How is anticipation, as part of system resilience, operationalised on the flight deck, and to what extent does the regulation facilitate it?

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Abstract

Resilience is a contemporary 'hot topic' in aviation - as well as in many other safety critical industries. The need for understanding resilience has been recognised since it has been noted that serious incidents and accidents are often related to very complex and unexpected situations and failures that cannot be managed with compliance, or which are not covered by existing procedures or checklists. In aviation, resilience has largely been defined as the capability of the crew to 'bounce back', meaning their ability to function in an unexpected and unplanned situation, where procedures do not suffice or exist, and which has not been covered by training. However, scientific literature sees many other shades of resilience. There are many interpretations of resilience not as an 'ability' that someone possesses, but instead a process that incorporates continuous potentials such as learning and anticipating, or 'looking ahead'. Science also talks about resilience much more as a system function, instead of an ability at the sharp end. This qualitative study has its starting point in an interest on how the concept of resilience is implemented in aviation. The study has a special focus on 'anticipation', which seems to be recognised in science as a resilience potential but does not seem to receive corresponding recognition in the airline industry. This research deals with the definition and training of resilience and especially anticipation in the airline industry. The purpose is to view how the European regulator (EASA) defines resilience and what role it grants anticipation in resilience development. The research enters the airline organization from the perspective of flight crew training and explores how crews, instructors and examiners view the regulation, and how it further spreads via CRM and simulator training into line operation. This research also observes and compares how airline crews anticipate, and how they foresee the potential of risks and threats that affect normal operation by using skills and experience most effectively.

Acknowledgements

Our master's thesis completes a long and rewarding journey together in the world of human factors and system safety. This program has taught us to question even those thoughts and opinions which we have held as obvious truths and cleared space for a totally new kind of thinking and learning. In a way, the completion of the programme feels like a new start, an eye-opening experience how much there still is to learn.

We would like to thank our supervisor, Mr. Erik van der Lely, for his patient and consistent guidance and support during our wonderful journey. We believe that his background as a long-time pilot and instructor, and his patient and analytical character, made him a perfect supervisor for our work. We also wish to thank our main instructor and examiner, Dr Anthony Smoker, for his patience and the great advice he gave us several times along our journey.

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Abbreviations

ACARS: Aircraft Communication Addressing and Reporting System

AMC/GM: Accepted Means of Compliance / Guidance Material

ATC: Air Traffic Control

ATIS: Automatic Terminal Information Service

CIS: Crew Information System

CRM: Crew Resource Management

CRMI: Crew Resource Management Instructor

EASA: European Union Aviation Safety Agency

EBT: Evidence Based Training

ECAM: Electronic Centralised Monitoring system

EFB: Electronic Flight Bag

FL: Flight Level

FMS: Flight Management System

FOB: Fuel On Board

FORDEC: Facts - Options - Risks/Benefits - Decision - Execution – Check

MEL: Minimum Equipment List

NASA: National Aeronautics and Space Administration

NOTAM: Notice To Airmen

OEB: Operations Engineering Bulletin

PA: Passenger Address

PF: Pilot Flying

PM: Pilot Monitoring

QRH: Quick Reference Handbook

TEM: Threat and Error Management

TOGA: Take Off and Go Around

TRI: Type Rating Instructor

UPRT: Upset Recovery Training

VMC: Visual Meteorological Conditions

ZFW: Zero Fuel Weight

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Personal Reflections

Our personal stance on this topic comes from our background as airline pilots and safety and CRM instructors. We have seen a 20-year timeline in flight deck work, and personally lived the steps taken in the evolution of CRM over that time. As pilots and 'insiders', we have witnessed the improvement in safety through CRM, but also seen the loopholes and challenges created by the complex environment and increased automation. As instructors, we have had deep insights into the principles of CRM and how it has been implemented and trained in an airline. We have seen anticipation on the flight deck, performed and experienced it, and recognised its meaning for safe flight deck work. But what we have not seen is its place and position in a bigger picture of resilience. In our experience, the connection between anticipation and resilience in our industry has been unseen and undiscussed by the regulators.

Through our MSc studies, we have had a chance to compare all that we have seen in our work with the most modern ideas about human factors and system safety. Our long-time experience may expose us to personal opinions and biases which can potentially be considered a limitation of this study. On the other hand, this background has helped us find the topic for this MSc study, and we believe that we have found an interesting and important area where the regulatory text, the airline perspectives, and modern safety science may not be fully synchronised.

Research Question

Anticipation, as a concept, can be found in scientific literature where it is connected to resilience by e.g. Hollnagel (2017), Rerup (2001), and Hale & Heijer (2006). However, anticipation is not included in the definition of resilience that the aviation workers, in our own experience, commonly use: 'the ability to bounce back'. Therefore, anticipation is a good example concept, a tool for us to examine resilience in aviation and its correspondence with science. From these standpoints we formulated the main research question of the study: *"How is anticipation, as part of system resilience, operationalised on the flight deck, and to what extent does the regulation facilitate it?"*

Short Overview and Structure

This study begins with a look into the research design itself. It opens up the underlying scientific approach and the methodology and the methods used in the study and explains why they were selected. The limitations and ethical aspects are also introduced in order to ensure the reliability and integrity of the study. The research itself begins with a review of the existing literature on resilience and anticipation. The data collection part explains our data collection setting for our methods, which are document analysis, interviews, focus groups, and observations. It also reviews the gathered data and opens the door for the discussion chapter, where the data is analysed and connected with the scientific literature on the topic. Finally, as a result, we list our conclusions and make some suggestions for further research, which were inspired by our findings but fell outside the scope of this study.

Review of the Literature and Previous Research

It seems that resilience and anticipation are both known and researched notions. Sometimes resilience has been defined without anticipatory aspects. In some literature they have been seen as two separate but necessary concepts in safety (e.g. Comfort et al,. 2001). But in many cases, anticipation has been regarded as a crucial part of resilience, especially in the newer safety literature (e.g. Rerup, 2001; Hollnagel, 2011).

Resilience as a notion has been in the safety discussions from roughly the turn of the century, according to Woods (2000). First, we must note that the concept has evolved over the last 20 years. Hollnagel and Nemeth (2021) illustrate the evolution by highlighting how Hollnagel's own definition of resilience changed between 2006 and 2011. In 2006, Hollnagel defined resilience as "the intrinsic ability of an organisation (system) to maintain or regain a dynamically stable state, which allows it to continue operations after a major mishap and/or in the presence of a continuous stress" (Hollnagel, 2006, p. 16).

However, after five years Hollnagel (2011) had amended his definition, taking on a more processual and anticipatory stance:

> Resilience can [in the same manner] be defined as 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. (p.xxxvi)

In a list of four abilities that are necessary for a system to be resilient, Hollnagel (2011) mentions.

- Knowing what to look for (what is or can become a threat)
- Knowing what to expect (how to anticipate threats and opportunities)
- Knowing what to do (how to respond to disturbances) and
- Knowing what has happened (how to learn from experience). (p. xxxvii)

In other words, the timeframe of resilience seems to have broadened. It was no longer a reactive capability, dedicated to recovering from an event. It became closer to something that is processual, forward-looking, that can also take place prior to [a disturbance]. Hollnagel and Nemeth (2021) describe the change: "the emphasis on risks and threats had been reduced, and the reference instead became how systems performed in 'expected and unexpected conditions,' including how such conditions could be anticipated" (p. 3).

Let us keep Hollnagel in focus but proceed another six years forward. In 2017, Hollnagel (2017) renamed four resilience potentials: the potential to respond, the potential to monitor, the potential to learn, and the potential to anticipate. The potentials broaden the notion from reactive 'bounce back' or 'robustness' capabilities into a continuous process, taking advantage of both foresight and hindsight. Of these four potentials, the most reactive and momentary in nature could be argued to be 'to respond', but according to Hollnagel (2017), it too can sometimes be forward-looking. "For events or situations that occur regularly, it may be cost efficient to prepare a response, but for events or situations that are irregular or infrequent, responses cannot realistically be prepared. These have to be developed when the event happens" (p. 49).

Anticipation plays a powerful role in Hollnagel's (2017) text. According to him, "Anticipation 'looks' at that which is beyond the event horizon, either something that lies further into the future of something that has no immediate relation or impact on the organisation's primary activity" (p. 64). He argues that anticipatory thinking is fundamental for individuals, for groups, for organisations, and for societies large and small (p. 60).

Woods (2015) introduces four concepts or interpretations of resilience, all somewhat different. According to Woods (2015), resilience can be: (1) rebounding, which means a process of recovering from a traumatic or disrupting event, and returning to a previous equilibrium; (2) robustness, the ability of a system to absorb (rather than recover from) disrupting events; (3) graceful extensibility, which he explains as a capability to reformulate the system in the aftermath of the shock, and to extend its capacity to deal with future shocks; or (4) sustained adaptability, which means the ability to manage/regulate adaptive capacities of systems that are layered networks and are also a part of larger layered networks. In his analysis of the NASA Columbia Disaster, Woods (2005) concludes that one measure of resilience is the ability to create foresight – to anticipate the changing shape of risk, before failure and harm occur (p. 305).

Woods (2011) discussed the ability to anticipate and its connection to resilience by naming six patterns of anticipation. He argues that to be resilient, a system looks ahead to read the signs that its adaptive capacity, as it currently is configured and performs, is becoming inadequate to meet the demands it will or could encounter in the future (Woods, 2011, p. 1). This appears as an introspective ability, looking more inwards at the system itself than outwards. Woods (2011) says that resilient systems are able:

- to recognise the signs that adaptive capacity is falling
- to recognise the threat of exhausting buffers or reserves
- to recognise when to shift priorities across goal tradeoffs
- to make perspective shifts and contrast diverse perspectives that go beyond their nominal position
- to navigate changing interdependencies across roles, activities, levels, goals, and
- to recognise the need to learn new ways to adapt.

