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Resilience Engineering within ATM - Development, adaption, and application of the Resilience Analysis Grid (RAG)

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Abstract

Resilience Engineering has evolved during the recent century and could be a good complement to the prevailing ideas concerning safety within the air traffic industry. The concept of Resilience Engineering stresses the fact that in order to keep up the high standard of safety, there must be greater attention directed to the importance of being proactive, and to implement measures before dangerous situations arises.

The purpose of our work was to develop the Resilience Analysis Grid (RAG) to help LFV, the leading Air Navigation Service Provider in Sweden, to identify their ability to deal with disturbances and unexpected events. By testing our RAG on seven active air traffic controllers and operational managers, we were able to produce a final set of assertions, with a total number of 22 items, which LFV (or other similar organisations) can use as a foundation for future RAG studies.

As a first attempt we also rated the answers which gave us an opportunity to produce a star diagram, showing the relationship between the areas covered by the RAG. During the interviews we discovered that resilience is already today in many aspects a big part of the everyday work and that the RAG method can therefore be applicable in the industry with some modification. However, there are certain areas within LFV that we believe there is room for improvements. We believe that the RAG could serve as a helpful tool in identifying these areas as well as assisting LFV in their striving to remain one of the safest organisations in the world.

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Glossary

Naming conventions used in the thesis are stated below.

Air traffic management (ATM) is about the process, procedures and resources which come into play to make sure that aircraft are safely guided in the skies and on the ground.

Minimum Safe Altitude Warning (MSAW) is a ground-based safety net intended to warn the air traffic controller (ATCO) about the increased risk of controlled flight into terrain by generating, in a timely manner, an alert of aircraft proximity to terrain or obstacles.

Short Term Conflict Alert (STCA) is a ground-based safety net intended to assist the controller in preventing collision between aircraft by generating, in a timely manner, an alert of a potential or actual infringement of separation minima.

Surface Movement Radar (SMR) is radar equipment specifically designed to detect all principal features on the surface of an airport, including aircraft and vehicular traffic, and to present the entire image on a radar indicator console in the control tower.

Air Navigation Service Provider (ANSP) is an organisation responsible and authorised to provide air navigation services.

1 INTRODUCTION

The understanding of safety and how it is achieved has undergone a great deal of development during the last century. Within aviation, safety has for a long time been an integrated part of the everyday operations, with extensive regulation on both an international and national level. From being one of the most hazardous ways of transportation, it is nowadays considered as a very safe system, with a low rate of severe accidents per year. Traditionally, the way of improving safety has been to look at recent incidents and try to analyse what went wrong, in order to prevent it from happening again. For aviation, this means that there are few situations that are being investigated in order to understand safety, in relation to the total number of 'normal' situations that happen. If, for instance, the probability of two aircraft coming too close to each other is 1:10,000, then there will be 9,999 cases where the outcome will be normal (no separation loss). As it is today focus is only put at this single negative event, despite the fact that these happen far more seldom than the things that go right.

During the last decade a new discipline dealing with safety management has evolved, were this focus on the unsafe functioning is being questioned. This concept, called Resilience Engineering, argues that both failures and successes basically can be explained in the same way, and if we want to improve safety, we should not only try to reduce the number things that go wrong, but also try to increase the number of things that go right. The more likely it is that something goes right, the less likely it is that it goes wrong. In fact, it is much easier to increase the things that go right; we have so many more cases to study (everyday work). Resilience Engineering aims at making safety more proactive, a goal it shares with the aviation industry. The Air Traffic Management System (ATM) has already several proactive means of improving safety, e.g. several integrated safety nets, such as Minimum Safe Altitude Warning (MSAW) and Short Term Conflict Alert (STCA).

To assist organisations that wish to introduce the concept of Resilience Engineering as a part of their safety management work The Resilience Analysis Grid (RAG) was developed by Erik Hollnagel and is a methodology to measure how well an organisation is performing in the four main abilities of resilience, namely the ability to respond, monitor, anticipate and learn (described in chapter 2.4). The RAG is constructed as a questionnaire, consisting of four sets of questions, each set addressing one of the abilities. The questions are meant to be answered by personnel from the organisation according to a chosen rating scale to make it possible to produce a resilience profile (Hollnagel, 2011). Furthermore, the RAG is a helpful tool to identify what the strength and weaknesses are within the organisation, in order to know in which areas that focus need to be put in the future safety management work.

1.1 Purpose and objective

The objective of this thesis work was to develop the Resilience Analysis Grid (RAG) so that it could be used to identify resilience, with regards to which abilities the Swedish Civil Aviation Administration's (LFV) has to deal with disturbances and unplanned events. Our version of the RAG was tested on a reference group, to improve the usability of the methodology. As a result we present our final RAG version, consisting of 22 assertions that can be used as a foundation for future studies of resilience within the LFV organisation. Our RAG test also enabled us to create a resilience profile based on the answers from the participating entities,

which was the secondary purpose of our work.

Resilience Engineering, as a concept has not been a part of the traditional work done within aviation safety management. To our understanding this is the first time that anyone is examining resilience within the aviation industry with the use of the RAG methodology.

1.2 Methodology

The RAG is a relatively new methodology for determining the resilience of an organisation, and there are no previous examples relating to air traffic management that we could use as a foundation for further development. In order to be able to produce a useful result within this thesis timeframe we chose to introduce the RAG, adapt it to the field of ATM, as well as evaluate the methodology simultaneously. The developing process of this thesis is based on the concept of action research, which is characterised by being emergent, and having the nature of being cyclic in its structure (Dick, 2000). Furthermore, the client is involved as an active participant in the research process, providing feedback along the way. In figure 1, the steps in an action research cycle are outlined. For a detailed method description of our RAG developing process, see chapter 4.

Figure 1. Revised action research model (Rossouw, 2009)

1.3 Identified Delimitations

In order to obtain a usable result the RAG should be tested and applied several times during an extended period of time (Hollnagel et. al, 2011). Since this thesis is done during a limited period of time, with limited resources, we instead chose to conduct the RAG only once, targeting only the areas of which LFV is responsible for. The result will therefore not provide a complete picture, since there are several other agencies which also have a responsibility for the safety at the airport, e.g. the emergency response unit. By only basing the analysis on the answers we received from air traffic controllers and operational managers we also lack the information about what is being done higher up in the organisation, especially when it comes to anticipating future threats and opportunities.

1.4 Source Criticism

As a primary source we have used material, authored or co-authored by Dr. Erik Hollnagel, one of the creators behind the concept of Resilience Engineering, as well as the one who has developed the RAG methodology. We consider these sources to be very reliable, due to the fact that most of them have gone through the normal academic criticism before publication. Most of the other information used in our work was gathered from chosen organisations online web pages, such as LFV, ICAO and Boeing. These are also considered to be reliable and could be used to substantiate the theories used in this thesis.

1.5 Company Description – LFV

LFV is a Swedish Air Navigation Service Provider (ANSP) responsible for the safe, efficient and environmentally friendly air navigation service of civil and military aviation in Sweden. LFV strives to always be one step ahead to minimise risks. This approach means that they try to uncover weaknesses and risks before they become real problems. A systematic risk assessment is always done before introducing new systems or making changes in systems already in use. The risks they identify are handled and corrective action taken to bring them to an acceptable level before the change is introduced. LFV analyses trends and problem areas and take relevant measures where needed to continuously improve the level of safety (LFV 1 2010).

2 AVIATION SAFETY AND RESILIENCE ENGINEERING

In this chapter we review previous understandings and concepts of safety and risk management. First we give a brief summary of the view of safety and how it was achieved during the 20th century. After that we present how the traditional safety management and understanding of safety is today. Finally, we give an introduction to the field of Resilience Engineering and how it differs from previous understandings of safety, as well as a description of the four main abilities of resilience.

2.1 History of Safety Within Aviation

In the early years of aviation, air travel was considered as a very hazardous and risky mean of transportation. Why safety within aviation so often failed was explained by technological factors and technological malfunctions. Accidents were attributed to unreliable technical systems, such as the equipment on board the aircraft. Therefore, was the work for improving safety focused on making the technology more robust and trustworthy. This universal mind-set, that if we make sure that the technology works, then we will be safe, was valid until the late 1960s (ICAO, 2012, Hollnagel, 2008, Hollnagel et al, 2006).

In the beginning of the 1970s had technological improvements and enhancements to safety regulations significantly reduced the rate in which accidents happened. Over a decade, between the years 1959-1969, the accident rates within aviation had been reduced by close to 90 % (Boeing, 2013). However, the improvements in technology did not remove all of the negative outcomes. In fact it seemed that the relatively rapid technological advances had resulted in a new type of accidents, which could be explained by failure in the interaction between the technical system and its human operator. As many accident investigations came to the conclusion that the technology in itself had worked as intended, and that the root cause could be explained by ‘errors’ caused by the human operator, a new way of explaining accidents was introduced, called the human factor approach. With this approach humans were considered as the unreliable part of the system, and work needed to be done to help the human to understand and work with the system as intended. Safety management should therefore be directed at creating new, more comprehensive rules and procedures and at the same time make it easier for the pilots and air traffic controllers to follow them (ICAO, 2012, Hollnagel, 2010). This view, that an individual’s wrongdoing is the reason behind many major accidents is still today the conclusion of many accident investigations within the aviation industry (Sydsvenskan, 2011, The Guardian, 2012)

After the Chernobyl nuclear power plant and the Challenger space shuttle accidents in 1986, many argued that it is not enough to only look at technological or human failure when one try to find out why accidents happened. Organisational factors should also be added to the explanation formula. One must also try to understand the system in itself, and not look at each area individually (ICAO, 2012, Hollnagel, 2010).

2.2 Traditional Safety Management - Reducing the Unwanted Outcomes

Even though the understanding of what causes failures in systems have shifted during the last century, accidents have always been seen as result of a malfunction of one (or many) components in the system, either human or machine. With this understanding, the objective of an organisation's safety management work is to find the deficiencies in its system and then constrain or remove these, in order to make the system functional in as many situations as possible. This safety management approach, also referred to by Hollnagel (2012) as Safety-1, is most often based on a reactive way of dealing with safety issues. Safety is improved by identifying what have gone wrong, or by risk identification what could go wrong, and then try to eliminate the cause or control the identified risk. Both ways addresses safety issues after it has become a safety liability.

According to safety-I can safety only be achieved by preventing negative outcomes from happening, such as accidents or incidents, or at least by reducing their number to an acceptable level. The purpose of safety management is then to keep the number of negative outcomes as low as practicable possible (Hollnagel, 2012). The traditional definition of a safe organisation is one that operates with freedom from unacceptable risk (Hollnagel et.al, 2011). Within the aviation industry this definition of safety is very common. For example, does the International Civil Aviation Organisation (ICAO) define safety as:

Safety is the state in which the risk of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and risk management (ICAO, 2013).

In figure 2, the range of all possible outcomes in a system such as ATM are shown, where the x-axis show the likelihood of an outcome to happen, and the y-axis show the value of the outcome, ranging from negative to positive.

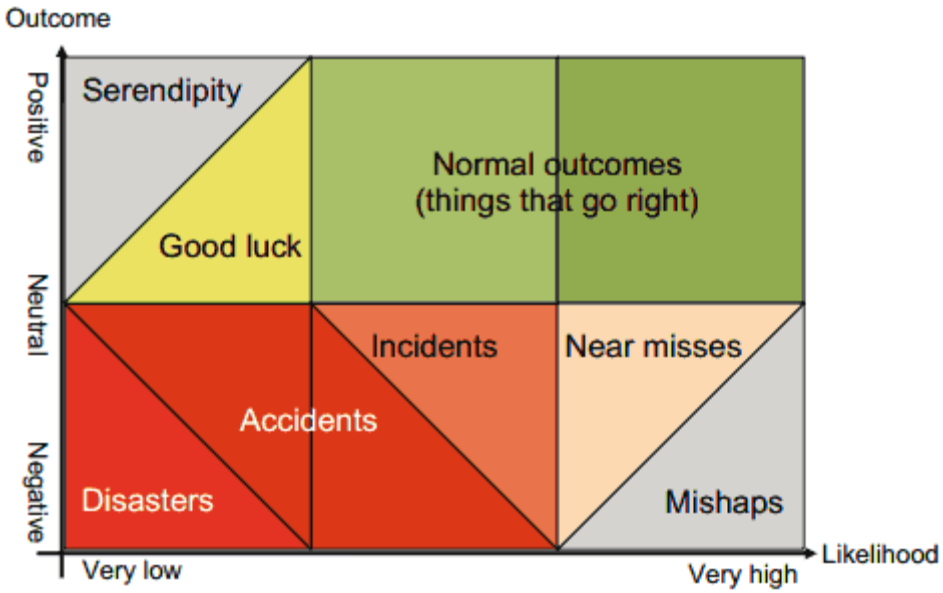

Figure 2. The possible range of outcomes within a system (Albrechtsen et al, 2010)

For stakeholders within the aviation industry the focus have been to reduce the occurrences of the red outcomes in the bottom-left part of the figure. This means that the focus of the safety efforts will almost always be focused on the thing that went wrong. It has almost been a widespread agreement between safety management personal that things can be learned by only studying the things that go wrong (Hollnagel, 2012). This complete focus on the things that goes wrong has also meant that safety is measured by the occurrence of negative outcomes, or rather the absence of negative outcomes. Both the European Aviation Safety Agency (EASA) and the Swedish Civil Aviation Administration (LFV) uses this method. According to EASA (2012) was the rate of inadequate separations between aircraft in European airspace 35 per Million flight hours for the year 2012, while LFV reports that the goal for 2012 of maximum 1,49 losses of separation per 100,000 flight hours was well met, the actual occurrence was 0,36 per 100 000 flight hours (LFV 2, 2012).

