing the implementation of the operations manuals, it was realized that some factors range over the whole management of rules and not only within the walls of LFV or in the head of an operator. This insight pushed the analysis to a macro and micro level that has been hard to unit and resulted in the desire to find a theory that could better account for all factors instead of having to separate them apart. The Functional Resonance Analysis Model (FRAM) could have been the right tool for interconnection of all the functions. However there is still the fundamental issue of describing less definable functions such as “rule application” by defining preconditions and constraints between the four abilities of interest.

7.2 Research Method

The advantage of ethnographies is the possibility to commit an in-depth description of an organization or a work place. Validity and reliability are, however, disadvantages and the latter that deals with the grade of generalization cannot be addressed in this study. Data triangulation is one way to strengthen the validity of qualitative field studies, (Patton, 2002; Svenning, 2003) but has not been possible because of too few observations.
The implementation of rules was difficult to observe especially with respect to the brief insight into the domain of knowledge. Neither was it easy to raise rule-related questions nor detailed explanations in position since the work requires an operator’s full attention. In order to overcome this problem and to reveal strategies behind the implementation of rules, simulated implementation was thought of. The method has been used within the area of usability design and means that the user explains reasons about an action while performing it (Patton, 2002). In addition, the air traffic controllers have spent many hours in simulators and a relaxed attitude could have encouraged them to think aloud. However, factors such as access to equipment and disproportionate big focus on the implementation part turned the method into its initial purpose with the observations: to familiarize and obtain base knowledge about the domain of air traffic control. The observations were still useful in adapting the domain language and locating the operation manuals and the extracted material in the controls.

Also, other techniques were considered in order to reveal the opinions of the operators. Inspired by a similar study it was for a short moment tempting to mail informants paper surveys mixed with multiple-choice and open-ended questions. Opinions from additional air traffic service units could have been represented, given that the informants would have answered the questionnaires. Among several disadvantages for this method, the worst is that predetermined answers contradict the initial purpose to reveal the informant’s opinions. By using predetermined answers, one prevents all possibilities to uncover hidden issues and in order to avoid this, the interview guides were continuously improved as the study went on. With respect to available time, reaching the core of the topic relatively fast was prioritized, and the results showed that despite this, a grade of saturation has been reached. Many opinions have been shared among the informants.

It was initially difficult to conduct the interviews and the topic as, the set of regulations was perceived to be sensitive among the air traffic controllers. A researcher can often gain trust by being present in the environment for long periods (Sanne 1999; Cox et al., 2007), but this could not be realized. The idea of an exploratory study therefore served its purpose and a different approach was taken during the interviews that followed. The combination of a different vocabulary and a more careful presentation of the purpose with the study resulted in fruitful answers. For example, it was important to underline the complete disinterest in the individual performance when implementing the rules. Another method that could have been used in order to encourage a more relaxed discussion was plenary brainstorming sessions. Apart from the support that the operators could have received from each other, the method is beneficial when trying to reveal concrete examples of situations and requested improvements. Unfortunately, there is always the risk that operators unintentionally synchronize their answers rather than delivering their own personal opinions (Patton, 2002). The limited access to air traffic controllers due to their shift was also a
reason rule out this optional method. Instead, some interviews were preceded with observations with the same person.

The domain experts that contributed with an overall perspective of the rule management in the whole organization were the last ones to be interviewed. When considering the order in which the data has been collected, it could have been beneficial to have gotten this background information before the interview sessions with the operators were initiated.

7.3 Results and Analysis

The goal of this study was to explore the rule management from which the operations manuals at LFV are derived and to find out how the air traffic controllers employed by LFV experience the operations manuals. It was expected to obtain more detailed information about the two operations manuals, but the interviews and observations turned the analysis of results towards another direction due to the operator’s low use rate of the manuals and the way in which procedures are applied. This section concludes some of the reflections that have been raised during the study.

At first, there were signs of a gap of knowledge between the students and the experienced staff at some ATS unit that are driven by LFV. This mismatch and potential lack of knowledge, that has been discussed so far from the point of different forms of education and common ground, needs further investigation in order to state the grade of severity of low knowledge. For instance it could be so that what until now has been called “lack of knowledge” is actually a sign of an unfortunate collision between two generations of air traffic controllers that have different methods of applying two sets of regulations: the national one in the operations manuals and the international documents of ICAO.