Several other scholars introduced anticipation as an aspect of resilience even before Hollnagel. Hale and Heijer (2006) define resilience as the ability not only to bounce back and recover from an adverse event. They argue that the definition of resilience should be extended in order to encompass the ability to avert the disaster or major upset. "Resilience then describes also the characteristic of managing the organisation's activities to anticipate and circumvent threats to its existence and primary goals" (p. 35). They refer to Rasmussen's (1997) 'drift to danger' model and state that "resilience is the ability to steer the activities of the organisation, so that it may sail close to the area where accidents will happen, but always stays out of that dangerous area" (p. 36). Carroll and Malmquist (2021) process Hale's and Heijer's (2006) aforementioned definition of resilience, applying it to aviation:

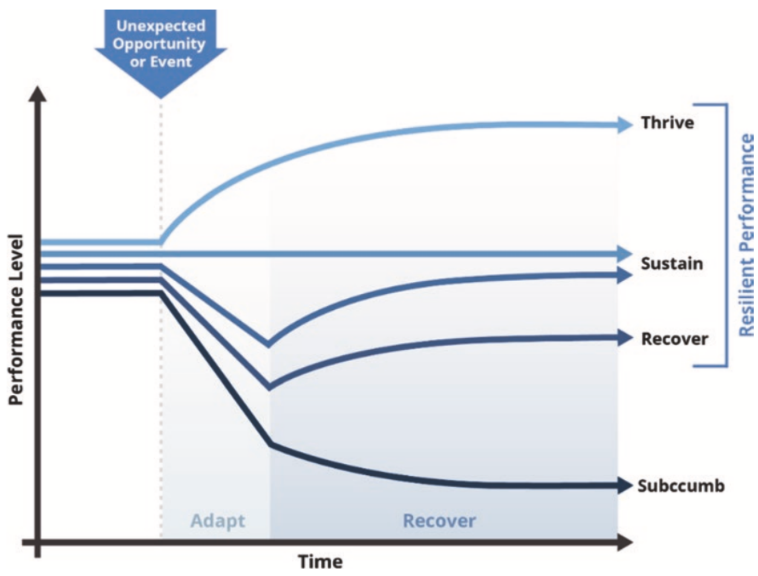
> With respect to aviation, this hinges on pilots having the knowledge, skills, abilities, and resources to anticipate unexpected events such as those discussed previously, so that they can make an effective decision regarding how to prevent and/or respond. These are often events for which they have not received training or procedures. (p. 86)

Carroll and Malmquist (2021) refer to the visual model of resilient pathways from Carroll et al. (2012) and argue that when performers successfully anticipate an unexpected event and effectively adjust performance, they are able to maintain performance and sustain the required operations (Carroll and

Malmquist, 2021, p. 87). Thus, the performance decrements are minimised or even avoided if an unexpected event occurs.

Figure 1

Model of resilient performance pathways



Note. Adapted from Carroll et al., 2012.

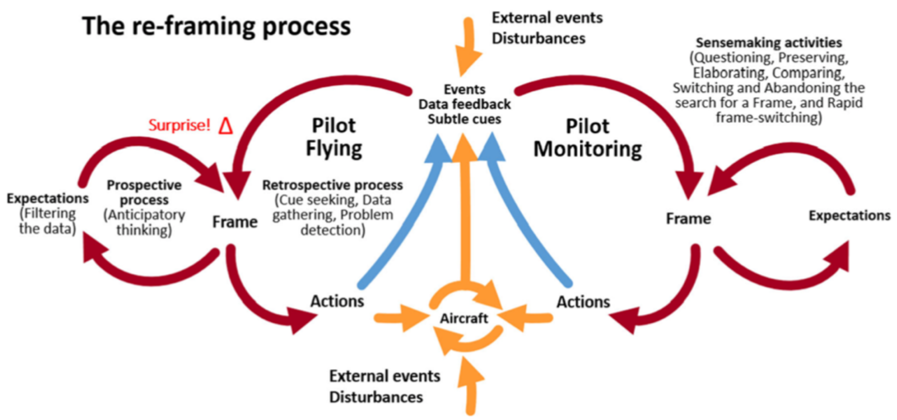
Rerup had already introduced his idea of resilience by 2001. Rerup's (2001) definition consists of two separate techniques: anticipation and improvisation. In his view, both improve distinct aspects of the adaptive capability of the organisation. "If an organisation intends to remain resilient while coping with unexpected events, it will have to develop not only one, but both anticipatory and improvisational skills." (p. 2). Together, they generate organisational resilience.

Improvisation is needed in situations that happen despite all anticipatory efforts. Rerup (2001) admits that it is impossible to anticipate all problems and dangers in advance (p. 1). But anticipation is crucial too. Rerup (2001) uses the case of Apollo 13 as a justification. He describes the anticipatory capabilities and skills of NASA and argues that they played a crucial role in the crew's survival. "It was the combination of these [anticipatory] skills and the involved personnel's ability to improvise that helped the astronauts to return safely to the Earth" (p. 16).

Is there a connection between these two aspects of resilience: recovering from surprise (or improvisation, in Rerup's terms) and anticipation? Or are they fully separate from each other? The literature indicates that they are not. Though surprises are inevitable and always present in a complex environment (Perrow, 1984, p. 17), anticipation will lead to fewer surprises, and reduce their effects when they happen. Lay & Balkin (2021) suggest that anticipation can be seen as forecasting behaviour that attempts to avoid the need to respond to surprise by forestalling the surprise itself. Some even suggest surprise to be a consequence of incomplete anticipation. However, this interpretation appears very straightforward and simplistic, since anticipatory models will always, even under the best of circumstances, be inaccurate (Lay & Balkin, 2021, p. 150). Rankin et al. (2016) see anticipation as a part of sensemaking, and as the prospective process which is used not only to cope with the unexpected after the fact, but also to avoid surprises (p. 633).

Figure 2

Crew-aircraft contextual control loop



Note. Adapted from Rankin et al., 2016.

What is anticipation if we shift the focus from theory towards practice? Rerup (2001) offers some practical basis for his views, and how anticipation can show up in one domain. He mentions the simulations that NASA used to expose mission controllers to a variety of potential situations that they considered possible. During the simulations, it was critical to detect and consider small, almost imperceptible signs ('ratty data') that were visible in advance, but which required concentration to be able to take into account when making decisions.

'Ratty data' (Rerup, 2001, p. 14) seems to be visible, but still very uncertain and imprecise. Klein et al. (2011) use the term 'weak signals', which seems to have a similar meaning. Nemeth (2009) describes the uncertainty that must be anticipated: "The best that our visual language has to offer to indicate uncertainty is dotted, rather than solid, lines" (p. 8). He acknowledges that the line between certainty and uncertainty is not clear, and that a continuum exists between them. In any case, anticipation focuses into something that is neither well defined nor clear (p. 8). It looks for future possibilities, and potential, in a creative way, with the help of imagination.

What differentiates anticipation and monitoring? Hollnagel (2009) explains the difference and describes monitoring as "knowing what to look for" whereas anticipating is "knowing what to expect" (p. 120). Their time frame is different, and they are also done in different ways, as Hollnagel discusses:

> In monitoring, a set of pre-defined cues or indicators are checked to see if they change, and if it happens in a way that demands a readiness to respond. In looking for the potential, the goal is to identify possible future events, conditions, or state changes - internal or external to the system - that should be prevented or avoided. While monitoring tries to keep an eye on the regular threats, looking for the potential tries to identify the most likely irregular threats. (p. 126)

Klein (2017) draws a line between Endsley's (1995) Level 3 situational awareness (making predictions) and anticipatory thinking. "Anticipatory thinking is aimed at potential events, including low-probability high-threat events whereas situation awareness is aiming at the most predictable events" (p. 236). He adds that where anticipatory thinking is functional, as it helps to prepare to act, situation awareness merely predicts. This seems to be an operationally significant issue, especially for a safety-critical field where simply stating things, even if oriented towards the future, is not enough.

Klein et al. (2011) take a psychological perspective, and they see it as a part of the sensemaking process and naturalistic decision making. They describe three common forms of anticipatory thinking: pattern matching, trajectory tracking, and convergence. In 'pattern matching', the circumstances of the present situation bring out similar events and clusters of cues from the past (p. 237). It reflects an image of the past and from a similar, experienced situation into the future, to help foresee events. 'Trajectory tracking' is more than projecting history; it is noticing and extrapolating trends. They illustrate it with the capability to catch a moving ball: those who have age and practice learn to reach where the ball will be by the time they can move their hand. The third form, 'convergence', is most advanced. It appreciates the implications of different events and their interdependencies. It sees connections between separate events and notices an "ominous intersection" of conditions, facts, and events (p. 237).

This last form of anticipation receives support from others. According to Nemeth (2009), Hollnagel notes that current ways of thinking about systems extrapolate data from the past into the future in order to estimate risk, but fail to grasp complex emergent interactions among multiple elements. Anticipation of emergent future events must go beyond simple cause-effect relationships (p. 10).