Safety-1 argues that advanced socio-technical systems, such as ATM, nowadays are basically safe in themselves. They are tested and behave as they are supposed to. They are also tractable, meaning that they are almost entirely understood (Hollnagel 2012). These systems have a high degree of reliability in terms of equipment, procedures and operations. The liabilities in these systems are instead considered to be the human performance variability, meaning the fact that people handle the same type of situations differently, and sometimes they do errors which result in negative outcomes. Physiological and psychological factors can have a great impact on the individual's performance which makes the human operator a very unreliable part of the system, because one cannot predict how humans will act in certain situations. This could for an example be how a pilot responds when a warning system is triggered in the cockpit, or an air traffic controller that does not follow the standard phraseology in certain situations. The safety management should aim towards making the work as standardised as possible, so that the overall system predictability increases. This is done by constraining the human performance variability with the use of e.g. procedures, safety barriers, and regulations (Hollnagel 2012).

With the traditional view of how system works there is also a difference between the normal state and the failed state of a system. The system is considered to be in a normal state if everything works as intended and the outcomes are positive, in the sense that the number of negative happenings is acceptable small. When normal operations are disrupted or impossible and the outcomes become negative, meaning something adverse has happened it is considered to be in a failed state. By dividing the system into two parts, based on if the outcomes are positive or negative, it is easier to fix the system when something goes wrong, because the things that happen when the system is in a failed state are different from those that happen when it is in a normal state. The goal for safety management is to maintain a normal state by preventing disruptions or disturbances, meaning keeping an organisation's operations from reaching a failed state (Hollnagel, 2008, Hollnagel, 2012).

2.3 Resilience Engineering – Increasing the Wanted Outcomes

Even though there has been a lot of development during the last century in how to explain accidents in order to make air travel safer, safety improvements have too often first been introduced first after a major incident or accident has occurred. The field of Resilience Engineering has evolved as a discipline during the last decade, and approaches safety and the way it can be achieved by looking at the system performance in general. It argues that all

types of systems are inherently imperfect and deeply conflicted. They always have to meet multiple opposing goals at the same time and always under the pressure of limited resources. It is only people who can hold together these systems and create safety through practice at all levels. Safety is therefore not the absence of something, but rather people's ability to recognise, adapt to, and absorb changes and disruptions (Hollnagel, 2011). Furthermore, Resilience Engineering argues that it is necessary to focus on the things that go right (successes) as well as the things that go wrong (failures) in order to be able to improve the safety in a system (or an organisation).

The term resilience is old and can be found in areas such as psychology, physiology, and ecology. It can for instance be used to describe the pace at which an ecosystem is able to recover after e.g. a fire, or a child's ability to cope with a difficult childhood. What is common is that resilience is the ability to recover from and/or resist different types of disturbances (Begon, 1990). Within Resilience Engineering, resilience is considered as:

Resilience is the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions.
(EUROCONTROL, 2009, Hollnagel, 2012, Hollnagel, 2011).

This definition includes the prevailing definition of safety since sustaining required operation is synonymous with 'freedom from unacceptable risks' (Hollnagel et al, 2011). But while safety management of today often only focuses on how to cope with failures, Resilience Engineering explores ways to enhance the way in which organisations are prepared to cope with the unexpected, both prior to, during and following a failure (Hansson, 2008). This makes this discipline a more proactive way of working with safety.

Resilience Engineering argues that the things that go wrong and the things that go right are the result of the same underlying processes and should therefore be explained in a similar way. Failure happens because people need to adjust their actions in order to cope with the underspecification of the real world, rather than from a breakdown or malfunctioning of normal system functioning (Hollnagel, 2011). People must be able to adjust their actions according to the needs of the specific situation, and the system should have an ability to provide means so that these adjustments will result in a successful outcome. Therefore, safety should instead be defined as 'the ability to succeed under varying conditions' (Hollnagel, 2010).

According to Hollnagel (2011) have the technological developments in advanced social-technological systems, such as ATM, meant that these systems have become so complex, that traditional safety management is now insufficient. Resilience Engineering argues that performance variability is inevitable a part of these systems and must be there in order to function properly. Every day people find themselves in situations which are not described in procedures or regulations, and are therefore forced to make actions based on their experience and ability to adapt to new situations. For instance is an air traffic controller often faced with situations which are not described in procedures or instructions, in terms of telling them exactly what do to and in what order. In these situations it is necessary for the air traffic controller to have the ability to adjust his or hers actions to be able to solve the situation. In fact, by following the regulations to the letter would make the work in some situations both inefficient and unsafe (EUROCONTROL, 2009). Resilience Engineering sees the human as

having a dynamic role, with the ability to adjust its actions to various situations, and therefore in a proactive way intervene in situations before they become a reality with negative outcome. The system should provide means for the human operator to adjust and improvise when unexpected situations occurs. Therefore cannot negative outcomes or failures be prevented by eliminating or constraining performance variability since that would also affect the desired positive outcomes (Hollnagel, 2012).

Furthermore safety needs to be redefined from 'avoiding things that go wrong' to 'ensuring that everything goes right'. Resilience Engineering questions the approach where focus is solely put on the negative and asks the question why not look at things that go right? If this is done, safety and safety management will be based on understanding the things that go right, which basically is an understanding of the everyday work (Hollnagel, 2012). An illustration of the frequency of possible outcomes is shown in figure 3. This is to show how many things more an organisation will have the opportunity to study if focus is shifted from the negative to the positive range of outcomes.

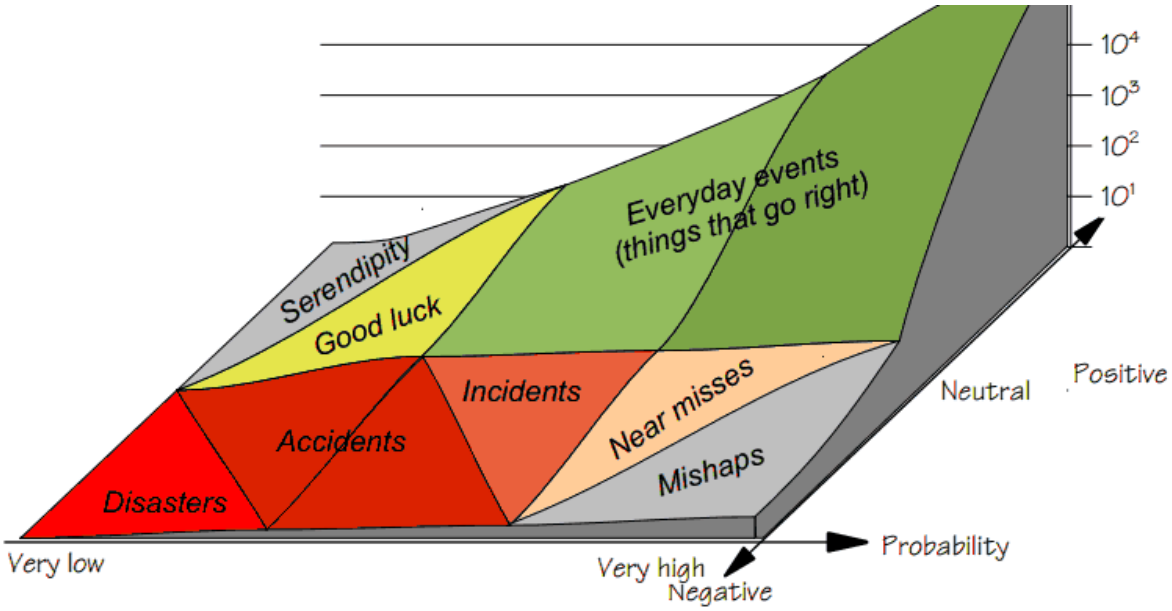

Figure 3. The frequency of outcomes of ultra-safe systems, such as ATM (Hollnagel, 2011)

As the figure demonstrates, as well as both of the examples in chapter 2.2 about the occurrence of inadequate separations, things that go right happen far more often than things that go wrong. So when focusing on successes, an understanding of everyday work will become easier. If more things go right, it will also consequently lead to a reduction of the things that goes wrong (Hollnagel, 2012).

Within safety management it is important to foresee what could happen, with acceptable certainty, and prevent it with the appropriate means. A vital part to accomplish this is to understand how the system works in regards of how the surroundings develops and changes and how everything is connected. A way is to look for patterns and relations across events instead of on the causes of individual events. A big challenge is to know when a prediction might be incorrect or imprecise. Being proactive for large-scale events is easier, partly since they normally develop slowly and more regular than small-scale events, making the indicators more easily perceived and are therefore easier to respond to (Hollnagel, 2012).

2.4 Safety-1 VS Resilience Engineering

Even though the progress in safety management have made flying one of the safest way to travel, there is a strong consensus that safety is something that always need to be improved, otherwise there is a risk that it will stagnate and/or deteriorate (LFV 3, 2013). Resilience Engineering aims to making safety management more proactive and should not be seen as a total replacement of the prevailing safety management approach. Rather should one act as a complement to the other. The difference between the two is schematically shown in table 1.

	Traditional Safety Management (Safety-I)	Resilience Engineering
Definition of safety	Freedom from unacceptable risk	Ability to succeed under varying conditions
Understanding of safety	Systems are tractable and performance conditions can be completely specified	Systems are intractable, and performance conditions are always underspecified
Explanations of accidents	Accidents are caused by failures and malfunctions	Things basically happen in the same way, regardless of the outcome
View of the human factor	Liability	Resource
safety management principle	Reactive, respond when something happens	Proactive, try to anticipate developments and events
Aim for safety management	Learn from mistakes and calculate the probability of future failure	Improve the capability to cope with the complexity of the present and the future

Table 1. Juxtaposing of traditional safety management and Resilience Engineering (Hollnagel, 2012, Hollnagel, 2011)

2.5 The Elements of Resilience

In order for an organisation to be considered as resilient, its system must be able function under both expected and unexpected conditions. Resilience Engineering divides this ability into what is called 'The Four Cornerstones of Resilience'. These four abilities are presented below.

2.5.1 The Ability to Respond - Actual

The first ability addresses the organisations ability to respond to usual and unusual disturbances and opportunities. The basis is to know how and when to respond, and eventually have the right means to implement the response. In order to know what action is suitable for the disturbance or opportunity, there must be a predetermined set of events available for usage (Dekker, 2008). To determine that the events are still useful and relevant, and also to create more effective responses, it is important to know the underlying cause why they are actually included. If the underlying cause is not understood this may result in a few issues:

- While preparing for events that may not be relevant the opportunity to prepare for events that actually are relevant decreases.
- Formulating the responses becomes more difficult and therefore lowers the effectiveness of the responses.
- Maintaining the readiness might be more difficult to motivate in terms of resources since it is a cost in one way or another (staffing, knowledge, material) to always be ready to respond.

(Hollnagel, 2010, Dekker, 2008)

2.5.2 The Ability to Monitor - Critical

The second ability addresses the organisations ability to monitor/observe what might happen in the short-term future. In order to do that, one must know what to look for, which could be described as indicators, as they indicate what may happen before it happens. These indicators must both have high validity and reliability in order to be useful (Dekker, 2008). The most difficult part is to how to define these indicators, which probably is unique for every area it is used in. E.g. in a completely technological system, the easiest and probably most reliable way is to choose indicators which addresses the critical processes of the system. In the air traffic management industry an indicator could be bad weather approaching, and thus making it more complicating to manage the traffic.