Another part of the analysis showed that the operators have a relatively low insight into each other’s work. At the same time, there was a parallel discussion held regarding a possible separation of the content in the manuals. The purpose with such a separation would be to extract those parts that are not necessary for the operator and to adjust the content to the work duties in the control of interest. Taking these suggestions into a practical situation, a contradiction becomes visible between the two requests that raise the question: How does one integrate the operators into their work duties even though those same duties will be segregated through reorganization of the operations manuals? Another concern deals with the meaning of common ground and the distinction between knowledge and understanding. This seems relevant in order to examine a potential gap between the operators at LFV and to see if shared understanding can be reached through clear definitions of the work duties between the controls. Otherwise, it might be a matter of deeper understanding that, in relation to the abil-
ity to anticipate and the capacity to predict and imagine the intentions of another person deals with aspects of the “Theory of mind” (Premack & G. Woodruff, 1978).

The physical external and internal structure of the set of regulations is perceived by the operators as confusing. In the analysis it has only been discussed as a result of constrained resources, but there might be additional reasons for the low priority. The first concerns the indented purpose of the operations manuals and deals with the distinction of implicit and explicit knowledge, which is one of the main issues in rule following. Given that the manuals serve as dictionaries, this means that most of the information is supposed to be memorized inside the head of the operators and that the priority of the physical structure may seem less important. A central question to such an assumption is how the correctness of rule implementation can be measured when it in one sense is “done” and removed from the mind of an operator? A second reason can be the result of a collision between two goals, whereupon the other one deals with a proactive approach to the changing market of aviation. The development of the set of regulations at LFV might be hindered due to potential future changes and, above all, the vision of a common set of regulations (SERA).

Following up the purpose of the set of regulations because of the potential differences between the operators and their need of flexibility in the rules, it would be of interest to examine further what features make up the differences between the controls and to what degree these features actually affect the implementation. In relation to the leading indicators that direct the ability of monitoring (Dekker et al., 2008), one could suspect that the operators’ varying use rate of the operations manuals is triggered by different indicators. From such a reasoning comes the following question: if the operators deal with different competence envelopes, which walls are defined with respect to different conditions, and furthermore, do three controls require different amounts of performance variability? Also differences in the rate of use between students and experienced operators can be discussed from new points of view. Similar studies that treat procedure following have revealed that a novice’s higher need of procedures is not necessarily correlated to their level of knowledge. It can also be a sign of insecurity and the strive to not fail.

Reconnecting to the theory of Grote et al. (2009), a balance between less flexible and flexible rules is emphasized, the next argument deals with the necessity of different rules. If some rules need to be more rigidly followed than other rules, this balance is perhaps already reached at LFV, given that the central manual and the local manual are perceived by the operators to complement each other. The fact that operators work out their own methods can based on two kinds of standardization be interpreted in two ways: The first as a will or a need of standardization in the first sense to reduce the possibilities of action and to facilitate the decision making. What they do is to establish the ideas and knowledge that have been kept in their minds as concrete facts and documents in the operations
manuals. The other option is the need to replace or complete current and heavily constrained standards by adding crucial information from the context in which the guiding of aircraft takes place.

Operators request more explanations and more flexibility in rules. This immediately generates three relevant questions; First, is there really a need for both explanations and flexibility in the rules, or are we dealing with a casualty, in that the need of explanations is a result of the amount of flexibility? If so, it could be in both directions, that either a high grade of flexibility makes the procedure too vague so that explanation is a must? Or, on the contrary, that too specific procedures are hard to interpret. Considering the fact that operators think that the local manual needs more explanation, there is most support for the latter answer. Second, do more specific procedures require more explanations because of their inflexibility or, is it a matter of language use? Third, how would explanations and flexibility affect the walls of the competence envelope, or rather how are they perceived today? Spoken in a metaphorical manner, does a need for more flexible rules imply that the envelope today is too small?
8 Conclusions

Based on observations and interviews that have been conducted, two important lessons have been learnt from this study: First, that the set of regulations at LFV is a part of a complex rule management system that ranges all the way from the organ of the United Nations ICAO, to the local air traffic service unit. Despite the fact that the operations manuals are the last products of an extensive transformation process possibilities to modify large parts of the content still remain. Second, that rule application is more than pure reading from the document of procedures and that LFV, besides from the formulation work with the operations manuals, can support their operators by improving some of the underlying functions of rule application.

The questions of issue have been answered through the following findings from this study and are summarized and presented here as recommendations:

- How are the operation manuals administrated in terms of constitution, revision, update and elimination?
- How do the operators perceive the content and the structure of the operations manuals?
- In what ways does the organization support the operator’s application of rules?