Adamski and Westrum (2003) use the term 'requisite imagination', which they call "the fine art of imagining what might go wrong". Westrum (2009) also, like Rerup, refers to the case of Apollo 13, and states that the use of requisite imagination saved the astronauts when the supply module suffered a major blowout (p. 138). At the same time, Westrum (2009) argues that later in NASA's history, it was the erosion of requisite imagination that led to the disasters of space shuttles Challenger and Columbia. Westrum (2003) also gives some more background on 'requisite imagination' and how it is tied in with experience:

> Requisite imagination… depends on expertise, that is to say, a fundamental understanding of the system and how it works. Part of expertise is learning from experience. In a narrow sense, experience means seeing what has happened before. But more broadly, experience means developing judgement about the kinds of things that are likely to go wrong, what can be trusted, and what cannot be trusted. (p. 139)

Klein (2017) researched expertise and demonstrated how experts can see many things that are invisible to everyone else. Klein compresses these aspects under two themes: pattern matching and mental simulation.

> Pattern matching (intuition) refers to the ability of the expert to detect typicality and to notice events that did not happen and other anomalies that violate the pattern. Mental simulation covers the ability to see events that happened previously and events that are likely to happen in the future. (p. 149)

In many fields, the time needed to develop expertise is up to ten years (Klein, 2017, p.147). It is more typical for novices to rely on known procedures or familiar patterns, as they do not know what is supposed to happen or are unable to improvise if they are pushed outside the standard patterns (Klein, 2017, p.156). What experts do not always realise is that novices are unable to detect what seems obvious to them (Klein, 2017, p.147). This indicates that mental models and ways to handle difficult situations come with experience and that developing that expertise and learning mental models takes time and is somewhat challenging. "If we cannot teach people to think like experts, perhaps we can teach them to learn like experts" (Klein, 2017, p. 169). This challenges training departments because it is through experience that experts have learnt to see things that are invisible to others, including things that have not happened but should have (negative cues) (Klein, 2017, p.151). This is what makes a significant difference between novices and experts. Only through expectancies can someone notice whether something did not happen (Klein, 2017, p.149).

We see a close connection here to anticipation and being able to see the big picture, thus being mentally ahead of the situation. In commercial aviation, contingency planning represents the use of anticipatory activity in promoting resilient performance. This narrowest and most "mechanical" use of the term resilience applies when the designer anticipates a specific kind of problem that could arise and designs a specific solution to detect and respond effectively to this kind of problem (Smith, Stone, and Spencer, 2006; Smith, Bennett, and Stone, 2006). Probability is one of the factors in contingency planning, as the uncertainty of different factors like weather conditions and (re)routings cannot be accurately forecasted. How this 'operational' kind of anticipation is applied and how the industry teaches it to the personnel, including pilots, or whether it does at all, is a core question.

> Reactive safety management also requires that the process being managed is sufficiently familiar and that adverse events are sufficiently regular to allow responses to be prepared ahead of time

(anticipation). The worst situation is clearly when something completely unknown happens, since time and resources then must be spent to find out what it is and work out what to do before a response can actually be given. (Hollnagel, 2014, pp. 56-57)

Hollnagel (2014) notes that performance variability is, indeed, not merely reactive but also – and perhaps more importantly – proactive. People not only respond to what others do but also to what they expect that others will do (p. 133-134). "People always have to adjust work to the actual conditions, which on the whole differ from what was expected – and many times significantly so" (p. 126). Hollnagel also reminds us that the adjustments people make, in reaction and in anticipation of what others may do, become part of the situation that others must deal with. This gives rise to a dependence in a system, through which the functions and their performance variability become coupled (p. 134). This is a good reminder that anticipation and resilience are not individual, but rather systemic by nature.

This literature review demonstrates the vital role of anticipation in contributing to system resilience. In the aviation industry, a complex domain governed by hierarchical structures and stringent regulations, it becomes important to examine how anticipation manifests itself in real-life flight decks. Does anticipation receive specific training, or is it overlooked? Additionally, what impact does rulemaking have on this process? These questions highlight the gap that we want to research and the validity of our own research question: "How is anticipation, as part of system resilience, operationalized on the flight deck, and to what extent does the regulation facilitate it?"

Research Design

Epistemology, Methodology

Resilience is socially constructed. It emerges from a social or socio-technical interaction and is also related to mental capacities, such as mental flexibility. According to Crotty (1998), a constructionist viewpoint means that "all knowledge and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context" (p.42).

Our role as researchers has been to interpret the observations we make during the research project, understand their contribution to the notion of resilience (or how we end up defining it), and translate them into findings and conclusions. The theoretical perspective of this research has been interpretivism. Understanding is key. Weber argued that understanding of causation comes through an interpretative understanding of social action and involves an explanation of relevant antecedent phenomena as meaning-complexes (Weber, 1962, as cited in Crotty, 1998). The researched phenomena were not only related to the precise moment when something happens. Instead, the time dimension has been necessary to understand as well. Anticipation, as one part of resilience, can be assumed to be a product of many aspects in the history of the observed individuals, such as training, experience, and personal background. An interpretivist approach makes a natural and functional connection with our constructionist epistemological viewpoint.

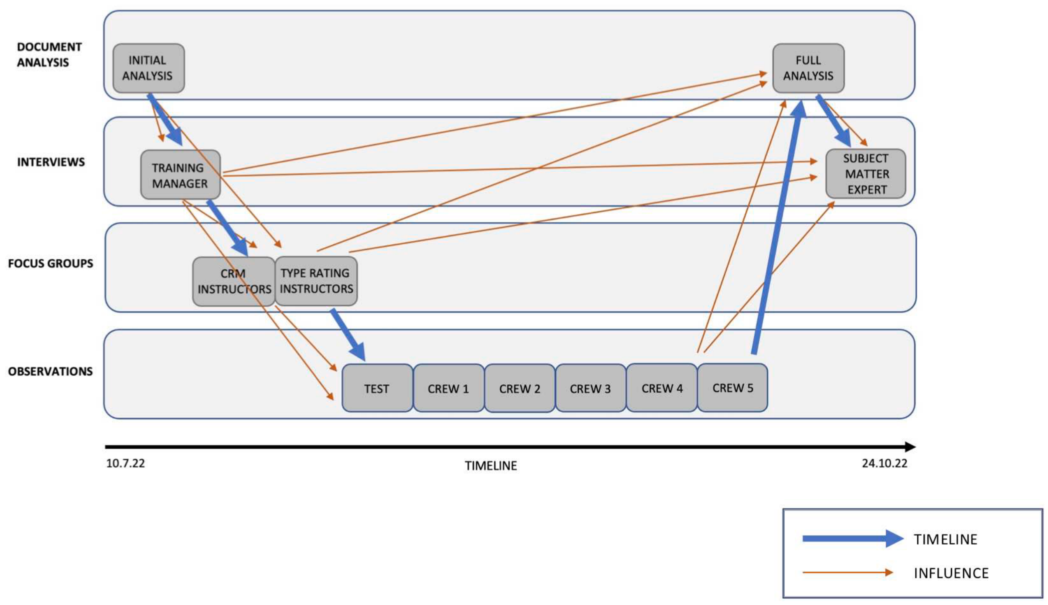
Methodologically our research draws on the basis of 'grounded theory', observations and document analysis. Seale et al. (2006) describe grounded theory: "The process of data collection for generating theory whereby the analyst jointly collects, codes and analyses his data and then decides what data to collect next and where to find them, in order to develop his theory as it emerges' (p. 83). Our research design allows this. The data collected during the process influenced the subsequent steps, and the researchers' understanding of the topic also evolved throughout the entire research.

The initial document analysis of the EASA regulation provided the basis for the training manager interview. The setting of the focus group sessions was influenced by this interview and the document analysis. The data gathered through training manager´s interview and focus groups was coded to find common nominators and themes and allow preliminary conclusions.

The coding happened in one cycle and did not strictly adhere to the depth of the 'grounded theory' methodology protocol. The main goal of coding was to organize and make sense of the data collected in studies focused on resilience-anticipation related phenomena. It allowed for the identification of patterns, themes, and relationships within the data, leading to meaningful interpretations and insights. Through coding, researchers could systematically analyse and extract relevant information to address research questions, explore new ideas, and uncover valuable findings. Additionally, coding served as a means to delve deeper into the discussed topics, fostering a comprehensive understanding of the subject matter.

Figure 3

Research Design and timeline



The data gathered from interviews and focus groups served as a foundation for the observations. Based on this data, the researchers had an initial understanding of the elements that constitute anticipation and the indicators to expect and observe. The final conclusions of the research emerged as products of the whole process, representing new knowledge that the researchers did not possess at the starting point.

Methods

This research uses a combination of qualitative methods: document analysis, semi-structured interviews, focus groups, and observations.

Document Analysis

A preliminary analysis was conducted on the EASA regulation on Crew Resource Management (CRM) to provide a starting point for the topic. This initial analysis included an unbiased examination of the regulation, exploring its relevance to the research topic. From this stage, some preliminary conclusions were drawn, enhancing the researchers' knowledge and understanding while also giving rise to new questions and areas requiring further clarification.

The second step, the comprehensive analysis of the regulation took place utilising specific keywords such as 'anticipation', 'anticipate', 'resilience' and 'threat'. These keywords were systematically located within the text, and their contexts were analysed to understand their contributions. The findings from earlier stages of the research were integrated into this analysis as well. The aim was to develop a comprehensive understanding of how the regulation influences the anticipatory behaviour of crews, using the observed crews as references. As part of this analysis, documentation from Bergström & Dekker (2019) was consulted to compare their findings with those of the researchers.