Since it is impossible to have indicators for every possible disturbance and opportunity it is important to be aware which indicators that could have the most affect of the organisations operations. It must also be clearly stated how often and on what basis these indicators shall be updated (Dekker, 2008). This is important since otherwise the indicators will only be updated when something unexpected has occurred, making the update of the indicators hasty and insufficient. The difference is between what you also might call leading and lagging indicators, where leading is the proactive and lagging is the reactive, hence making the leading more desirable. (Hollnagel, 2010, Dekker, 2008)

2.5.3 The Ability to Anticipate - Potential

Foreseeing into the future, looking in a long term perspective of how developments could affect the organisation could be a description of this third ability. The basic idea of this ability is to discover possible events in the future, internal as well as external, that may harm or negatively affect the organisation, and therefore need some sort of action to be taken in order to be prevented. The road to foreseeing the future is rather difficult since it requires some kind of imagination from whoever is trying to foresee it (Dekker, 2008**).** There is also a resource issue involved and it can many times be hard to motivate any changes based on predictions of something that could possibly happen far into the future (Dekker, 2008). The organisation cannot only limit itself to simply look at what happens within the company, a much wider view of the matter must be used. Looking at what changes in the surrounding environment, such as demands and resources must also be considered. A tool for making this possible is to have a defined understanding/model of the organisation as well as one dealing with the organisation's surroundings (Hollnagel, 2010).

2.5.4 The Ability to Learn - Factual

The last ability addresses the organisations ability to learn from the past, including both failures as well as successes. The path to a successful learning process depends on what is being learned from the past and if this information is used to change the existing behaviour or

the way that the work is done. In order to actually learn from past events, emphasis is on what happened and even more important why it happened. One mistake that can be done, is to go '*the easy way'*, and learn what is '*easy to learn'* and neglect what is actually '*meaningful to learn'*. There are three guidelines that should be used to ensure that learning is meaningful (Hollnagel 2010):

1. There must be frequent opportunities to learn, meaning having situations where something can be learned to occur with a high frequency. This is why it is easier to learn from ordinary events rather than learning from rare events.
2. The situations must be similar enough to allow simplifications to be made so the situations can be compared to each other.
3. It must be possible to confirm that the right lessons have been learned from the events. To verify if something has been learned it is easy to check if there has been any change in the behaviour, if nothing has changed, probably nothing has been learned.

Since everything costs in one way or another and all resources are limited it is important that an organisation's focus is limited to relevant events. To sort what is relevant and irrelevant can be tricky, since the relevance is often based on what data has been collected and how it has been analysed. When looking at how the learning process should be made, a thing to ask is; "When and how do the learning take place?" (Dekker, 2008). There are two options, either the learning process is event driven or it is something that takes place on a recurring, i.e. the learning process is initiated after an accident or similar or the organisation learns from normal events "right doings". The latter is what Resilience Engineering argues for (Hollnagel, 2010, Dekker, 2008).

2.5.5 The Interrelationship Between the Four Abilities

For an organisation to be considered as resilient, it must be able to pay attention to the actual, the critical, the potential, and the factual. If an organisation lacks any of these abilities, it is not considered as a resilient organisation (Hollnagel, 2010, Hollnagel, 2011). The importance on how well the organisation performs on each of the abilities, and the proper balance between the four abilities depends on what kind of operations the organisation does. For example is it very important for information technology companies to be able to anticipate future costumer demand, because it often takes many years of development before a new product can be introduced on the market. For emergency rooms, on the other hand, the ability to respond might be considered as the most important ability. Another example could be a company trading with stocks and funds were anticipating the future and monitoring the present is more important than learning from previous mistakes or successes, since the industry is constantly changing. The relationship between the abilities is visualised in figure 4.

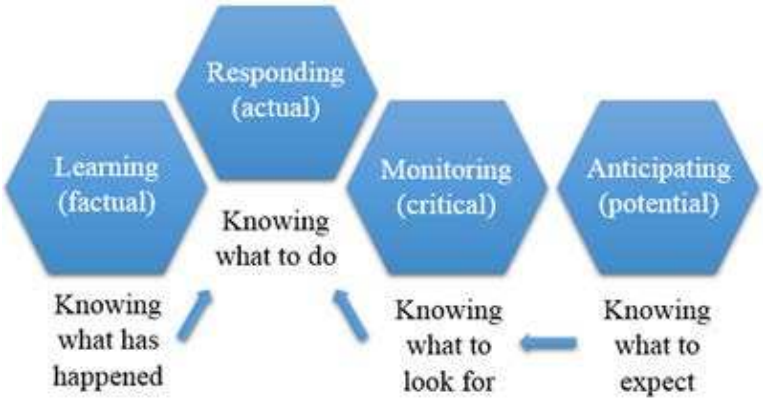

Figure 4. How the abilities are related to each other (Hollnagel, 2010)

3 THE RESILIENCE ANALYSIS GRID (RAG)

In this chapter we describe the purpose behind the RAG, and how it can be constructed and used as a part of an organisation's safety management work.

3.1 The Need for a Resilience Measurement Tool

When stakeholders within the air traffic industry measure safety, emphasis is most often put on how many times an unwanted outcome has happened. When LFV evaluates how they have met their safety targets they do it by counting the number of incidents, accidents, separation loss between aircraft, air space infringements etc. compared with the targets set for the period examined (LFV 2, 2012). Since resilience refers to something that an organisation does (its ability to adjust the way things are done), rather than to something that an organisation has (e.g. number of incidents/accidents), it cannot be measured by counting specific outcomes, such as accidents or incidents (Hollnagel, 2011, Hollnagel, 2010).

The realisation that previous safety measurement tools cannot be used in a resilience context, has led to a number of newly developed methods aimed at providing organisations with tools to help them to improve their resilience capabilities. One method is the Resilience Analysis Grid (RAG) developed by Erik Hollnagel, which is a question based tool that assesses the four capabilities of resilience. The RAG is designed to be used as a tool to support safety management in its effort to improve the resilience of the organisation.

3.2 Creating Questions and Using a Rating Scale

For the RAG to be useful as a safety management tool it is important that it is customized to address the specific kind of operations of the selected organisation. The questions should be tailor made so that it is possible to determine which qualities the organisation has concerning the four abilities. Therefore one cannot use the same RAG questions for different organisations. By considering the content of each of the abilities, the questions should be specific enough to make it possible to use the result as an input for future improvements. But they should also be general enough to make it possible to compile a fair resilience profile. The questions in table 2 can be used as a starting point before creating more detailed questions for every capability.

• **Respond**: How ready is the organisation to respond and how able is it to respond when something unexpected happens?
• **Monitor**: How well is the organisation able to detect changes to work conditions that may affect the organisation's ability to carry out current or intended operations?
• **Anticipate**: How large an effort does the organisation put into what may happen in the future? Is anticipation a strategic concern?
• **Learn**: How well does the organisation make use of formal and informal opportunities to learn from what happened in the past?

Table 2. General questionnaire addressing the four abilities (Hollnagel, 2010).

After the questions are finalised they should be answered by people within the organisation. Various approaches could be used such as one-on-one interviews, group discussions involving

persons from the same work place, or an online survey. To get a useful result from the RAG the answers from the interviewees must be rated according to a common terminology. Hollnagel (2011) suggests using the Likert scale described in table 3 when rating the questions.

Excellent – The organisation on the whole exceed the criteria addressed by the specific question
Satisfactory – The organisation fully meets all reasonable criteria addressed by the specific question
Acceptable – The organisation meets the nominal criteria addressed by the specific question
Unacceptable – The organisation does not meet the nominal criteria addressed by the specific question
Deficient – There is insufficient capability to meet the criteria addressed by the specific question

Table 3. Rating terminology (Hollnagel, 2011)

The formulation of the questions can either be as normal questions, similar to those presented in table 2, where the interviewee can elaborate on the questions, or they could be formulated as assertions. The decision should depend on if the purpose is to make fewer but in-depth interviews, or if you wish to receive multiply answers without the need to know so much information of the background to the answers. If you use assertions, this will shorten the time needed to finish the RAG. In either case, rewriting the questions is easily done to fit the need for the individual organisation.

3.3 The RAG Output

After the RAG has been answered according to the common rating scale, on way of presenting the result is to use a star diagram. In the example presented in figure 4, the four abilities are rated wholesale where each axis is marked using the five rating categories described above. By assigning each rating category with a numerical value (1 to 5), and combining the ratings for each subset of questions into one, this is a simple approach if you want to present an overall resilience profile of the organisation. What also is important is to decide upon an appropriate weighting system for the questions. If every question is considered to be of the same importance, then the star diagram will show the mean value of the ratings for each of the abilities. If this is not the case, and there are certain questions considered more important for the organisation to perform well on then others, this must be clearly stated if you use this approach (Hollnagel, 2011).

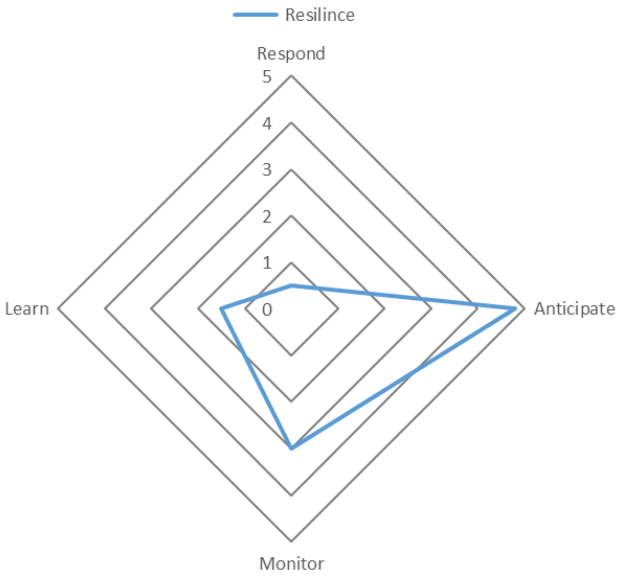

Figure 5. Star chart example

The combined star chart in figure 5 can also be complemented by adding four additional star diagrams, one representing each of the abilities. This will provide the organisation with an additional, more explicit understanding on how they are performing on each of the individual questions. Together with a summary, or a short account of what the interviewees has stated on each of the questions, the result of the RAG will give the organisation a good foundation to make decisions on how to improve the organisation's resilience.

3.4 Using the RAG to Improve Resilience

The purpose of the RAG is to identify how the organisation in a normal state is able to handle different situations, and not to evaluate the way it dealt with recent accidents or incidents (Hollnagel, 2010). It is therefore important that it is being used to follow how the resilience develops over time. This is done by conducting the RAG several times during a long period of time, using the same RAG questions for every occasion (Hollnagel, 2011).

The first time the RAG is used will provide the organisation with a 'snapshot' of its resilience performance. Based on this information the organisation may introduce some changes in the areas in which they want to improve. This could for example be installing new equipment, emergency training, or changing its procedures when dealing with certain situations. By comparing the results from numerous occasions, the RAG gives the organisation both information on how the newly introduced changes has affected the organisation, as well as information about in what direction the other 'not-changed' domains are moving. If, for instance, the RAG show that the rating for the ability to respond has decreased between two occasions, the organisation can do an extensive analysis of this ability, and hopefully identify the reasons behind the decrease and impose changes before it reaches an unacceptable level. Some changes have perhaps not lead to the intended result, and should be analysed further, while others meant that the organisation made a great improvement in its resilience performance.

The RAG does not provide any explicit assistance in determining how well an organisation must perform in the four abilities in order to be considered as resilient. Instead it gives its user a well-founded estimation on how well the organisation performs, comparable between

several occasions. It is then up to the organisation itself to decide upon which ability needs to be better and how to reach this goal.

4 DEVELOPING A RAG FOR LFV

In this chapter we present how our processes for developing the RAG for LFV proceeded. Each step can also be followed in figure 6.

4.1 Initial Set of Assertions

After reviewing the existing literature on Resilience and especially the Resilience Analysis Grid (RAG) we created an initial set of assertions, primarily based on the suggestions made by Hollnagel (2011) in the final chapter of *Resilience Engineering in Practice*. This first step in the development process resulted in a list consisting of 35 assertions, where nine were dealing with the ability to respond, four with the ability to monitor, ten with the ability to anticipate, and twelve dealing with the ability to learn. These assertions were the ones that we believed could be used in an air traffic management context and were meant to be answered according to the Likert scale proposed by Hollnagel (2011), Excellent - Satisfactory - Acceptable - Unacceptable - Deficient. We then translated the assertions into Swedish for the purpose of making them useful in in an assessment with Swedish air traffic management personnel. We also added follow-up questions in order to give the interviewee possibility to elaborate on certain questions. The full list of our initial set of assertions is presented in Appendix A.