- **Participation in rule formulation**: LFV would need to express the structure of the current rule formulation that ranges over the international organs more clearly. In combination with clear channels in which rule-related proposals could be mediated, this would gain wanted participation of the operators in the rule formulation.

- **Learning**: Today the responsibility of the study of the national regulations is partly individual and partly institutional. What LFV would need to consider is to examine and decide where the responsibility for teaching the national rules will be and when this learning should take place?

- **Updates of the operations manuals**: Changes are not always appreciated or perceived as motivated among the operators. Therefore LFV should be careful modifying existing rules and to make sure that changes of the updates are well-motivated. Learning could be even more meaningful if it would be more focused on successful performance.
• **Common ground:** There are signs of low insight of different professions among the staff. LFV could consider to integrate their employees into each other’s work and making them aware of sub-goals within the system.

• **Physical structure of the set of regulations:** There is need for a renewal of the central operation manual that cannot be realized due to constrained resources. In order to support operators’ implementation of rules, the formulation of the manuals needs to be more prioritized.

• **Purpose with the operations manuals:** There might be different goals with the different collections of procedures they might have different purposes in combination with the fact that the operators also have different needs for the manuals. A further examination of this area could facilitate the distribution of rules and benefit the overall implementation of procedures.

• **Creativity and imagination:** The major part of the work of an operator treats the task of planning. LFV could, in order to support the operators with the ability to anticipate, show more support for imaginative thinking rather than historical events. A possibility would be to include this into the part of Proactive safety in the Safety Management System at LFV.

• **Flexibility in rules:** The operators perceive that there is less room for interpretations of the procedures today and request explanations and flexibility in the rules. LFV would need to examine exactly in what ways that flexibility is requested and how it could be realized in practice combined with possibilities to develop operators’ abilities to match the procedures to the context.
References


Appendix A: Interview guide 1

Snabb presentation av mig och syftet med intervjun och uppsatsen.
Informera om avkodning i rapporten samt inspeln av intervjun och rätten att avbryta.
Fråga om respondenten har frågor.

Bakgrund
Hur länge har du arbetat på LFV?
Vad har du för bakgrund innan du kom till LFV?
Berätta lite om ditt arbete, vilka huvudsakliga uppgifter har du?
Inom vilket regelverk har du utbildats på Sturup, internationella/nationella?
Hur upplever du att övergången mellan utbildning och ”riktig” tillämpning har fungerat? Finns det något stöd för att övergången ska gå så smidigt som möjlig?

Användning
Hur använder du drifthandböckerna ANS, ATS i ditt arbete?
Använder du någon drifthandbok/del oftare? Vid vilka tillfällen i så fall?
Hur ofta skulle du säga att du slår i någon av de olika handböckerna?
Tycker du att det finns förväntningar från ledningen/organisationen kring på vilket sätt dessa handböcker ska användas i arbetsmiljön?

Innehåll
Hur tycker du det är att hitta saker i handböckerna? (intranätet)
Hur tycker du att det är att läsa/tolka en regel?
Vad tycker du är de största fördelarna med drifthandböckerna?
Vad tycker du är de största nackdelarna med drifthandböckerna?
Finns det någon information som du saknar/tycker är överflödig i någon av böckerna, i så fall vad?
När drifthandböckerna uppdateras, hur får du då reda på vilka förändringar som gjorts?
Sett utifrån ett längre perspektiv, hur upplever du att drifthandböckerna har förändrats de sista 5-10 åren? Vad har blivit bättre och vad har blivit sämre?

Organisation
Anser du att det finns en diskussion kring handböckerna/regelverket på LFV (vilka deltar, vilka ämnen)?
Anser du att du har möjlighet att framföra åsikter om regelverket (hur)?
Vilken medverkan känner du att du har i utformningen av drifthandböckerna?
Känner du att du har ett förtroende/respekt för regelverket, eller har saker hänt som har urholkat respekten/förtroendet?
Den hjälp du får av gällande regelverk och regelverksfrågor, upplevs den som tillräcklig för att ni ska kunna leva upp till förväntningarna och utföra ert jobb?
Implementering

Uppstår det ofta situationer då flera regler måste handskas/tillämpas samtidigt?
Vad kan det finnas för orsaker till att en sådan situation uppstår?
Hur handskar man en sådan situation (stöd estratégiaer)?
Är det möjligt att kunna förutse en sådan situation?
Anser du dig få något stöd från handböckerna för att hantera en sådan situation?