Semi-Structured Interviews

"In-depth interviews are optimal for collecting data on individuals' personal histories, perspectives, and experiences, particularly when sensitive topics are being explored." (Mack et al., 2005, p. 2). "The meaning of perceptions can be comprehended by researchers only by inquiring of the individuals" (p. 177).

To explore diverse perspectives on the concepts of resilience and anticipation, two semi-structured interviews were conducted. The researchers developed a comprehensive list of questions (Appendix 1), including appropriate probes, follow-up questions and thematic guidelines, to facilitate meaningful discussions on the topic.

The data collection began with the interview of the airline training manager. The focus was on how the EASA regulation is seen at their level, how resilience is understood, what role anticipation plays, and how all this is incorporated into the pilot training.

Another semi-structured interview was held with a subject matter expert who has a strong background in Human Factors and Crew Resource Management-related projects in several aviation entities, including the EASA rulemaking task (RMT).0411 'Çrew Resource Management (CRM) Training'. The focus of the interview was on the origins of the EASA regulation regarding CRM training, how resilience and anticipation were seen by the rulemaking task group, what is the assumed outcome from the resilience training, how anticipation should be trained, and what the change in performance should be after training in resilience.

During the interviews, the researchers assumed the roles of moderators, introducing relevant topics for discussion. They aimed to create an environment where participants felt comfortable expressing their thoughts, feelings, and experiences freely and openly, without interruptions. While some answers naturally emerged during the discussions, the researchers also guided the conversation when necessary.

Specifically, regarding anticipation, the researchers refrained from explicitly introducing the topic themselves. Instead, they employed open-ended questions to gauge whether the participants would naturally bring up resilience in the context of anticipation. It is worth noting that the interviewees were not required to prepare in advance for the interviews. Furthermore, participants were encouraged not to discuss the research or their interview experiences with other interviewees or individuals involved in group discussions, aiming to maintain the integrity of the data collection process.

Focus Groups

Of the focus groups, the first consisted of a group of senior flight examiners and the second of CRM instructors to uncover different anticipatory behaviour of crews. The researchers acted as moderators of the discussion. Researchers had a basic set of moderator questions to inspire and guide discussion within the group. The purpose was to create an opportunity for the interviewees to openly take a stand on things without the moderator interfering substantially in the course of the conversation.

The first focus group session brought four experienced CRM and Safety instructors (all pilots) to the table. The researchers' goal was to investigate how the understanding of resilience is displayed by the CRM instructors, how their views corresponded with the views of EASA and the training manager, and what their thoughts on anticipation were as resilience contributors.

The second focus group session was arranged for four senior flight instructors, all carrying the Type Rating Instructor (TRI) validation. The goal was similar with CRM instructors, to investigate how the understanding of resilience is displayed, how their views corresponded with the views of EASA and the training manager, and what their thoughts of anticipation were as resilience contributors.

There was also an interesting setting created where it was possible to see how congruent the answers between these two focus groups were – i.e., between CRM and flight instructors. The researchers prepared sets of questions for both focus groups. The sets of questions (Appendix 1) partly contained the same questions, but the questions of the TRI group also contained aspects related to the assessment of the crews.

Participating in the group discussion did not require the participants to prepare in advance, and the researchers stressed the secrecy of the research participants regarding the questions presented in the study in order to avoid the formation of opinions on matters in advance.

The discussions within both focus groups were characterized by active and lively participation, with clear and sometimes opposing opinions. Instances of disagreement were also encountered during the sessions.

The use of coding

The coding process of the interviews and focus groups happened in one cycle. It involved systematically and structurally analysing the collected qualitative data. Its purpose was to identify and categorise information based on predefined codes and themes. This included examining interview transcripts and notes and assigning labels to specific text segments representing concepts or ideas. The coding process facilitated easy recognition of relevant sections for different topics, enabling comparisons and cross-checks without disrupting the logical flow.

Another specific goal for the coding was to derive categories of anticipatory behaviour. These categories could be used as indicators of anticipation in the simulator observations. These categories were derived 'in vivo', a method in which the codes are not predefined by the researchers but instead inspired by the participants. Terms and concepts were extracted from the participants' own words (Saldaña, 2015).

Observations

"Participant observation is appropriate for collecting data on naturally occurring behaviours in their usual contexts" (Mack et al., 2005, p. 2).

Observation brought the authors to the professional environment to collect observable behaviour that builds system resilience and anticipation, and how it affects system resilience as a whole. In the scenario, the crews were offered an open field to perform anticipatory behaviour. Both researchers were present, running the simulator, playing the role of other personnel (the purser, the air traffic control etc.), and at the same time observing the behaviour of the crews. Five flight crews with varying degrees of experience were selected based on volunteering (Table 1). The crews did not include any pilots with instructor positions. Before the observation flights, the planned scenario was tested with a test crew who made a trial flight. The scenario, the simulator settings, the recording adjustments, and the manuscript were adjusted according to this test.

Table 1

The observed crews´ background and experience

	CREW 1	CREW 2	CREW 3	CREW 4	CREW 5
Captain	20 years total 14 years as captain	12 years total 1 month as captain	17 years total 1 year as captain	21 years total 14 years as captain	20 years total 14 years as captain
Copilot	4 years	6 years	13 years	12 years	6 years

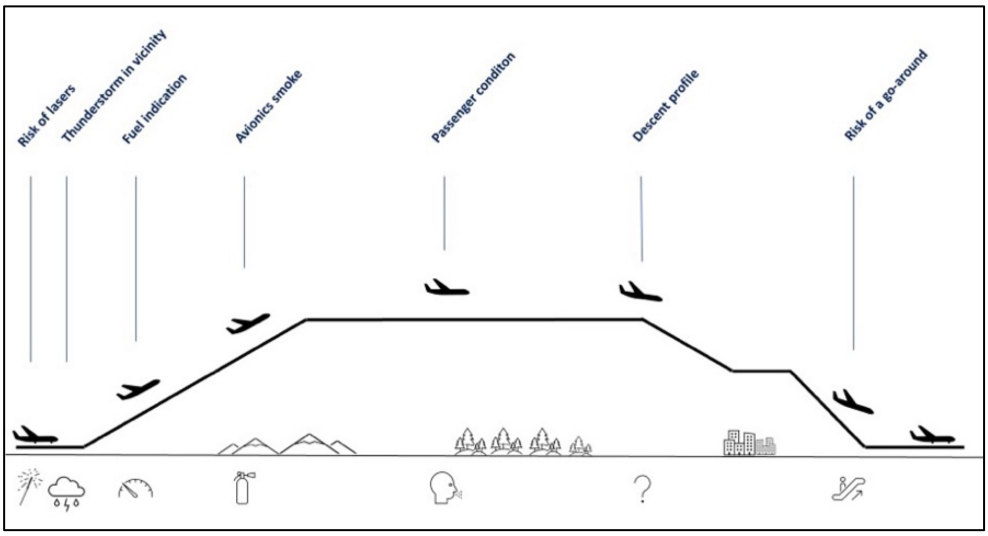
The crews were not told the topic of the research or the behaviour to be observed. They were asked to perform everyday work, as in a normal flight. These can include symptomatic events, suspected trends, gut feelings, and intelligent speculation (Hollnagel et al., 2006, p. 59), even nonevents, which might be harder to detect. In the end, the topic of the research was announced, which let them freely share their thoughts on CRM, anticipation, resilience, and safety. This part did not include specific pre-planned questions. Instead, it was an open discussion whose purpose was to supplement the observation flight and the crew´s own experience of it.

The crew was briefed that a regular, scheduled flight was to be performed. They would receive the preflight briefing material in the simulator, were expected to perform a normal preflight and flight deck preparation, decide about the fuelling, and operate the flight accordingly. They were free to decide the roles of PF and PM themselves. The crews were asked to work as similarly as possible to a normal workday. They were encouraged to use normal, good quality CRM and communicate with all the stakeholders they would on a normal flight, and that the researchers were to play their role.

The observation of the flight crews was carried out in the Finnair Flight Academy's Airbus A320 simulator, where a 50-minute flight from Oulu (OUL) to Helsinki (HEL) was simulated (Figure 4). The flight was built to include several different unpredictable phenomena, the consideration and processing of which was the focus of our observation. These selected phenomena were manifests of 'ratty data' (Rerup, 2001) or 'weak signals' (Klein, 2011). They were not intended to trigger any prescribed abnormal or emergency procedures, but instead some anticipatory thinking (Klein, 2011).

Figure 4

Overview of the simulation flight



The flight was preceded by a short briefing on the operation to be carried out and on the required ethical aspects. This briefing was audio recorded. To be feasible in the simulator, the data collection was performed with two video cameras, one in the front of the pilots and one behind them. The main purpose of the front camera was to verify the sound recording of the pilots' discussions, while the rear camera mainly recorded the pilots' actions.

The flight was followed by a short, conversational interview with the pilots, during which they reflected on their thoughts and actions during the flight, and freely shared their thoughts of CRM, anticipation, resilience, and safety. The comments were recorded to supplement the observations from the flight concerned, and to allow possible additional information and comments by the crews.

During the observation, attention was paid to the anticipatory indicators (Table 3) that signified the crews' anticipation. These indicators were compiled from focus group discussions and interviews with the training manager and with the subject matter expert. The observable behaviours served as the basis for the initial observations in the simulator. Following the simulation, a brief conversation was conducted with the crews, providing an opportunity to discuss refinements as needed to support the observation and enhance the researchers' understanding of the crews' behaviour.