4.2 Adapting and Culling the Assertions for Our Purpose

After the initial phase of developing the assertions we asked our mentor at LFV to evaluate our work so far. He has great experience when it comes to safety management in practice, as well as an understanding of the concept of Resilience Engineering. In consultation with him we decided to rephrase the assertions into questions as well as to provide more examples in the different areas. This we did because we wanted to 'force' the interviewee to take a position on the different questions. Otherwise, if you only use the Likert scale there is a risk that the answers only will be given in the middle-part of the scale, without any understanding of what their answer is based upon. Furthermore, one cannot really know that the interviewee have understood in which context the assertions are made to reflect.

By rephrasing the assertions into questions along with providing examples the chance of getting a useful answer increases, which enables us to do a better selection for our final RAG compilation. However, the possibility of rating the answers gets more difficult compared to if we would use the suggested method by Hollnagel (2011), where the answers should be rated by the interviewee according to the Likert scale. We did this choice due to the fact that the primary purpose of this thesis was to develop the RAG, while the secondary purpose was to provide an example of an LFV resilience profile. The RAG version we used when we conducted the interviews is presented in Appendix B.

4.3 Conducting the interviews to test our RAG

Together with our mentor at LFV we decided to test our version of the RAG on four different airports operated by LFV, namely the ATS units at Malmö Airport, Ängelholm Airport, Ljungbyhed Airport, and Kristianstad Airport. We wanted to see if our questions were

formulated in a way so that they were understood correctly and also to find if some could be removed but still receive the same amount of information.

The RAG was implemented as interviews with one person responsible for ATM, and with one air traffic controller at each site. All of the interviewees had an active air traffic controller license, and several years of experience in their job. Of the interviewees were two women and five men, in their late twenties to late fifties. In total was the interviews conducted with seven persons, as Ängelholm and Ljungbyhed have the same Operational Manager. The primary data source was noted material, with audio recording to fall back on when necessary. Each of the interview sessions started with a brief introduction to the purpose of this thesis as well as an introduction to the field of Resilience Engineering. The meaning of each of the four abilities was given with the associated questions.

We found that some of the questions were given duplicating answers, and could therefore be merged into one. There were also some questions that were very hard to explain the meaning of, if you did not have any previous knowledge about the concept of Resilience Engineering. These were therefore removed from the list, which gave us a total of 26 questions along with examples left. These questions along with the answers we received are given in Appendix C.

4.4 Making the Final Selection and Rating the Answers

After conducting the interviews we received another expert evaluation from our mentor at LFV. He wanted us to reduce the number of questions a bit, removing some questions which he believed were dealing with the same area. Together we also decided to present the result as assertions, all of which reflect one important quality which LFV should strive to fulfil. These lead to a final set of 22 assertions which are presented in chapter 5.

At the same time as we made our final selection of assertions we also compiled and rated the answers. This work is presented in chapter 6 and are based on the 26 questions that we received answers on in our interviews. We also created a star diagram based on our interpretation of the answers. A motivation behind every individual rating we made on each of the questions is presented in Appendix D. Lastly, we evaluated our work, where we explain what lessons we have learnt during this process, as well as what might be important to have in mind for future users of the RAG methodology.

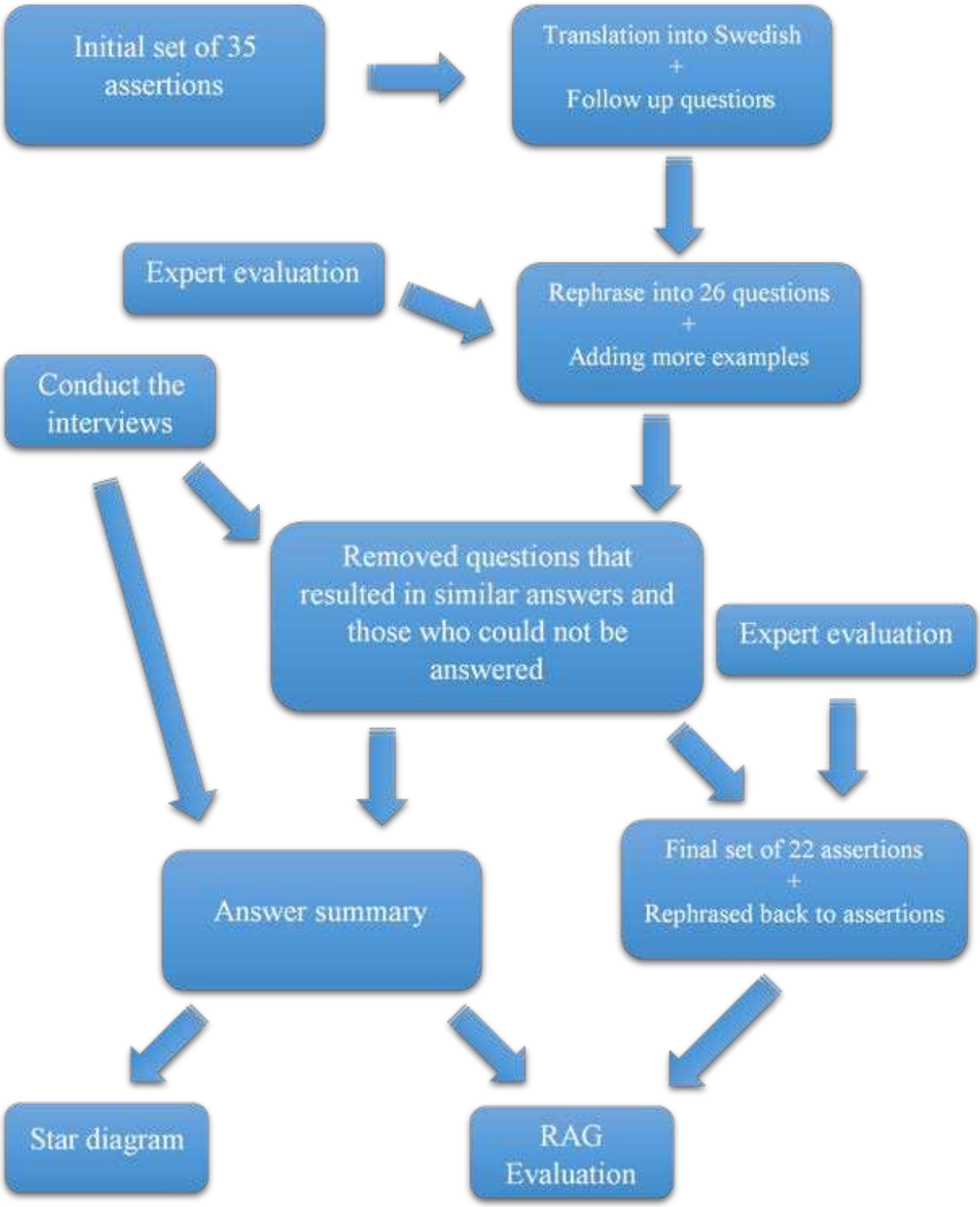

Figure 6. Our method of developing the RAG, visualised in a flow chart

5 THE FINAL RAG

In this chapter we present the result of our thesis. We first present our final RAG assertions. These are the ones that have been tested on all of the units, and that we believe can be used as a foundation for future Resilience assessment within LFV.

5.1 The Ability to Respond

The assertions made about the ability to respond addresses the possibility to act on disturbances and opportunities as discussed in chapter 2.4.1. To be able to know what kind of response that is suitable for each situation they have to be predefined in some way. In the air traffic management industry this is what is being defined in the local- and central operational manual. The important part is to determine the validity of the operational handbooks and if they are adapted to the unit. The assertions are focusing on how well the operational manual functions at the unit and also what is being done to maintain the ability to respond.
The areas we addressed were;

- If the predefined methods and procedures are adapted to fit the operations at the aerodrome
- How often the operational manual is updated to confirm its validity
- If the operational manual is consistent with how the job is being performed
- How easy it is to understand the methods and procedures
- If the manual is flexible and provides an opportunity to interpret yourself
- If there are resources enough to meet the demands of the manual
- If there is any actions made to ensure that the overall ability to respond is maintained.

If these questions is addressed then they also covers the knowledge of the underlying cause which is discussed in chapter 2.4.1.

1. The working methods and procedures described in the operation manual are adapted to fit the kind of operations of this unit.
2. The operational manual is continuously updated to reflect the current operations of this unit.
3. The procedures and methods in the operational manual comply with my view of how the work should be carried out.
4. The operation manual is easy to understand and can be put in an operational context.
5. The operational manual allows the individual operator to adjust their actions as he/she deems appropriate.
6. There are enough resources available (staff, technology) to meet the requirements of the operational manual.
7. There is measures being taken to ensure that the ability to respond is maintained, in the form of simulator practices, theoretical tests and systems checks and updates etc.

Table 4. Assertions dealing with the ability to respond

5.2 The Ability to Monitor

The purpose of the assertions in the ability to monitor is to address how well the unit are able to foresee what might happen in short-term and if the aids available to foresee what might

happen, so called indicators, are sufficient to do so. It might be difficult to actually define an indicator and make the interviewee come up with own definitions of what could be an indicator. An indicator could for example be the radar or the flight progress board indicating that an increase in traffic is approaching, or as simple as a yawn indicating fatigue, which might lead to loss of focus. The main purpose is to know what to look for (indicators) and, just like in the ability to respond, determine the validity in these indicators. Finally is it important to know what (if any) are more important than others.

1. There are clear indicators of what could have an impact on the units' ability to accomplish current or planned operations.
2. These indicators are reliable.
3. The knowledge of what kind of situations that may lead to problems is good.
4. The ability to monitor is sufficient.

Table 5. Assertions dealing with the ability to monitor.

5.3 The Ability to Anticipate

During the interviews we found that most of the questions dealing with the ability to anticipate could not be answered due to the fact that these were areas dealt with by people higher up in the organisation. Since our RAG was conducted with air traffic controllers and lower management, the focus of our final set of assertions therefore became to ensure that possible threats and opportunities are being spread to all concerned members of the organisation from the headquarter, i.e. that the organisation has a good vertical information flow, and making sure that risk awareness is an important part of the unit's organisational culture. The assertions address what could happen in the long term, affecting the organisation and the unit. This is important in order to establish that those affected by the future really has a perception of the risks/opportunities that exist in the organisation and in the environment.

1. The expectations/prognosis about the future is spread to all members of the unit.
2. Future threats are well defined, and spread to all employees.
3. Risk awareness is a big part of this unit's organisational culture.

Table 6. Assertions dealing with the ability to anticipate

5.4 The Ability to Learn

Within LFV reports are written when an irregularity happens, such a technical failure or a separation loss between aircraft. These reports are the main method used when the organisation want to learn from previous mistakes. Our assertions therefore address the reporting process and its functioning. To ensure that meaningful learning is achieved from the reports we follow the three guidelines from chapter 2.4.4. We also included assertions that aim to identify what is being done to ensure to also learn from things that go right. The areas we addressed were;

- Are the employees motivated to write reports and hence increases the amount of reports?
- Are there enough resources to write reports as often as one would like?
- Is it clear what types of occurrences that needs to be reported?
- Are there established procedures to ensure that lessons are implemented?

- Is the learning process continuously or is it solely done after an incident or similar?
- Is learning from "right doings" performed? Or is it just in a correcting manner and learning from "wrong doings"?
- Does some kind of exchange in learning take place with other units? Thus making it possible to determine if the learning is based on relevant events or not.

1. It is clearly established what should be reported.
2. Submitted reports are being investigated sufficiently.
3. There are good responses/feedback on submitted reports.
4. The time from the submission of a report until a response is acceptable.
5. There are sufficient resources to write reports.
6. The employees are being motivated to write reports.
7. Lessons are learned from things that go right, as well as things that go wrong.
8. We meet with personnel from other units to learn from each other.

Table 7. Assertions dealing with the ability to learn

6 THE RESILIENCE OF LFV

In this chapter we present a summary of the answers we received during the interviews, along with an assessment of each of the abilities. Each subchapter begins with an answer summary followed by a motivation for every rating. The combined ratings have made it possible for us to construct a resilience profile, which is presented in the final part of this chapter as a star diagram, visualising the relation between the different abilities. A more thorough motivation for every question on why the specific value is chosen is presented in Appendix D, and again, this is based on the authors' interpretation of the answers.