Uppstår det situationer då en regel inte finns eller kan följas, och i så fall i vilka situationer? Ge gärna exempel!
Vad kan det finnas för orsaker till att en sådan situation uppstår?
Är det möjligt att kunna förutse en sådan situation?
Hur handskar man en sådan situation (stöd/strategier)?
Vad för slags följder kan en sådan situation få?
Anser du dig få något stöd från handböckerna för att hantera en sådan situation?

Avslutning

Är du nöjd med drifthandböckerna, och om inte - hur skulle du istället önska att de istället såg ut?
Känner du att det finns något ytterligare som du vill tillägga eller ändra/förklara? Någon aspekt som vi kanske har missat, som har kommit upp i efterhand?

TACKA!
Appendix B: Interview guide 2

Snabb presentation av mig och syftet med intervjun och uppsatsen. Informera om avkodning i rapporten samt inspeling av intervjun och rätten att avbryta. Fråga om respondenten har frågor.

Bakgrund
Vad har du för bakgrund innan du kom till LFV? Hur länge har du arbetat på LFV? Berätta lite om ditt arbete, vilka huvudsakliga uppgifter har du?

Användning
Vad har du för förväntningar på vilket sätt flygledarna ska använda/kunna drifthandböckerna? Skiljer dessa något mellan den centrala och lokala? Hur kompletterar lokal och central Dhb varandra (i skarpa lägen)?

Utformning av drifthandböckerna
Olika uppdragsgivare uppgifter:
EU - Transportstyrelsen - nedifrån) redogör för olika processer, skiljer sig åt? Genomgår reglerna någon process/omarbetning, vilka är inblandade i denna process? Hur går det till när de hamnar i handboken- OMA/SUPP? Vad händer med de regler som redan finns?

Vad skulle du säga det finns för för - och nackdelar med dagens utförande/hantering av regelverken? Några speciella delar av processen som fungerar mer eller mindre bra? Skulle du önska att processen såg annorlunda ut, och i så fall hur?

Förändringar
Som jag har förstått genomgår regelverket en hel del förändringar, vad ger upphov till förändringarna? Hur genomförs dessa förändringar? Genomgår reglerna någon process/omarbetning, vilka är inblandade i denna process? Borde vara med? Hur förmedlas dessa etc (pärmar,möten,intranät)?

Långt perspektiv:
Med hänsyn till de förändringar organisation och regelverk har genomgått, har det varit till det bättre eller sämre? Internationell påverkan för/nackdelar? Utbildningen i internationella reglerverk, hur har övergången till nationellt fungerat jmf tidigare (för/nack)?
**Innehåll**
Struktur, kapitel, sektioner, register
Tolkningar, hur mycket utrymme (bör/skall) ska finnas?
Känner du att du har koll på regelverket, en överblick samtliga böckers innehåll och var information kan hämtas?
Finns det specifika delar som du anser dig/folk ha (mer/mindre) bra koll på?
Finns det någon information som du saknar/tycker är överflödig i någon av böckerna, i så fall vad?
Vad är de största för/nackdelarna med drifthandböckerna?

**Organisation**
Vilka är det som deltar i diskussioner, syn på rv inom LFV? (förståelse för varandras arbete)

Uppifrån:
På vilket sätt kan ni påverka dessa krafter?
Vad för slags kontakt och hur upprätthålls den?
De förutsättningar ni har för utformningen, upplevs de som tillräckliga? Hur skulle det kunna bli bättre, vad fattas?
Upplever ni att ni kan ge flygledarna rätt förutsättningar för att de ska utföra sitt jobb på bästa vis?

Flygledarna:
Finns det möjlighet för operatörerna att framföra åsikter, och isf till vilka och hur förmedlas dessa (väg i kedjan)?
Skillnad central/lokal?
Rapportsystemet - synergi, DA, QA 3e?
Av vilka anledningar hör de av sig, vad tycker de tolkning, struktur etc?
Känner du att flygledarna har det ett förtroende/respekt för regelverket, eller har saker hänt som har urholkat respekten/förtroendet?

**Implementering**
I situationer då regelverket inte kan stödja flygledarna? (konflikter/”brott”) kan man underlättas dessa situationer genom ett ”bättre” regelverk, alternativa sätt?
Fördelning generella/strama regler?
Vilken roll spelar rapporteringssystemet i implementering vs regelverk?

**Avslutning**
Hur skulle du önska att regelverket skulle se ut? Förslag, tankar idéer?
Känner du att det finns något ytterligare som du vill tillägga eller ändra/förklara?
Någon aspekt som vi kanske har missat, som har kommit upp i efterhand?

**TACKA!**