The Setup. The aircraft was an Airbus A320 with no technical defects or MEL (Minimum Equipment List) items. The aircraft zero fuel weight (ZFW) was 57,1 tons, which is within typical, acceptable range. Finnair Flight Academy's Airbus A320-200 simulator is an EASA D -certified full flight simulator. The engine selection in the observation flights was CFM56-5B. The simulator was fully operational during all observations, and artificial motion was used.

The environment in the departure airport of Oulu was partly cloudy, scattered clouds in 2200 feet with good visibility. The clouds included Cumulonimbus clouds (CB), and thunderstorms were reported in the vicinity. The temperature was relatively warm, and the winds were from the west, which led the crew to select westerly runway 30 as the departure runway. Generally, from the pilots' perspective, this kind of weather is good, but the reported cumulonimbus clouds and vicinity thunderstorms gave reason to be aware of the location and effect of the thunderstorms. For the route, weather was good and mostly VMC (Visual Meteorological Conditions), with some scattered to broken clouds below the cruise altitude.

Relatively strong tailwinds prevailed in the upper altitudes, which shortened the flight time a little and created a factor to be aware of, considering the descent profile. There was no significant turbulence.

Flight briefing material was given to the crew in a simulator, allowing them to perform a normal flight preparation. The briefing material consisted of weather information, NOTAMs, and other operational information pertaining to the flight.

Figure 5

Flight briefing material, METAR/TAF

EFOU - OUL - Oulu Airport

METAR:
SA 111220Z AUTO 26011KT 210V310 SCT020 BKN030CB 26/15 Q1011 VCTS

TAF:
FT 111128Z 1112/1212 25016G26KT CAVOK
TEMPO 1112/1115 BKN022CB -SHRA
BECMG 1115/1117 27010KT
TEMPO 1207/1212 27015G25KT

EFHK - HEL - Helsinki Airport

METAR:
SA 111220Z 21017KT 9999 FEW030 24/16 Q1019 NOSIG

TAF:
FT 111127Z 1112/1212 22018KT 9999 FEW030
BECMG 1117/1119 24005KT
TEMPO 1200/1204 1500 BCFG PROB40 1202/1204 0600 FG VV002
TEMPO 1204/1206 BKN006

EETN - TLL - Tallinn Airport

METAR:
SA 111220Z 24014KT 210V280 9999 BKN041 25/15 Q1021 NOSIG

TAF:
FT 111130Z RRX 1112/1212 26015KT 9999 FEW035
PROB40 TEMPO 1112/1115 27016G28KT
BECMG 1119/1121 20007KT
PROB40 TEMPO 1202/1205 0500 BCFG BKN002
TEMPO 1205/1206 BKN003
BECMG 1208/1210 28010KT

EFTU - TKU - Turku Airport

METAR:
SA 111220Z AUTO 25010KT 210V280 9999 FEW024 22/16 Q1019
TAF:
FT 111127Z 1112/1212 23011KT CAVOK
BECMG 1118/1120 VRB01KT
TEMPO 1122/1205 1200 BCFG PROB40 1200/1205 0400 FG VV002

EFTP - TMP - Tampere-Pirkkala Airport

METAR:
SA 111220Z 26013KT 230V290 9999 FEW036 23/15 Q1017

TAF:

FT 111127Z 1112/1212 24016KT 9999 FEW035

BECMG 1117/1119 30002KT

TEMPO 1123/1204 1200 BCFG

EFJY - JYV - Jyväskylä Airport

METAR:

Figure 6

Flight briefing material, NOTAM:s

Notams

EFOU - OUL - Oulu Airport

EFOU - B1508/22 - Aug 8, 2022 00:00 to Aug 30, 2022 23:59
OULU TWR OPR HR:
MON-FRI 0220-0320 0415-1915 2110-2225,
SAT 0220-0320 0505-0700 1005-1200 1310-1505 2110-2225,
SUN 0220-0320 0510-0650 1005-1200 1305-1800 2110-2225

EFOU - A1509/22 - Aug 12, 2022 00:00 to Aug 29, 2022 23:59
PAPI RWY 30 U/S

EFOU - A1510/22 - Aug 2, 2022 00:00 to Sep 02, 2022 23:59
LASER POINTING TOWARDS A/C REPORTED IN THE VICINITY OF AIRPORT.

EFHK - HEL - Helsinki Airport

EFHK - B1738/22 - Aug 12, 2022 00:00 to Aug 31, 2022 23:59
TWY ZS CLOSED.

EFHK - A1740/22 - Aug 2, 2022 00:00 to Sep 05, 2022 23:59
UNKNOWN DRONES OBSERVED AT THE VICINITY OF AIRPORT BLW 3000 FT.
ESTIMATED SUBCATEGORY A1 OR A2.

EETN - TLL - Tallinn Airport

EETN - O7/22 - Feb 1, 2022 00:00 to UFN
FINNAIR COMPANY NOTAM
CATEGORY B AERODOME.
THIS AERODROME IS CATEGORY B ONLY BECAUSE THE PUBLISHED CIRCLING MINIMA IS HIGHER THAN 1000 FT ABOVE AERODROME ELEVATION.
PLEASE FAMILIARIZE YOURSELF WITH OM-C AND ALSO WITH ADDITIONAL BRIEFING MATERIAL IF INDICATED IN CIS. CATEGORY B INEXPERIENCED STATUS RESTRICTIONS DO NOT APPLY.

EFTU - TKU - Turku Airport

EFTU - A1396/22 - May 25, 2022 00:00 to Sep 3, 2022 23:59
BACKTRACK NOT ALLOWED FOR A/C WITH MTOW 35000 KG OR MORE

EFTU - A1422/22 - Aug 18, 2022 00:00 to Sep 1, 2022 23:59
RWY 26 NOT AVAILABLE FOR LDG DUE SURFACE GROOVING. RWY 08 AVAILABLE SHORTENED.
TORA 1550/TODA1550/ASDA1550/LDA1550

EFTP - TMP - Tampere-Pirkkala Airport

No relevant NOTAMs available.

EFJY - JYV - Jyväskylä Airport

EFJY - B1566/22 - Aug 3, 2022 09:00 to EST Aug 29, 2022 13:00
ILS LOC RWY30 U/S

EFJY - B1600/22 - Aug 6, 2022 15:00 to Sep 03, 2022 23:59
JYVASKYLA TWR OPR HR:
AUG 06 0215-1900, AUG 07 0400-1830 2100-2200,
AUG 08 0215-1700, AUG 09-10 0230-1700,
AUG 11 0230-1700, AUG 12 0230-1545,
AUG 13-14 CLSD, AUG 15-19 0230-1545, AUG 20-21 CLSD,
AUG 22-28 0230-1200 AUG 29 - SEP 03 24H

EFJY - O9/22 - Feb 1, 2022 00:00 to UFN
FINNAIR COMPANY NOTAM
CATEGORY B AERODOME.
THIS AERODROME IS CATEGORY B ONLY BECAUSE THE PUBLISHED CIRCLING MINIMA IS HIGHER THAN 1
000 FT ABOVE AERODROME ELEVATION.
PLEASE FAMILIARIZE YOURSELF WITH OM-C AND ALSO WITH ADDITIONAL BRIEFING MATERIAL IF INDICATED IN CIS. CATEGORY B INEXPERIENCED STATUS RESTRICTIONS DO NOT APPLY.

EFJY - B1607/22 - Aug 8, 2022 12:54 to EST Sep 9, 2022 11:00
DVOR/DME LNE 112.300MHZ U/S

EFKK - KOK - Kokkola-Pietarsaari Airport

EFKK - B1553/22 - Aug 8, 2022 00:00 to Aug 30, 2022 23:59
KRUUNU TWR OPR HR:
MON-TUE 0635-0800 1500-1620,
WED 0635-0800 1500-1620 2025-2145,
THU 0155-0315 0830-0955 1500-1620 1725-1850 2110-2230,
FRI 0310-0430 0830-0955 1500-1620 1725-1850 2110-2230,
SAT 0440-0600, SUN 1455-1615

EFKI - KAJ - Kajaani Airport

EFKI - B1526/22 - Aug 8, 2022 00:00 to Aug 30, 2022 23:59
KAJAANI AFIS OPR HR:
MON-TUE 1420-1550, WED-FRI 0855-1020 1420-1550,
SAT CLOSED, SUN 1420-1550

EFKU - KUO - Kuopio Airport

No relevant NOTAMs available.

EFRO - RVN - Rovaniemi Airport

No relevant NOTAMs available.

ESSA - ARN - Stockholm Arlanda Airport

ESSA - A758/22 - Jul 1, 2022 06:49 to EST Aug 31, 2022 14:00
RWY 26 TKOF. DUE RISK OF ASPH DAMAGES AT THR RWY 26 FLW TWY X5 CL WHEN LINING UP.
SHARP AND BRAKE ASSISTED TURNS TO BE AVOIDED. NEW INTERMEDIATE DIST INT X5 TORA
2440 TODA 2440 ASDA 2440 LDA NOT AFFECTED.

ESSA - A668/22 - Jun 27, 2022 05:00 to Aug 30, 2022 14:00
RWY 01R/19L CLSD DUE WIP.

ESSA - X68/21 - Jul 22, 2021 00:00 to UFN
SX0068/21 AIP SUPPLEMENT
ESSA/STOCKHOLM/ARLANDA - HALOGEN INSTEAD OF LED RWY 01L/19R -
22JUL21-UFN
RWY 19R - RCLL, LED LIGHTS REPLACED BY HALOGEN LIGHTS.
RWY 01L - RCLL AND RTZL, LED LIGHTS REPLACED BY HALOGEN LIGHTS.