It is important to clarify that in order to make a proper analysis of the resilience, the assessment should be based on assertions, ranked according to some scale of value, e.g. Excellent - Satisfactory - Acceptable - Unacceptable - Deficient - Missing. The detailed assessment should also be done by persons who have a good understanding of how the organisation operates (Hollnagel, 2010). Since our primarily task was to produce a RAG questionnaire that can be used in the future to assess resilience, we did not ask the interviewees to take a stand according to a certain scale. Instead we asked them to describe how they believed that the organisation is performing and what improvements they think should be done for the future.

6.1 Respond

According to the answers we received about the questions relating to the operational manual the main view is that its content covers the operational activities very well. All of the respondents wish to have an operational manual that gives room for the individual controller to be innovative and adapt their actions to the specific situation. The trend is that for each year the manual gets more extensive, and covers more areas with greater detail. This can pose a threat to the air traffic controller's ability to be creative and flexible. However, the overall view is that some of the content in the manual are open for interpretations which makes it possible to be flexible. The big issue, according to almost all of the interviewees is the way in which new rules and regulations are implemented. They feel that in recent years have there been a number of changes in the operational handbook that have been implemented too fast and hard to understand the reason behind the change. These changes have affected the daily work to a great extent. One example is the change in required separation minima when vectoring an aircraft close to uncontrolled airspace. This distance was changed from 1 nautical mile (NM) to 2 NM. For small terminal areas, such as Ängelholm and Kristianstad, this meant a quite big decrease in airspace that you are allowed to vector aircraft in. Another example is the introduction of a rule that strictly prohibits the air traffic controllers to clear aircraft into uncontrolled airspace. Earlier, there was a Swedish exception from this ICAO rule, allowing the air traffic controllers to clear arriving and departing aircraft into uncontrolled airspace in specific situations, e.g. if this meant a better flow of traffic. The opinion of both the air traffic controllers and the operational managers are that changes such as these sometimes happen too fast and in the wrong order. The interviewees had wished that these change processes had begun with a change of the design and size of the airspace first, and then introduced the regulation changes afterwards.

When it comes to the available resources, such as staff and their competence, the general view is that these are more than well meet the requirements of the operational handbook. To ensure

that the ability to respond is upheld every air traffic controller need to do a theoretical tests and have one work shift with an assessor behind, making sure that current rules and regulations are being followed. There is also a simulator day each year were the staff practice different situations, e.g. emergencies and high traffic load.

6.1.1 Rating of the Ability to Respond

Overall is the ability to respond at the units is very well, probably because the profession and industry requires it to be and the operators are thoroughly trained to respond and act quickly and efficiently. However there are improvements to be made and the ability to respond can be better. A common respond to the manual was:

> "We have a checklist with unusual situations, and how to react on these. However it feels like they are not always thought through."

This response, amongst others, meant that the newly introduced procedures and legislations often felt like they were not entirely suitable for that specific unit. Many thought that this was an attempt to adapt more to the international procedures and legislations produced by Eurocontrol.

In order to present the result of the ability in the star diagram we rated the answers given (appendix D) which gave the ability to respond a mean value of 3, 67.

6.2 Monitor

For normal situations, such as traffic increases, there are several indicators in what may affect the units' ability to carry out its intended operations. With the use of tools, such as the radar and Flight Progress Board (FPB), the air traffic controller can predict the number of, and what type of traffic that will show up in the near future. Information about activities considered to be outside of the normal operations is most often available well in advance. This could for example be the military that wants to use a part of the units' airspace for practice purposes, or a school flight that wishes to practice touch-and-go landings. These are occurrences that are known to the units well in advance.

There are some indicators that several of the interviewees would like to see be introduced, such as weather radar and a system which allow you to check the flight plans for the coming hours. At Malmö Sturup they have for a long time asked for a Surface Movement Radar which would make it possible to see the aircraft in situations where there is low visibility. At the same time they realise that it is impossible to detect all of what is about to happen, and all new tools comes with an economical cost.

6.2.1 Rating of the Ability to Monitor

There are well defined indicators in the different units but they can be improved and more can be introduced. The only way to have a complete set of indicators is to have a pure technological system, where all indicators can be defined. The indicators that are available are not really reliable, since they often are based actions performed by humans (aircraft, planned events) or Mother Nature (weather). There are improvements to make in order to make the

ability to monitor more efficient, however it is a cost issue, and difficult to motivate its necessity.

The air traffic management profession is much about handling unexpected situations and being able to act efficiently. Adding more tools would benefit most controllers but they are however not dependent on them and a usual response was:

> "Not knowing what could happen next makes the job more exciting, and is a reason why it's so fun"

It is almost always a matter of cost and resources to implement new procedures and technology to improve this ability, which the controllers understand. Our rating of the ability gave us mean value of 3, 0 which would be neither good nor bad, and therefore has a good opportunity for improvement but however is not urgent. The individual rating for each question is presented in Appendix D.

6.3 Anticipate

All of the respondents said that the work for evaluating future threats and opportunities is something that is being done higher up in the organisation. Furthermore, they are not aware of how this vision looks for the future. The information is not being communicated to the units, at least not in a formal way. If an individual air traffic controller is interested they think that they can retrieve the information from the intranet, but this is something none of the responders have done yet. This makes it hard to determine exactly what is being done and what the organisation believes that the future may look like. However, they believe that when it comes to the implementation of new regulations, these have many times happened too fast. As one respondent told us, often you only have one month to review the new regulation before it is being implemented. This implementation process can according to many of the responders definitely be improved.

6.3.1 Rating of the Ability to Anticipate

This ability should be addressed to other employees than the ones interviewed, hence a perhaps misleading value. However the threats and possibilities are not well spread in the organisation, only major discussion subjects like procurements are known of but it seems to be done by the involved employees on their own. A response retrieved from many respondents was

> "We are not evaluating possible threats locally, but I suppose it's being done higher up in the organisation."

This response indicates, as mentioned before, that the information concerning an evaluation of possible threats and opportunities is not being spread in the organisation. Therefore was the rating of the ability set to 1, 5, it could have been missing also, but there was no way of distributing the information and hence the rating.

6.4 Learn

The overall reporting system is according to the interviewees very good. The air traffic controllers think that they are being motivated to report disturbances and occurrences. This

belief is also shared among the operational managers. It is the operational managers who collect the reports as well as the one who distributes the analysed result to the rest of the staff. All of the units have a 'take part' binder where feedback from filed reports which are considered to be useful for everyone to take part of. The main view is that the reports are being investigated enough, however some think that the time it takes to receive feedback from a filed report can be too long. Also there are some who believes that the feedback could be better and less difficult to read.

When it comes to learning from the things that go right, all of the responders believe that this is something that takes place as a part of the ATS meetings or as informal talks between colleagues. However, there are no formal activities or any systematized approach that aims towards making the learning a continuing process. Many of the interviewees see it as a part of the job to share one's knowledge about successes as well as failures to others. This is especially important if you are one of the elder members, with a lot of experience from different situations.

Finally, it is very seldom that the ATS units meet with other ATS units in order to share knowledge and talk about certain situations. This was something that happened much more often in the past, but is now something that has a lower priority, probably due to economic savings. The only interaction between the units, face to face, is when the operational managers of the different units have their annual meetings.

6.4.1 Rating of the Ability to Learn

The learning process is well implemented in the organisation, continuous learning as well as reactive learning after an incident or similar. The reporting system is very good, easy to understand, and reports are being investigated enough. Yet it still lacks some abilities on feedback and the time to receive the feedback. There are possibilities to enhance the learning but overall is the ability to learn well designed within the organisation. An answer retrieved that symbolizes a general way of no formal way of learning was:

> "When we are working two at the same time we often talk about different situations, however there is no formal way of learning from successes."

This statement indicates that those controllers who are working together in pairs have the possibility to learn in a greater extent from successes rather than those who work alone. Since an exchange in knowledge and experience is carried out continuously during the working period. We rated this ability with 4.2 since there are a good learning from past events, however to increase the rating there should be a formal way of learning from successes and a possibility for everyone to have access to past events.

6.5 Result Presented in a Star Diagram

In order to show how the RAG could be used to measure resilience and how this could be presented in a star diagram, we have on our own, as an example, also interpreted the answers and assessed them accordingly. To simplify we chose to weigh the questions equally, thus making the star diagram to represent the associated questions mean value.

In figure 6 it is possible to see the relationship between the different abilities, and where they are graded according to the Likert scale (Excellent - Satisfactory - Acceptable - Unacceptable - Deficient - Missing) where 5 is Excellent and 1 is Deficient. The star diagram shows that the abilities respond and learn are good but can be improved, where monitor is neither good nor bad, and finally the ability to anticipate which is not sufficient. This means that system could be safe in the short term but are however not considered as resilient (Hollnagel, 2011). The star diagram does not simply measure the resilience but is a way of visualising the relationship between the abilities. It is not possible to have a predetermined balance which defines if the resilience is good or bad within the organisation, since this differs from industry to industry. Our personal opinion is that the most important ability for the ATM business is respond. This is the ability to handle the unexpected as well as the expected on regular basis and to always be flexible enough to take actions whenever necessary to maintain required safety.

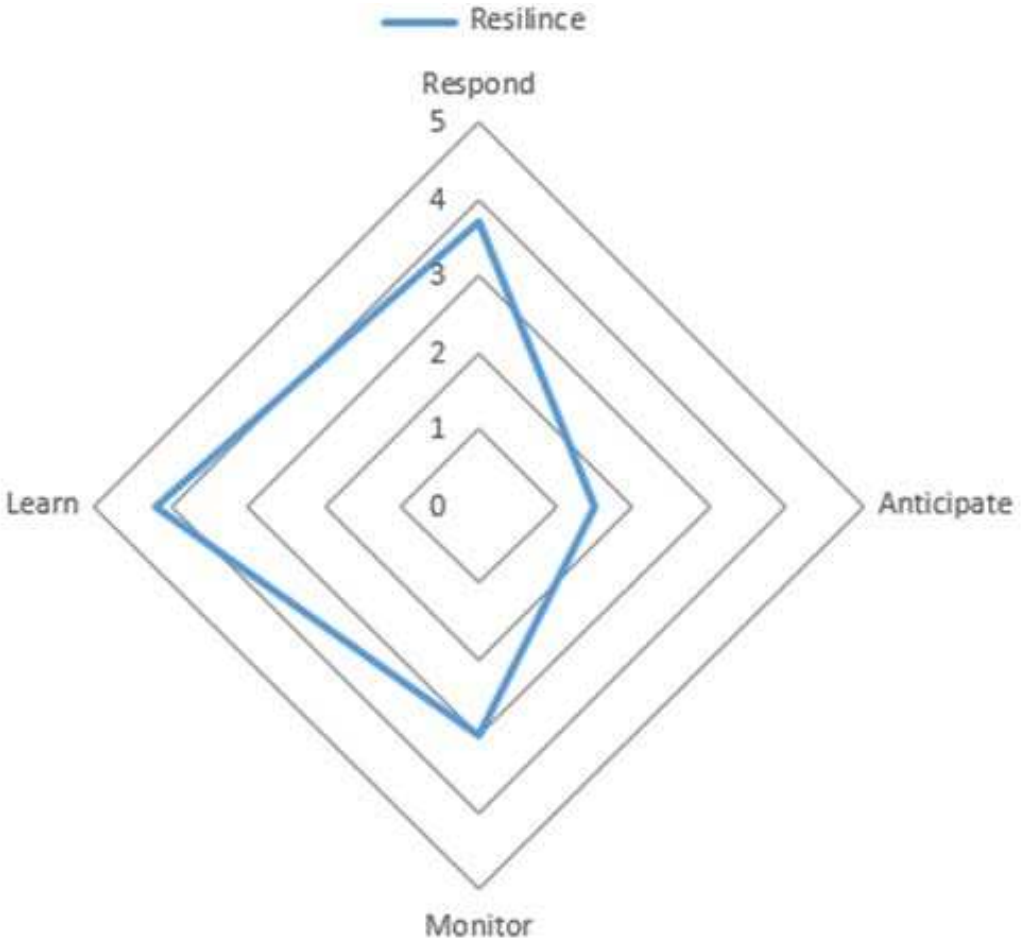

Figure 7. The resilience of the units assessed, presented in a star diagram

7 EVALUATION OF OUR RAG APPROACH

In this thesis we have adapted the original version of the RAG so that it can be used on air traffic controllers and lower management. By conducting interviews with persons who more or less only works with the daily operations have given us a great deal of information about the unit's ability to respond and learn. However, when we asked questions about how they work to anticipate future threats and opportunities, the overwhelming answer was that this is something being done higher up in the organisation. Because of this, many of the assertions dealing with anticipate were excluded from the final list. Instead the focus of our assertions is on how well the organisation shares this knowledge to its employees.

In order to make the RAG analysis as useful as possible and fulfill its purpose, we think that it is very important to include personnel on all levels within the organisation. If people responsible for the safety management higher up in the organisation would be involved in the RAG, would in our opinion lead to a more accurate result of how the organisation as a whole performs on the four capabilities.

When evaluating the assertions and rating them according to the Likert scale we believe that one should strive to have an equal number of questions for every capability. Also, with every additional question you reduce the risk of getting a misleading result. In our final set of assertions we only have 4 and 3 items dealing with the abilities of monitor and anticipate. This could be too small of a number to receive a useful result from the RAG, since misunderstanding only one of these assertions would falsify the result to a great extent. If instead e.g. ten assertions where included for every capability, one misinterpretation would not have the same effect on the end result. For the RAG to be useful it is of course also necessary to receive truthful answers. The risk of participants wanting to praise their own work to the skies as well as the risk of certain participants venting their anger towards the unit or organisation might be a problem. By involving a greater number of participants would reduce this risk considerably.

In our test run of the RAG we as interviewers did the evaluation of the answers. In order to get a more accurate and valuable RAG output an experienced controller/supervisor or safety management expert should be present during the rating of the answers if this method intends to be used. The rating of the ability to anticipate could be done by a person responsible for LFV's strategic work. However, then comes always the a risk of that person is being too self-opinionated to the organisation which in that case would lead to an "excellent" rating in all cases, this issue is however addressed in the next chapter.

Our final opinion is that there are two different approaches on how the RAG can be used in the future. The main difference between the approaches is whether to use the material as questions or assertions, providing two different ways of conducting the RAG and assessing the answers. The formal way, developed by Hollnagel is by using assertions. The other way is by conducting interviews, like we did, to get more of a discussion with the participants. There are advantages and disadvantages with both methods;

Using Assertions

Advantages

- The RAG can be distributed with a web-based form, making it more like a survey which several units can participate in simultaneously to an almost negligible cost.
- No expertise needed when assessing the result, because the responders do the rating themselves.
- Easy to make a summary of the answers and present the result in a star diagram

Disadvantages

- No certainty of the participants understanding of the assertions.
- Greater risk of misinterpretation.
- No possibility to provide examples or additional explanations.

Using Questions

Advantages

- A more discussion based interview may lead to more detailed answers.
- Constantly assessing the questions making it possible to review and update them to be more accurate.
- With expertise available during the interview examples and explanations can be given in order to make sure the interviewees really understand

Disadvantages

- Resource-intensive to conduct long interviews several times at different locations.
- Expertise required during the interviews and when assessing the result.

8 CONCLUSION

As mentioned in previous chapter, we strongly suggest including an experienced air traffic controller or supervisor in the rating process in order to make the process of assessing the answers better. We do not possess that kind of experience and are therefore not equally suitable rating the abilities and to define what abilities LFV need to improve. As already stated are the final questions developed in this thesis meant to be a basis for future resilience research. However, our questions cover all of the abilities and can be applied to other units as assertions, and with proper answers (Likert scale) also be put into a star diagram showing the relationship between the abilities. As mentioned in chapter 7, there should be an equal amount of assertions/questions in order to get a more fair rating when presenting in a star diagram. If no more questions is added or if the question basis is not equal this may be solved by adding more value to those questions which are underrepresented, however this is a mathematical issue to solve which is being left to the future RAG users.

Another interesting aspect that might be valuable to investigate is if the results varies a lot if they are being assessed by the interviewees themselves (assertions method) compared to if an expert would assess the answers (questions method). Perhaps the difference would be insignificant and therefore making the method with the questions useless. It could also lead to a huge variety in the answer-material making it very interesting factor when choosing which method that should be used and motivating why it has been chosen. This could also appear in a result showing that according to the operators everything seems perfect and nothing can be improved (exaggerated) but according to the expert/supervisor there is a lot of improvement to be made, or vice versa.

9 LFV'S FUTURE USE OF THE RAG

For the future work, we suggest that LFV start by identifying which key elements of each of the abilities that they believe are especially important. This could for example be making the design of the operational handbook so that it easy to find information, making sure that no changes in rules or regulations happens to fast, or that LFV as an organisation should give formal room provide time and opportunity for the air traffic controllers to learn from each other. LFV could then reformulate and complement our set of assertions to cover each of their identified key areas. The next step is to decide what type of answer that will result in which rating category according to the Likert Scale.

If LFV decide to use the 'questions method' when conducting the RAG, we suggest that the assessment is being done by someone who are not directly working with the areas that the RAG is meant to examine. This could be an external safety management person or someone within the organisation that is not directly involved in the everyday decisions. If they use the 'assertion' method we suggest that LFV give the people that are supposed to answer a short introduction of Resilience Engineering, as well as to the purpose of RAG. This we believe will increase the chances that the participants will give as full, truthful answers as possible that also conforms to the way in which the organisation performs in reality.

After determining which RAG method to use, assertions or questions, LFV should finally decide on the weighting of the different items. If its decided that all items truly represents an important ability that LFV should possess, then it is simple to go ahead and create a star diagram to show the rest of the organisation how the work for being a more resilient organisation progresses. For the authors, it would be very interesting to see in what direction LFV are moving, due to the fact that we hopefully will become a part of the organisation as future air traffic controllers.

10 REFERENCES

Albrechtsen, E, Hollnagel E & Tveiten, K (2010). *Resilience Engineering and Integrated Operations in the Petroleum Industry*, [www] http://www.sintef.no/upload/Teknologi_og_samfunn/Sikkerhet%20og%20p%C3%A5litelighet/Rapporter/Resilience%20Engineering%20and%20Integrated%20Operations%20in%20the%20Petroleum%20Industry.pdf Received 2013-11-22

Begon, M, Harper, J.L, Townsend, C (1990). *Ecology: individuals, populations and communities*. Boston: Blackwell Scientific.

Boeing (2013). *Statistical Summary of Commercial Jet Airplane Accidents, Worldwide Operations (1959-2012).* [www] http://www.boeing.com/news/techissues/pdf/statsum.pdf Received 2013-10-22

Dekker, S, Hollnagel, E, Woods, D & Cook, R (2008). *Resilience Engineering: New directions for measuring and maintaining safety in complex systems* [www] https://www.msb.se/Upload/Kunskapsbank/Forskningsrapporter/Slutrapporter/2009%20Resilience%20Engineering%20New%20directions%20for%20measuring%20and%20maintaining%20safety%20in%20complex%20systems.pdf Received 2013-11-02

Dick, B (2000). *A beginner's guide to action research.* [www] http://www.uq.net.au/action_research/arp/guide.html Received 2013-11-20

EASA (2012). *Annual Safety Review 2012*. [www] http://www.skybrary.aero/bookshelf/books/2300.pdf Received 2013-11-05

EUROCONTROL (2009). *A White Paper on Resilience Engineering for ATM* [www]. http://www.eurocontrol.int/eec/gallery/content/public/document/other/conference/2009/safety_r_and_d_Munich/Resilience_engineering.pdf Received 2013-10-12

Hansson, L & Herrera, I (2008). *Applying the Resilience Concept in Practice: A case study from the oil and gas industry*. SINTEF, [www] http://www.sintef.no/upload/Teknologi_og_samfunn/Smartere%20sammen/Dokumenter/ESREL%20paper%202008%20v%203.pdf Received 2013-11-02

Hollnagel, E, Woods, D. & Leveson, N (2006). *Resilience engineering: Concepts and precepts.* Aldershot, UK: Ashgate

Hollnagel, E (2010). *An introduction to the Resilience Analysis grid (RAG),* Sustainable Transformation: Building a Resilient organization, Toronto Canada

Hollnagel, E (2011). (Slides). *Resilience Engineering and Safety Management,* [www] http://www.arbeidshygiene.nl/~uploads/text/file/2011-01-20%20Erik%20Hollnagel.pdf Received 2013-10-20

Hollnagel, E, Pariés, J & Woods. D (2011). *Resilience Engineering in Practice: A Guidebook*, Aldershot, UK; Ashgate

Hollnagel, E (2012). *A Tale of Two Safeties*, [www] http://www.resilienthealthcare.net/A_tale_of_two_safeties.pdf Received 2013-11-02

Hollnagel, E (2013). (Slides). *The Resilience Analysis Grid (RAG)*, [www] http://www.uni-graz.at/isap13/ISAP13_Hollnagel_The%20four%20resilience%20abilities.pdf Received 2013-11-03

ICAO (2013). *Doc 9859, Safety Management Manual, Third Edition*, [www] http://www.icao.int/safety/SafetyManagement/Documents/Doc.9859.3rd%20Edition.alltext.en.pdf Received 2013-11-04

Kristianstad (2013). *Fakta om Kristianstad Österlen Airport*, [www] http://www.kidairport.com/fakta Received 2013-11-13

LFV 1 (2010). *LFV's ledningsystem*, [www] http://www.lfv.se/sv/Flygsakerhet/LFVs-ledningssystem/ Received 2013-11-12

LFV 2 (2012). *LFV och flygsäkerheten*, [www] http://www.lfv.se/Global/press/Dokumentbank/T13-256_Flygs%C3%A4kerhet-2012_ver4.pdf Received 2013-11-20

LFV 3 (2013). *LFVs Flygsäkerhetsarbete*, [www] http://www.lfv.se/sv/Om-oss1/LFV-luftrum-och-flygsakerhet/LFVs-flygsakerhetsarbete/ Received 2013-11-20

Rossouw, D (2009). *Educators as actions researchers: some key considerations.* http://www.scielo.org.za/scielo.php?pid=S0256-01002009000100001&script=sci_arttext Received 2013-11-20

Sydsvenskan (2011). *Mänskliga faktorn bakom flygkraschen*, [www] http://www.sydsvenskan.se/sport/ishockey/mansklig-faktor-bakom-krasch/ Received 2013-11-18

The Guardian (2012). *Air France crash ruling: pilots 'lost control'*, [www] *http://www.theguardian.com/world/2012/jul/05/air-france-crash-ruling-pilots* Received 2013-11-18

Transportstyrelsen 1. *Trafikstatistik kvartal 1-4/2012*, [www] http://www.transportstyrelsen.se/Global/Publikationer/Luftfart/Trafikstatistik-2012_Q_1.pdf http://www.transportstyrelsen.se/Global/Publikationer/Luftfart/Trafikstatistik-2012-Q-2.pdf http://www.transportstyrelsen.se/Global/Publikationer/Luftfart/Trafikstatistik-2012_Q_3.pdf http://www.transportstyrelsen.se/Global/Publikationer/Luftfart/Trafikstatistik-2012_Q_4.pdf Received 2013-11-13

Transportstyrelsen 2 (2013). *Trafikstatistik svenska flygplatser 2012*, [www] http://www.transportstyrelsen.se/Global/Luftfart/Statistik_och_analys/Land_122012.pdf Received 2013-11-15

11 APPENDIX A - FIRST SELECTION OF ASSERTIONS

Förmågan att svara

1. Det finns metoder/procedurer för hur man ska agera vid olika situationer.
   1.1. Dessa metoder/procedurer, tar upp de onormala händelser som kan inträffa på denna enhet.
   1.2. Är det någon situation du saknar? någon situation som du anser inte borde vara med?

2. Det är klarlagt varför vilka händelser/situationer är med, respektive varför andra inte är med.
   2.1. Baseras metoderna/procedurerna på tradition, lagar/föreskrifter, erfarenhet, expertis, riskanalys, någon typ av organisationsstandard (inom LFV för alla torn)?
   2.2. Listan baseras på rätt input.

3. Metoderna/procedurerna uppdateras tillräckligt ofta för att spegla den verksamhet som bedrivs på flygplatsen.
   3.1. Det finns regler/riktlinjer för hur de skall uppdateras (förbestämt eller vid behov).
   3.2. Vilka grunder uppdateras de (e.g. efter incidenter/olyckor eller någon annan form av statistik)?

4. Det framgår tydligt när metoderna/procedurerna skall användas och när en speciell handling skall genomföras av operatören.