ESSA - A795/22 - Jul 8, 2022 12:52 to EST Oct 8, 2022 12:00
RWY CENTRE LINE LIGHTS RWY 08/26 LIGHTED DUE POOR DAYLIGHT
MARKINGS.

ESSA - A575/22 - May 31, 2022 13:00 to EST Aug 31, 2022 12:00
DME ANE/ARLANDA CH80X U/S

ESSA - A785/22 - Jul 6, 2022 14:26 to EST Sep 22, 2022 10:00
AUTOMATIC TERMINAL INFORMATION SERVICE (ATIS). D-ATIS U/S.

ESSA - A733/22 - Jun 28, 2022 14:35 to EST Aug 31, 2022 14:00
RWY 08 TKOF. DUE TO RISK OF ASPH DAMAGES AT THR RWY08 FLW TWY X2
CL WHEN LINING UP. SHARP AND BRAKE ASSISTED TURNS TO BE AVOIDED. NEW INTERMEDIATE
DIST INT X2 TORA 2397/TODA2697/ASDA2397. LDA NOT
AFFECTED.

The Phenomena.

Danger of laser pointing. The simulation scenario included the possibility of a laser pointing towards aircraft near Oulu airport. For Finnair pilots, no prescribed procedure exists on how to avoid possible laser pointing. This is left to the pilots´ consideration and judgement. For an actual laser attack, there is a procedure which aims at minimising risk of an eye injury and ensuring safe operation.

The crew were given two signals: the first one was a mention of it in the preflight NOTAM that the crew read in the flight preparation. The second signal came from the Air Traffic Controller, who gave an advisory about the possibility during the beginning of the taxi: *"Finnair 2PD, be advised that occasional laser pointing has been observed in the vicinity of the airport".* In the simulation, the actual attack never took place. The only question was how the pilots anticipated and prepared for the possibility of such an event.

Figure 7

NOTAM about laser pointing activity

EFOU - OUL - Oulu Airport

EFOU - B1508/22 - Aug 8, 2022 00:00 to Aug 30, 2022 23:59
OULU TWR OPR HR:
MON-FRI 0220-0320 0415-1915 2110-2225,
SAT 0220-0320 0505-0700 1005-1200 1310-1505 2110-2225,
SUN 0220-0320 0510-0650 1005-1200 1305-1800 2110-2225

EFOU - A1509/22 - Aug 12, 2022 00:00 to Aug 29, 2022 23:59
PAPI RWY 30 U/S

EFOU - A1510/22 - Aug 2, 2022 00:00 to Sep 02, 2022 23:59
LASER POINTING TOWARDS A/C REPORTED IN THE VICINITY OF AIRPORT.

Thunderstorm in the take-off sector. Another issue was about a thunderstorm nearby, in the take-off sector. Procedurally, the crews are strongly advised to avoid thunderstorms. They have been instructed to recognise the risk of a windshear during takeoff and landing if a thunderstorm occurs in the vicinity. However, what is 'vicinity' and how far and how strong should the thunderstorm be to be relevant in terms of avoidance at takeoff is left to the pilots' judgement.

The pilots received a few signals of the thunderstorm during flight preparation. The first and weakest signal was a rattling sound in their loudspeakers, which indicated possible electric activity nearby. The second signal was the present weather in the ATIS broadcast, which included the abbreviation "VCTS", standing for "vicinity thunderstorms". Thirdly, the pilots visually saw the thunderstorm ahead when lining up into the runway. They were also able to see it in the weather radar and analyse its distance and strength.

Figure 8

Front view towards departure sector EFOU Runway 30

Figure 9

Front view towards departure sector with weather radar display

Momentary loss of fuel quantity indication. When passing 8000 feet, a momentary loss of fuel quantity indication occurred. It was temporary and disappeared by itself shortly after the pilots made a first observation about it. After this, the fuel indication functioned normally.

Procedurally, the crews are allowed to disregard a malfunction which disappears by itself or after a reset. In other words, there are no prescribed procedures to be performed. If the pilots want to analyse the malfunction, or anticipate and prepare for it occurring again, it is left to their discretion.

Figure 10

Fuel quantity indications lost on fuel system display

Momentary Avionics Smoke warning. When passing approximately FL260 (26 000 feet), a momentary "AVIONICS SMOKE" warning was triggered in the aircraft's ECAM (Electrical Centralised Aircraft Monitor) system. The warning disappeared by itself after approximately three seconds, to allow crew to clearly observe it, but not to take any action or start the associated procedure.

Procedurally, the crews are allowed to disregard a malfunction which disappears by itself or after a reset. In other words, there are no prescribed procedures to be performed. If the pilots want to analyse the malfunction, or anticipate and prepare for it occurring again, it is left to their discretion.

Figure 11

Master caution (attention getter) after avionics smoke caution

Figure 12

Avionics smoke indication on ECAM and system display

Figure 13

Avionics smoke related indication on overhead panel

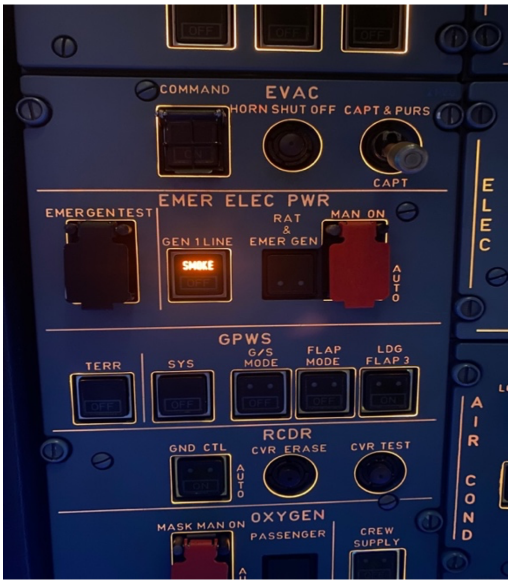
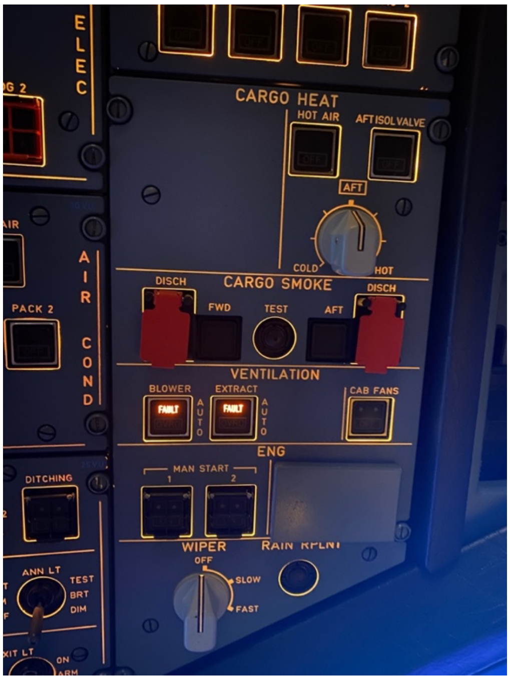


Figure 14

Avionics smoke related indication on overhead panel



Report of possibly worsening condition of a passenger. The cabin attendant who acted as the chief of cabin made a call with the interphone, and noted that one passenger in the front section, an adult male, had turned prominently pale. He was not showing any other symptoms of sickness, and in the chief of cabin's opinion, no imminent actions by the crew were necessary at this point. Therefore, no procedures were intended to be performed, just anticipatory behaviour in case the situation were to get worse.

Signs of a high descent profile. In the descent phase, the scenario directed the pilots to anticipate an exceptionally steep descent profile, and how to manage it. They were given two separate signals of this. The first and weaker signal was a mention of a military exercise near Helsinki in preflight CIS. It would reserve the airspace up to FL160 and could affect descent profiles. Another, stronger signal was the Air Traffic Controller, who upon reaching FL240 advised the pilots that further descent was to be given later: "Finnair 2PD, expect further descent 15 NM AFTER LUSEP", which in practice means that the aircraft was about to remain several thousands of feet above the optimal descent path.

Figure 15

Operational information about military exercise

OPERATIONAL BULLETIN

EFIN MILITARY EXERCISE

Finland and United States (USS Kearsarge) military exercise is held 8.8 - 19.8.2022 over the Southwest part of the EFIN FIR. This has some effects to EFHK departing and arriving traffic depending on the used runway combination. Most military traffic is between 9-14LT causing some extra flight miles compared to the normal traffic flow.

The affected area has an upper limit of FL130, which means that other traffic is able to fly over the exercise area FL150 or above. Departing traffic toward west is most likely vectored close to LAKUT to reach at least FL150. Also, arriving traffic might have an altitude restriction FL160+ over LAKUT.

Elevated risk of a go-around. The scenario directed the pilots to anticipate an elevated risk of a go-around. There were two signals given: the first was a preflight NOTAM which mentioned unknown drones observed in the vicinity of Helsinki Airport.

Figure 16

NOTAM about drone activity

EFHK - HEL - Helsinki Airport

EFHK - B1738/22 - Aug 12, 2022 00:00 to Aug 31, 2022 23:59
TWY ZS CLOSED.

EFHK - A1740/22 - Aug 2, 2022 00:00 to Sep 05, 2022 23:59
UNKNOWN DRONES OBSERVED AT THE VICINITY OF AIRPORT BLW 3000 FT.
ESTIMATED SUBCATEGORY A1 OR A2.