5. De åtgärder som skall vidtas enligt metoderna/procedurerna är lämpliga/tillräckliga för de situationer de hänvisar till.
   5.1. Vad baseras åtgärderna på?

6. Det finns tillräckligt utrymme för den enskilda operatören att frånse/lägga till åtgärder som han/hon anser vara lämpliga.

7. Det finns tillräckliga resurser (människor, material, kompetens) tillgängliga för att åtgärderna skall kunna genomföras.
   7.1. Vid behov, hur lång tid tar det innan extra flygledare är på plats?
   7.2. Vid behov, hur lång tid tar det innan extern räddningspersonal är på plats?

8. Det finns tillräckliga resurser för att säkerställa att förmågan att svara upprätthålls.
   8.1. Hur säkerställs det att beredskapen och förmågan att svara upprätthålls?

9. Åtgärder kan genomföras inom utsatt tidsram.
   9.1. Hur lång tid tar det för att kalla in extra resurser (flygledare, CISM)?

Förmågan att övervaka

10. Det finns möjlighet att se indikatorer som kan påverka de dagliga operationerna eller nödsituationer.
    10.1. Hur förskaffar man sig information om dessa indikatorer?
    10.2. Hur visar sig dessa indikatorer?
    10.3. Är dessa indikatorer pålitliga?

10.4. Är indikatorerna lätta att tolka?

11. Det finns tydliga indikatorer(instruktioner) för när en åtgärd behövs.
    11.1. Hur förskaffar man sig information om dessa åtgärder?

12. Det finns (tydliga) prestationskrav i form av säkerhets och effektivitetsmål.
    12.1. Hur följs dessa krav upp?
    12.2. Är dessa krav är rimliga?

13. Hur kan förmågan att övervaka förbättras?
    13.1. Vad är fördelarna och vad är nackdelarna?

Förmågan att förutse

14. Enheten arbetar med att utvärdera framtida hot och möjligheter.
    14.1. Hur ofta, på vilket sätt?

15. Utvärderingarna sker regelbundet.

16. Det finns expertis tillgänglig för att utföra utvärderingarna.
    16.1. Utförs de av organisationen eller externt?

17. Prognoser om framtiden förmedlas till alla parter inom organisationen.

18. Det finns en framtidsbild/modell utformad om vad man kan förvänta sig i framtiden.
    18.1. Är antaganden om framtiden tydligt formulerad?
    18.2. Baseras framtida hot/möjligheter på en formulerad modell eller är det sunt förnuft som gäller?

19. Enhetens tidshorisont när det gäller att förutse framtida möjligheter och hot är tillräckligt lång.

20. Det finns en definition av risk, i form vad man anses vara en acceptabel risk respektive oacceptabel.
    20.1. Vad grundar sig denna gräns på?

21. Framtida hot är väl definierade, och spridda till enhetens personal.
    21.1. Vilka är dessa, och hur kommer de att utvecklas i framtiden?

22. Framtida möjligheter är väl definierade, och spridda inom enheten.
    22.1. Av vilken karaktär, och hur kommer dessa att utvecklas?

23. Riskmedvetenhet är en stor del av organisationskulturen.

Förmågan att lära

24. Det är tydligt klarlagt vilka typer av händelser som skall rapporteras.

25. Alla rapporter gås igenom och analyseras.
    25.1. Varför utreds vissa medan andra inte?

26. Vi försöker läras oss av det som går rätt (det dagliga arbetet) såväl som från saker som går fel (misstag, incidenter).

27. Lärandet inom enheten sker kontinuerligt, och inte bara när en incident/olycka har inträffat.

28. Hur går rapporteringsprocessen till? Vem samlar in information och analyserar?

29. Personalen har genomfört utbildning på hur man fyller i rapporter.

30. Enheten förser individen med de rätta resurserna när rapporter skall fyllas i.

31. Tiden till att en rapport lämnas in till att man får ta del av det analyserade resultatet är inte för lång.
    31.1. Vilka får ta del av incidentrapporten, individen, gruppen eller hela organisationen?
    31.2. Vem har ansvaret för att se till att erfarenheter sprids för lärande till den övriga organisationen?

32. Det finns tillräckligt med resurser (tid, kompetens, personal) tillgängligt för att lära sig.
    32.1. Vilka då (individuell och organisationsnivå)?

33. Det finns fastställda procedurer för att säkerställa att lärdomar från tidigare händelser verkligen implementeras i verksamheten.
    33.1. Hur fastställs dessa? (nytt regelverk, procedurer, normer, via träning, instruktioner, omorganisationer).

34. Det finns specificerat vem som har ansvaret att lärandet av tidigare händelser verkligen genomförs.
    34.1. Vad görs för att inte glömma bort dessa erfarenheter, uppföljningen?

35. Det finns möjlighet, om så önskas, att undersöka tidigare rapporterade händelser.
    35.1. Hur? internt system där alla rapporter ligger uppe?

36. Denna enhet samarbetar med andra torn/kontrollcentraler för att lära av varandra.
    36.1. Hur?

12 APPENDIX B RAG VERSION USED WHEN CONDUCTING THE INTERVIEWS (EXAMPLES SHOWED IN CURSIVE)

Förmågan att svara

1. Tycker du att de metoder/procedurer som finns beskrivna i den centrala/lokala drifthandboken tar upp relevanta händelser som kan inträffa på denna enhet?
   1.1. Är det någon situation du saknar? någon situation som du anser inte borde vara med?
   Situationer som ofta uppkommer men inte finns med i listan eller situationer som orimligt kan hända.
   1.2. Vad baseras de metoder/procedurer som finns beskrivna på?
   Tradition, lagar/föreskrifter, erfarenhet, expertis, riskanalys, någon typ av organisationsstandard (inom LFV för alla torn)?

2. Överensstämmer handboken med hur arbetet sköts i verkligheten?

3. Tycker du att metoderna/procedurerna uppdateras tillräckligt ofta för att spegla den verksamhet som bedrivs på flygplatsen?

4. Tycker du att metoderna/procedurerna uppdateras för sällan/ för ofta?
   4.1. Finns regler/riktlinjer för hur de skall uppdateras (förbestämt eller vid behov).
   Efter incidenter/olyckor eller görs regelbundet?

5. Tycker du att handboken är utformad på ett sätt som gör att den är enkel att tolka, lättförstådd? *T.ex. om du läser ett avsnitt ur den, framgår det tydligt hur du ska agera för att följa det som står där.*

6. Tycker du att de åtgärder som är beskrivna i handboken är tillräckliga för de situationer de hänvisar till? *T.ex. om handboken säger att man ska göra en viss åtgärd vid en viss situation, räcker det för att lösa situationen eller måste man utöver det som är beskrivit göra fler åtgärder för att lösa situationen.*

7. Tycker du att det finns tillräckligt utrymme för den enskilda operatören att anpassa sina åtgärder som han/hon anser vara lämpliga?
   Används listan mer som ett stöd eller följs den till punkt och pricka.

8. Tycker du att det finns tillräckligt med resurser för att möta de krav som handboken ställer?
   Vid ökning av trafik, finns det möjlighet att kalla in extra personal. Om en olycka inträffar, finns det tid att sköta övrig trafik samtidigt som olyckan hanteras.

9. Vid behov, hur lång tid tar det innan extra flygledare är på plats?

10. Tycker du att det görs tillräckligt för säkerställa att förmågan att svara upprätthålls.
Simulationer, övningar, temadagar? Tester och kontroll av system (t.ex. kommunikationsmedel) kunskaps-kapacitetsprov.

Förmågan att övervaka

11. Tycker du att det finns tydliga indikatorer på vad som kan påverka enhetens förmåga att utföra nuvarande eller planerade operationer.
T.ex. Finns där möjlighet att upptäcka väder som kan försvåra operationer (t.ex. väderradar). Finns där möjlighet att förutspå ökad trafik, (t.ex. FPB). Planeras t.e.x militärövningar, systemunderhåll, underhåll av utrustning i tillräcklig tid innan de ska genomföras och distribueras denna information till er.
    11.1. Är dessa indikatorer pålitliga, kan de förbättras?
    Hur pålitliga är t.ex. väderradar, FPB, om det planeras en militärövning/systemunderhåll etc, utförs de alltid/ofta på utsatt tid.

12. Anser du att det finns tydliga indikatorer för när en åtgärd behövs?
T.ex. Om det är ett oväder som kommer påverka trafiken avsevärt så skall man t.ex. begränsa trafik eller kalla in extra personal. Eller om man ser i sitt FPB att trafiken kommer att öka avsevärt och måste därför sätta in en ny position etc. Samma sak med t.ex. militärövningar, systemunderhåll.

13. Hur vet man vilka typ av situationer som det krävs åtgärder för att hantera? *Finns det skrivet i handboken, får man reda på det genom briefings, är det sunt förnuft som gäller. T.ex. om militären belägger ett område som gör det svårt att hantera trafiken, ska man då öppna en ny position eller dyl.*

14. Anser du att förmågan att övervaka kan förbättras?
T.ex. köpa ny utrustning/nya system som gör det enklare att förutspå väderförhållanden, ökad trafik/mer komplex trafik.
Om ja
    14.1. Ge exempel.
    14.2. Vad är fördelarna och vad är nackdelarna?
    Kostnader?

Förmågan att förutse

15. Arbetar ni inom enheten med att utvärdera framtida hot och möjligheter, specifikt för denna flygplats?
*T.ex. Hur eventuella trafik-ökningar/minskningar komma påverka er**?** Vad framtida nya lagar/regler kommer att innebära för er? Hur ändrade konkurrensförutsättningar kommer påverka er? Om nya tekniska hjälpmedel, eller förändringar i det tekniska systemet skulle hjälpa er?*
Om ja
    15.1. Hur ofta, på vilket sätt?
    15.2. Vem utför värderingarna?

16. Tycker du att framtida hot finns definierade, och spridda till enhetens personal?
T.ex. Vad som händer om trafiken minskar avsevärt. Framtida systemförändringar, finns

det en risk i övergångsprocessen?

17. Tycker du att framtida möjligheter finns definierade, och spridda till enhetens personal?
T.ex. Vad som händer om trafiken ökar avsevärt. Framtida systemförändringar (t.ex. markradar), möjlighet för förbättring av trafikledandet?

18. Tycker du att riskmedvetenhet är en stor del av organisationskulturen?
Medveten om vad som utgör risker i vissa situationer/ vilka situationer som utgör risker?

Förmågan att lära

19. Tycker du att det är tydligt klarlagt vilka typer av händelser som skall rapporteras?
T.ex., incidenter, havererade utrustning.

20. Vilka får ta del av den inlämnade rapporten?
Individen, gruppen eller hela organisationen?

21. Anser du att rapporter gås igenom och utreds i tillräcklig utsträckning?
    21.1. Utreds vissa medan andra inte?
    21.2. Prioriteras utredningar olika, enligt någon skala?

22. Hur går rapporteringsprocessen till? Vem samlar in information och analyserar?

23. Lär ni er av det som går rätt (det dagliga arbetet) såväl som från saker som går fel (misstag och incidenter)?
    23.1. På vilket sätt?
    23.2. Tycker du att det finns tillräckligt med resurser avsatt för att lära sig båda sakerna?

24. Anser du att lärandet inom enheten sker kontinuerligt, eller endast när en incident/olycka har inträffat, eller både och?
Sker det utbildning över tid, refresher-utbildning, i vilken utsträckning?

25. Anser du att personalen har genomfört tillräcklig utbildning på hur man fyller i rapporter?

26. Tycker du att personalen motiveras personalen till att skriva rapporter?

27. Anser du att tiden från de att man lämnar in en rapport tills man får svar är rimlig/bra?
    27.1. Vilka får ta del av det analyserade resultatet? individen, gruppen eller hela organisationen?
    27.2. Hur sprids resultatet?

28. Finns det några fastställda procedurer för att säkerställa att lärdomar från tidigare händelser verkligen implementeras i verksamheten?
När en rapport kommer så sker även en förändring i t.ex. sättet att arbeta utföras.

29. Finns det specificerat vem som har ansvaret för att lärandet av tidigare händelser verkligen genomförs.
Det finns någon som har som formel uppgift att genomföra detta.

30. Finns det möjlighet, om man vill, att undersöka tidigare rapporterade händelser.
    30.1. Finns de tillgängliga?
    30.2. Hur?
    System där alla rapporter ligger uppe?

31. Hur ser samarbetet med andra torn/kontrollcentraler ut för att lära av varandra?
    För att ta del av varandras erfarenheter, misstag, framsteg, information.
    31.1. Är detta tillräckligt utbyte tillräckligt i dagsläget?
    31.2. Hur kan det förbättras?
    Studiebesök, korrespondens, temadagar.

13 APPENDIX C ANSWERS TO THE QUESTIONS

1. Are the working methods and procedures described in the operation manual adapted to fit the kind of operations of this unit?
Answer: Many of the situations that may occur on the unit is described in a manual, but there is absolutely a possibility to improve. This is where the difference of opinion occurs. Some think that there are too many situations described making it harder to be flexible and the possibility to interpret the manual in terms of making the work more manageable more difficult. The other way of looking at the improvement is to add more methodological guidance to some procedures making it easier to understand for newly arrived employees. The basic opinion is still that the manual is well prepared for the specific needs of each unit.

2. Is the operational manual continuously updated to reflect the current operations of this unit?
Answer: The manuals (Local and Central) are updated enough. Both on regular basis and on special occasions whenever something has happened that requires a change in procedures or methods. In some cases (central) updates can be issued in a short period of time making it difficult to intercept and comprehend.

3. Does the procedures and methods in the operational manual comply with my view of how the work should be carried out?
Answer: It is in broadly in line, but sometime it goes to quickly from the idea of a method/procedure to establishment without considering what impact it may have on the operations.

4. Is the operation manual easy to understand and can be put in an operational context?
Answer: Generally yes, but it is difficult to overview and often it lacks the reason why some procedures/methods are added.

5. Does operational manual allow the individual operator to adjust their actions as he/she deems appropriate?
Answer: The general opinion is that the manual used to be easier to use, and making own interpretations. Nowadays it limits the flexibility of the operator.

6. Are there enough resources available (staff, technology) to meet the requirements of the operational manual?
Answer: The demands are well met.

7. Are there measures being taken to ensure that the ability to respond is maintained?
Answer: There are different kinds of emergency training and tests. There are also binders which are mandatory to take part of to determine knowledge and competence are obtained and renewed.

The Ability to monitor

8. Are there clear indicators of what could have an impact on the units' ability to accomplish current or planned operations?
Answer: There are clear indicators of most of the situations that occur, such as weather, military traffic, an increase in traffic, school flights, and VFR etc. Generally the idea is that unexpected events is a part of the job and has been covered during training. A risk is when

sitting in a low-traffic unit where there can be a lot of moments without traffic, the problem gets to maintain the focus at the tasks, and thus making the indicators more difficult to interpret.

9. Are the indicators reliable?
Answer: The indicators are most of the time not reliable, however it is in the correct direction. An example if there has been scheduled school flights or military activity, these activities usually cannot become more difficult to handle than planned, the most common thing is that they do not take place at all, in terms of reliability.

10. Is it well-known/defined what kind of situations that may lead to problems?
Answer: Looking at the strips in the FPB or looking through the window and and observe precipitation. Besides from that it is stated in the local manual what procedures that shall be used when e.g. the radar breaks, or if there are a military activity in an area what kind of procedures that shall be used then.

11. Is the ability to monitor sufficient?
Answer: The ability to monitor is well covered, and those parts which are not is hard, if not impossible to cover. An example is VFR which at the moment cannot always be predicted. A solution could be forcing them to call well before the supposed arrival. But then another problem occurs, a lot of phone calls making to the unit disturbing the operator, and since these indicators are not reliable either it might just make it more complicated and unnecessary knowledge.

The Ability to Anticipate

12. Are there work being done to evaluate future threats and opportunities?
Answer: Generally this is a question being dealt with higher up in the organisation. Some evaluations is however based on DA:s. E.g. if there has been several reports on a particular event, new methods/procedures are developed and these might be included in the annual training, or otherwise it might just be added to the central manual. Specifically for the unit is more if e.g. a new airline is planning to launch a route, but the unit has often good contact with the airport and takes in those cases a decision whether to change the operations afterwards.

13. Are future threats/ possibilities well defined, and spread to all employees?
Answer: There are no formal way to access future threats/possibilities, they are located on the intranet of the organisation and it is usually up to the OP if the material is spread. Major threats/possibilities (procurement) are well distributed since there are a major interest in it.

14. Is risk awareness a big part of this unit's organisational culture?
Answer: What could pose a risk is discussed often, and the employees are well aware the risks that exist, everyone thinks that the risk awareness is on a high level.

The Ability to Learn

15. Is it clearly established what should be reported?

Answer: Generally the answer is yes, but several also agrees that it is impossible to define every single thing to report. Thereof it is a question of interpretation, but it applies only to smaller and less important matters.

16. Are submitted reports being investigated sufficiently?
Answer: Reports investigated at the unit are being investigated enough, but centrally is it more uncertain of how it's being done. There are also a difference depending on the severity of the report making less important reports not being investigated as much as more important ones, most likely a cost issue.

17. Are there good responses/feedback on submitted feedback?
Answer: Feedback is OK, could be better, there are always some kind of feedback. Has improved since the new automated reporting system was introduced. There are however a lack of feedback/answers on events not made by the unit but which still would be very interesting and valuable to get answers on. E.g. "private pilot" flying through the TMA without answering on the frequency, where the reason why it was done never reaches the unit. And therefore making the unit unable to suggest measures preventing it to happen again. The feedback is also more difficult to read and interpret since the system was digitalised.

18. Is the time from the submission of a report until a response is acceptable?
Answer: Could be better, it is neither good nor bad, probably a question of resources. Locally the response is quick but when being investigated centrally the response becomes slower.

19. Have the employees conducted education on how to write reports?
Answer: Yes. And the reporting system is very easy to understand and use so no extensive education is necessary. On the other hand it is much more difficult dealing with the submitted report.

20. Are there sufficient resources to write reports?
Answer: Yes. There are always time and if help is needed there are no problem to get it.

21. Are the employees being motivated to write reports?
Answer: Everyone is being motivated to write reports, used to be less motivated but it goes in the right direction. The operators feel like they are being motivated by the CO:s and the CO:s clarifies the importance of writing a report for a change to take place. Yet, regarding smaller disturbances, which is of less importance a lack of motivation can be found, this after several written reports on the same thing which did not result in any change.

22. Is it possible to study past reports from other units?
Answer: The CO:s has authority to read reports from other units since it is stored centrally. It is uncertain if operators are able to study other reports but they do not think that they have permission to do it. No one know why it is like this. Some CO:s are sending mail copies of the reports that they think is interesting to the operators.

23. Are lessons learned from things that goes right, as well as things that go wrong?

Answer: No formal work is done here. But in the units when two employees work at the same time one speaks to each other and discussing situations, which also occurs when working with each other and looking at work the other performs. When employees has worked with each other and perhaps roughly have as much experience the operational exchange decreases. The only formal way is in the ATS-meetings, which are held approximately every 1-2 month. In these meetings interested situations and areas of concern can be put forward. However, by just performing the everyday work, lessons are learned the whole time even if you have been working for several years and has a lot of experience.

24. Are there established procedures to ensure that the lessons learned from past events really are implemented at the unit?

Answer: There are formal ways to ensure that lessens has been learned or procedures has been implemented. But it might be difficult to actually measure or see if has been implemented and are therefore hard to do in practice. There are however a "take-part binder" where reports are inserted to and where the employees can mark when they have read the content.

25. Does the learning process, within the unit, takes place continuously or only when an incident/accident has occurred, or both?

a. The overall answer is both. The everyday work is a continuous learning process and since learning takes place every day, both by working alone and also be talking to colleagues and watching them work. The everyday learning process becomes better if it is mixed age difference between the employees. The more formal way is competence assurance which is held approximately once a year. Besides from there are theoretical tests and practical training when it deems necessary and in the event of an incident or similar.

26. Do you meet personnel from other units to learn from each other?

Answer: Some exchange is being done with the operators, but not on regular basis, probably a cost issue, since it has been done before. However the CO:s are meeting on regular basis and have constantly communication with each other. Some exchange is being done where the operators have dual qualifications (working on two units), but nothing more than that. Everyone thinks that it would be beneficial to have more exchange but also understands that it is a cost and resource issue.

Appendix D. Our resilience-ratings based on the answers

1. Are the working methods and procedures described in the operation manual adapted to fit the kind of operations of this unit?
Rating: (4/5) Sufficient, but can be improved

2. Is the operational manual continuously updated to reflect the current operations of this unit?
Rating: (5/5) Updated both on regular basis and in the event of something specific

3. Does the procedures and methods in the operational manual complies with my view of how the work should be carried out?
Rating: (4/5) More or less complete but with very few exceptions)

4. Is the operation manual easy to understand and can be put in an operational context?
Rating: (2/5) The lack of understanding why methods/procedures are added or removed and since it contains too much information to be easily too overview lowers the grade.

5. Does operational manual allow the individual operator to adjust their actions as he/she deems appropriate?
Rating: (3/5) The option to use the manual as an aid instead of using it to the letter decreases with time. However there are still good possibilities using it as a aid and thereof the grade.

6. Are there enough resources available (staff, technology) to meet the requirements of the operational manual?
Rating: (4/5) The demands are well met

7. Are there measures being taken to ensure that the ability to respond is maintained?
Rating: (4/5) It can almost never be too much training but taking into account that it is a cost issue, and also is a problem regarding resources makes the issue well covered.

The Ability to monitor

8. Are there clear indicators of what could have an impact on the units' ability to accomplish current or planned operations?
Rating: (4/5) Since the only way to cover every indicator is to have a pure technological system and thus is not possible in this context the highest degree is impossible. There is obviously a lack of indicators but since the job is much about to handle the unexpected in different situations does this cover such indicators.

9. Are the indicators reliable?

Rating: (2/5) The indicators which are available are not so reliable, but since in the event of an irregularity the situation becomes easier to handle thus safer the indicators are defined as neither or.

10. Is it well-known/defined what kind of situations that may lead to problems?
Rating: (3/5) The operators are well aware of what situations that could lead to problems but there are however no definition of them. These are instead based on previous experience of dangerous situations.

11. Is the ability to monitor sufficient?
Rating: (3/5) There can be improvements such as weather radar and other technical improvements, but since it almost always entails a cost one may question its necessity, especially for units which usually handles low amount of traffic.

The Ability to Anticipate

12. Are there work being done to evaluate future threats and opportunities?
Rating: (Missing)

13. Are future threats/ possibilities well defined, and spread to all employees?
Rating: (2/5) They can be obtained but with some difficulties, no formal way of spreading them.

14. Is risk awareness a big part of this unit's organisational culture?
Rating: (1/5)

The Ability to Learn

15. Is it clearly established what should be reported?
Rating: (5/5) To cover every single disturbance is an infinite work, and even if it would be possible the readability would be poor and locating disturbances would be very time consuming. Everybody agrees that the most important things that shall be reported are clearly stated.

16. Are submitted reports being investigated sufficiently?
Rating: (5/5) Every report is investigated more or less and prioritization between less and more important reports are good.

17. Are there good responses/feedback on submitted feedback?

Rating: (3/5) There are always some kind of feedback but not always as useful as one might would like it to be.

18. Is the time from the submission of a report until a response is acceptable?
Rating: (3/5) The general thought of the time until response is received is neither good or bad.

19. Have the employees conducted education on how to write reports?
Rating: (**5/5)** Everyone has conducted education and the system is easy enough to understand without education.

20. Are there sufficient resources to write reports?
Rating: (**5/5)** Intended resources are available.

21. Are the employees being motivated to write reports?
Rating: (4/5) The employees are being well motivated to write reports, but the lack of results/response regarding less important matters lowers the grade little.

22. Is it possible to study past reports from other units?
Rating: (2/5) Since it is uncertain if the possibility exists among the operators and they are must likely to go through the CO:s makes it quite difficult to study reports from other units.

23. Are lessons learned from things that goes right, as well as things that go wrong?
Rating: (4/5) No formal work is being done but by just performing the everyday work and talking with colleagues makes the learning from things that go right as well as things as go wrong sufficient.

24. Are there established procedures to ensure that the lessons learned from past events really are implemented at the unit?
Rating: (4/5) There are procedures but since they are not defined in way making them possible to check that they are established lowers the value.

25**.** Does the learning process, within the unit, takes place continuously or only when an incident / accident has occurred, or both?
Rating: (5/5) Even though there are no formal way of make use of continuous learning it is achieved in the work itself. And it seems to be well performed in the event of something **unusual.**

26**.** Do you meet personnel from other units to learn from each other?
Rating: (2/5) The operators are not included in a change cooperation which is an important part, however the CO:s are involved so they could mediate issues from the operators.