As with lasers, there is no prescribed procedure for the Finnair pilots on when avoiding drones is necessary, and how to do it. In other words, it is up to the pilots' consideration. However, the pilots understand that a collision with a drone is definitely undesired and can lead to major damage depending on the impact and the size of the drone. Therefore, an imminent and observed risk of a strike with a drone during an approach would make a strong rationale for a go-around.

Another signal for a possible go-around was received on the Helsinki Tower airport frequency. At approximately eight nautical miles final approach, the pilots were instructed to change to Tower Frequency 118.6 MHz. Immediately after tuning to the frequency, they heard a transmission: "Tower, Finnair six heavy going around from 22L", to which the tower replied: "Finnair six, roger, contact radar 129,85 MHz". In other words, they heard the preceding aircraft in approach making a go-around due to an unknown reason. A drone sighting could not be ruled out, but the reason remained unknown. Eventually, no reason for go-around actually occurred, and the pilots were given a landing clearance in the short final approach.

Ethical Aspects

In the aviation industry, almost every activity is clearly defined and proceduralised, making the industry very secure and protected. This thesis likewise aims to meet the applicable rules and guidelines for transparency and credibility of our research study. Ethical questions were discussed before the research to understand the ethical implications of the research and how to take them into account in the design of our study. The ethics codes of Lund University (https://www.researchethics.lu.se/) were also consulted to meet the criteria from the very beginning. If in doubt, the University was consulted.

Agreed-upon standards for research ethics help ensure that, as researchers, we explicitly consider the needs and concerns of the people we study, that appropriate oversight for the conduct of research takes place, and that a basis for trust is established between researchers and study participants (Mack et al., 2005, p. 8). We believe that this was an absolute prerequisite for the conduct of our research and also a condition that allowed us to get important volunteers for our research.

As a social event, research has its own set of interactional rules which may be more or less explicit, and more or less recognised by the participants. Our responsibility as researchers was to consider things that our candidates may not even understand for their protection. During the briefings, the observants were made aware of their right to withdraw from the project or raise a concern at any time.

The information collected from simulator sessions were video recordings and observations, and thus confidential by their nature, which raised ethical considerations. We clearly presented to the observants what was recorded and how, how the recordings would be stored, how it was used, analysed, and protected, and how it will be finally destroyed. There was no official or operational use of the data other than for anonymous research purposes. We even replaced names with numbers because names are irrelevant in our study. In order to create trust between researchers and observants, the agreements, both ways, were consented to before the study.

Our organisation was aware of our research study, and we were supported by the company by providing spare simulator capacity for the use of our research study. Although a normal and fully operational simulator was used for the research, it did not have any official effects on the licences and qualifications of the attending crew members. This was important to clarify. There was no push from the company side for the observants because the observation was a separate study, and the information did not go to the company. We did not receive any financial support for the study, thus there was no external push from our company or any other instances.

By nature, the focus groups were interactive and communicative, revealing personal information, opinions, and experiences, and thus containing confidential information. At the same time, it was impossible to predict what exactly would be discussed, nor to guarantee that the discussed information would stay in the room. The authors' task was to make sure that information from the conversations was used only for research purposes, but it must be noted that we as researchers did not have control over the information outside the room, although the focus group was guided by the authors, who also acted as moderators, to stay on the topic and conversations were controlled for possible harm/escalation. Before the event it was also important not to talk about the topic in any detail to avoid influencing what people said during the discussion.

Interviews were face to face and video conference conversations with particular topics in mind. To be able to get most out of the conversations, the data from the interviews needed to be secured and protected, and anonymity ensured just like in the focus groups. Unlike focus groups, information management was clearer because there were only two information holders at a time.

Research Limitations

We needed to acknowledge the limitations, influences, and biases which affect our own approach to the study. It is sometimes useful to attempt to view our own research from a distance, as an outsider (Blaxter et al., 2010, p. 243). The perspectives and previous experience of the researchers on the topic under study undeniably have implications for the conduct of the research.

Both researchers have also worked for a long time as the company's CRM trainers, which has shaped their perspective on the topic. This background, wearing a 'practitioner's hat' has exposed us to a certain bias, and been a challenge as the research itself requires an objective, scientific mindset. This bias has been minimised by systematically and critically reviewing each other´s thoughts and with appropriate critique from our supervisor.

The use of different languages, Finnish during one interview and both focus groups, and English for the thesis writing, is recognised as a limitation in our study. The translation process was made with careful attention to ensure that the ideas are accurately retained in the study despite the language transition.

Findings

Document Analysis, EASA Regulation

Aviation is structured by rules and regulations, the majority of which are issued by the aviation authorities. In the European area, the EASA (European Aviation Safety Agency) is the highest aviation authority, whose regulation of the administrative procedures and technical requirements for air operations (EC 965/2012) is a framework for all commercial aviation operations. Due to its crucial role, it is necessary to examine, as a part of our research, how this regulation deals with anticipation as a resilience contributor.

EASA's (2021) definition of Flight Crew resilience is: "the ability of a flight crew member to recognize, absorb and adapt to disruptions" (p. 180). This definition is short, emphasises reactivity, and is affiliated to an individual crew member. In other words, it misses the forward-looking aspect, and disregards the systemic nature of resilience.

The EASA (2021) publication is divided into three parts: 1) the Regulation itself, which is binding and has a legal status; 2) the Guidance Material (GM), which gives recommendations on the adoption and application of the regulation; and 3) Accepted Means of Compliance (AMC), which describes the ways in which a member state has adopted the regulation, said ways thus being allowed for all States.

The regulation itself only states for whom and at what intervals CRM training shall be provided. It does not describe requirements for the training contents itself and does not include any references to resilience. The AMC part (AMC1 ORO.FC.115 Crew resource management (CRM) training) lists elements of CRM training:

1. Automation and philosophy in the use of automation
2. Monitoring and intervention
3. Resilience development, which is divided into:
    a) Mental flexibility and
    b) Performance adaptation
4. Surprise and startle effect
5. Cultural differences

6 Operator's safety culture and company culture, and

7 Case studies

The descriptions of points 1-6, their subpoints, or even subpoints 3a) and 3b), do not mention anticipation or any forward-looking actions or behaviour, such as what Klein (2011) describes. The same part also incorporates a CRM training syllabus, which lists and separates the elements for different initial and recurrent CRM courses (Table 2). The same conclusion can be drawn, no anticipatory elements such as what Klein (2011) describes are listed.

Table 2

Flight Crew CRM Training syllabus, according to EASA AMC1

CRM training elements	Initial operator's CRM training	Operator conversion course when changing aircraft type	Operator conversion course when changing operator	Annual recurrent training	Command course
General principles					
Human factors in aviation; General instructions on CRM principles and objectives; Human performance and limitations; Threat and error management.	In-depth	Required	Required	Required	Required
Relevant to the individual flight crew member					
Personality awareness, human error and reliability, attitudes and behaviours, self-assessment and self-critique; Stress and stress management; Fatigue and vigilance; Assertiveness, situation awareness, information acquisition and processing.	In-depth	Not required	Not required	Required	In-depth
Relevant to the flight crew					
Automation and philosophy on the use of automation	Required	In-depth	In-depth	In-depth	In-depth
Specific type-related differences	Required	In-depth	Not required	Required	Required
Monitoring and intervention	Required	In-depth	In-depth	Required	Required
Relevant to the entire aircraft crew					
Shared situation awareness, shared information acquisition and processing; Workload management; Effective communication and coordination inside and outside the flight crew compartment; Leadership, cooperation, synergy, delegation, decision-making, actions; Resilience development; Surprise and startle effect; Cultural differences.	In-depth	Required	Required	Required	In-depth
Relevant to the operator and the organisation					
Operator's safety culture and company culture, standard operating procedures (SOPs), organisational factors, factors linked to the type of operations; Effective communication and coordination with other operational personnel and ground services.	In-depth	Required	In-depth	Required	In-depth
Case studies	In-depth	In-depth	In-depth	In-depth	In-depth

In the GM part (GM4 ORO.FC.115 Crew resource management (CRM) training), there are four bullet points that are familiar to us from Hollnagel, providing guidance for resilience development: the abilities to 1) learn, 2) monitor, 3) anticipate, and 4) respond. Additionally, it states that "Operational safety is a continuous process of evaluation of and adjustment to existing and future conditions" (EASA, 2021, p, 407), and "resilience development involves an ongoing and adaptable process including situation assessment, self-review, decision and action" (p. 407). The same GM also lists how 'mental flexibility' and 'performance adaptation' – which are listed in AMC1 – should be understood, but it does not address anticipatory actions (p. 408).

These above-mentioned parts are those where resilience is defined and explained, and where training elements are described. Hollnagel's four bullet points (alone) do represent the wider view, but they remain detached from other parts of the text and are not otherwise supported. The parts are somewhat incoherent and partly contradictory. Looking at the whole publication, it seems that a strong sense of the EASA's short definition "the ability of a flight crew member to recognize, absorb and adapt to disruptions" (p. 180) remains.

What can we conclude? The publication gives a narrow view of resilience, presents it as a reactive capability, not a process, and addresses the individual as a resilience unit. It also seems that the publication does not correspond with the views from the scientific literature and the research upon the topic. Therefore, we question the effectiveness of the regulation and its ability to convey the modern views on resilience to states and operators and their training. Concerning how essential resilience is, we argue that the regulation does not address safety in an optimal way.

Interviews

The Training Manager

According to the Training Manager, resilience has been a part of CRM training for a long time, but its importance has become even more important with EBT (Evidence Based Training). According to him, the EASA regulation mandates that crews be trained in resilience but does not provide direct answers on how. His experience was that it is left to the operators, and in Finnair's case, a lot of emphasis has been placed on the EBT concept which Finnair has implemented.

EBT is a recurrent flight training and assessment concept for pilots. It is characterised by developing and assessing a range of core competencies rather than by measuring performance in individual manoeuvres. Mastering a finite number of competencies should allow a pilot to manage unforeseen situations in flight for which the pilot has not been specifically trained (ICAO, 2013, p. I-1-1). Regardless of this, the training manager's picture of resilience itself seems to follow the EASA's (2021, p. 180) definition of resilience closely: he said that "resilience is the ability to bounce back from the unexpected. That means the ability of a pilot or the flight crew to resume the previous level of performance after a surprising event".

The training manager commented that observing the existence – or lack of – resilience is challenging. The challenge is at the individual level, "when you cannot get inside the person's head and you have to observe the visible achievements, the output". The manager stated that the instructor or examiner might not distinguish whether the output was really about a conscious process, and whether it was the outcome of that person having good resilience or if it was just luck that the right measures happened to be taken.

When the training manager talked about 'getting inside one's head' and about 'a conscious process', the researchers observed a connection to the aforementioned traps of the EASA regulation. Bergström & Dekker (2019) specifically criticise the regulation for its behaviourist approach, and responsibilisation of the sharp-end operators, which has little support in academic traditions (p. 421). The training manager admitted that resilience is an abstract topic and difficult to measure. "There is no such clear measure or definition for resilience. Or what would be the minimum level of resilience that should be achieved."

Anticipation was brought into the discussion by the researchers. Prior to that, the interviewee did not mention it. The training manager acknowledged that "with anticipation the crew can, in advance, prepare themselves to face unexpected situations and thus to be one step ahead of the situations". This notion, 'staying ahead of the aircraft', has also been used by Rankin et al. (2016) who described anticipatory thinking as being an important part of the pilots' strategy to help in sensemaking and re-framing in case of surprises (p. 632-633). The training manager noted that the regulation does not pay attention to anticipation, nor mention how to train it. The training manager himself connected anticipation to experience:

> With the accumulation of experience, we have been involved in various situations and perhaps know how to anticipate a little more widely, what possible variations there may be in situations, what may possibly happen, and what kind of chain of events can begin from an occurrence.

The training manager connects the idea of anticipation with the TEM (Threat and Error Management) philosophy. He mentioned that Airbus was changing its crew briefings to follow TEM-based philosophy, and Finnair was about to implement the same change. “One part of Threat and Error Management is that the threats are observed and anticipated. And that some kind of mitigations and preparedness are created as a follow-up.” The training manager highlighted certain predefined moments during the operation when those TEM briefings are conducted:

> If you think about the phases of the flight, then take-off and initial climb and then on the other hand the approach and related activities are in a certain way the most operationally active sections where these briefing practices and templates have traditionally been created, and it is natural that the utilisation of the TEM model is also highlighted there, but definitely it is present all the time in special places on the route, such as e.g. in the area of high terrain, in oxygen escape procedures, during a crew change in multi-crew operations, and in this type of situation where it should definitely be used.

When asked about how anticipation shows and becomes visible, the training manager mentioned communication, “The appearance of anticipation in the flight crew’s actions is strongly linked to the crew’s communication skills or the strength of the communication competence. If the crew members are strong in that area, then it is considerably easier for the trainer to observe that anticipation.”

From the interview of the training manager, the researchers derived the following set of categories associated with anticipatory behaviour:

- Relating past experience into the current situation
- TEM-based briefings
- Proactive communication
- Preparing for different situations (single pilot)
- Preparing for alternative operating models

The Subject Matter Expert

The subject matter expert expressed that in the process of designing the EASA CRM regulation, resilience was recognised as an important item that should be emphasised in the training of all safety-sensitive personnel. The book "Resilience Engineering in practice" by Paries, Hollnagel, Woods and Wreathall (2011) was used as inspiration. The purpose was to fit these ideas and cornerstones into the regulation text, but the limited word count became a challenge. It was just not possible to describe the complete principles in the regulation text.

He also described the problem created by the force from the airline industry, whose interest is lowering the requirements for CRM training. "Lots of companies try to limit the portion of CRM training as much as possible. So how to get all these elements of CRM as set in the table alive in two hours' time yearly? That is a super challenge." He also mentioned that the minimum time required for CRM recurrent training had been cut down to 6 training hours over a period of 3 years, and that the airlines who were implementing EBT concepts wanted to get most of the CRM training elements embedded in the simulator. He added:

> There's also these new EBT approach to these which puts lots of things in the simulator, where to my understanding it should be in the classroom, or at least a combination thereof. But there's lots of things are cut down tremendously, that is what I do see in the industry, which is very unfortunate.

Under these constraints, it was decided in the rulemaking task group .0411 to include only the cornerstones of resilience in the text and leave the application to the training environment. But the subject matter expert admitted the introduction of a problem, "When you look at the regulation it does not tell 'how' but 'what', and this is already vague". This corresponds very well with the troubles that the airline training manager expressed in his interview.

Having come into force, the AMC/GM has been amended once, recently. However, the associated guidance in this context has not changed. Neither has the CRM element 'resilience'. The subject matter expert recommended making the regulation more practical and less high-level. "We should tell people what they should focus on, for example work as imagined vs work as done." According to him, safety II principles should also be taken onboard more. "In simple words: it's not about what goes wrong but about things that go right, to do more of it. Instead of talking about the bad stuff, start about the good stuff."

With regard to the definition of resilience, the subject matter expert said that the nature of resilience has been widely misunderstood due to the vague regulation. "Seeing resilience as capability to bounce back is missing the point of resilience. That is simply taking the Hollnagel definition and leaving 90 % of the definition out." He expressed that the nature of the regulation leads to a situation where lots of organisations are tempted to limit the portion of CRM training as much as possible. He criticized the role of the authorities, "In the end, companies need to set up a programme which needs to be approved by the authorities, and as authorities are not looking into it, then you can cut things down like hell."

He had learnt that organisations have separated departments who plan and conduct simulator and ground training. In his opinion, this separation creates challenges: "You have to have the knowledge and you need to have the education to train people in these topics (CRM-training), yet that is not naturally given to a simulator instructor." He suggested better integration of the CRM classroom training and the simulator training:

> I think what we all are dreaming of is an integrated approach. And EBT, for example, would be a fantastic opportunity to link things. To put things together, so that you can have some in the

> ground part, and then put it into an active mode, and make the link. Unfortunately, that link is not, it's not lived out there.

When questioned about the role of anticipation in resilience development, the subject matter expert said that it is essential. He stated that anticipation emerges from experience and the situations that have been experienced before. "The more chair flying you do, the more you think about certain scenarios. The more plans you have in your long-term memories, the more you can retrieve." He also praised those learning experiences and courses where pilots are allowed to come together and exchange experiences. He considered them good opportunities to gain expertise.

The interview with the subject matter expert occurred subsequent to the observations. Therefore, the interview did not generate categories linked to anticipatory behaviour that could have been utilised during the observations. However, the researchers identified the following set of categories associated with anticipatory behaviour:

- What if -thinking
- Relating past experience into the current situation
- Contingency planning
- Proactive communication

Focus Groups

CRM Instructors

Among this group, discussion was lively and several interpretations of resilience were expressed. The spectrum and variability of interpretations was notable. To name a few:

> "Catching a pencil before it falls to the floor is resilience." (CRMI 2)
>
> "Resilience is the required reaction to change." (CRMI 2)
>
> "Resilience is the ability to prioritise primary tasks over secondary ones." (CRMI 4)
>
> "Every time we drop out of the focus area, our resilience appears weak." (CRMI 1)

The researchers' attention was drawn to the fact that resilience was often referred to as 'resilience-ability'. This expression leans strongly on the interpretation of resilience being a noun, in contrast to Woods' (2018) argument that resilience is a verb. Moreover, in the discussions, the resilience of a larger system was regarded as a sum of the resilience-ability of individuals in the system. However, with regard to the resilience unit, other perspectives appeared. CRMI 3 commented, "We can talk about the resilience of the flight deck, we can talk about the resilience of the entire crew, we can talk about the resilience of one operation or even the resilience of the entire company." However, an ensuing comment expressed that all individuals are not equal: the lack of resilience-ability in one individual (such as a cabin crew member) would not collapse the whole system's resilience, but lack of resilience-ability in a key person (such as the captain) could possibly do it. For the researchers this discussion quite strongly underlined 'the reductionist trap', described by Bergström and Dekker (2019).

Understanding that the need for resilience comes from the increased complexity and ambiguity of aircraft systems came up in the discussion:

> Today's pilots need even more resilience because airplanes have become so complex. In the past, mechanical laws and meanings could be established, but today the operation of a machine is like a spider's web; no one necessarily knows what the changes will affect in the event of a failure. Because of this, today's resilience has become a more important feature for us pilots than it was before. (CRMI 3)

The group was very coherent regarding the meaning of experience that CRMI 2 noted, "The effect of experience is related to previous situations and the working practices learned from them, escalation and action models, because without experience you have nothing." CRMI 3 commented that "it really makes a difference whether you have flown for one year or 25 years here". The group repeatedly referred to mutual storytelling, professional discussion, and sharing examples and other crews' previous experiences as a valuable substitute for one's own experience. "Going through cases is a very good way to build resilience, because there you kind of absorb others' experiences, so cases are very helpful" (CRMI 1). This power of storytelling was also endorsed by Klein (1998), who also noted that it has not been well studied by decision researchers (p. 27). Additionally, CRMI 2 gave an interesting perspective before the researchers brought the topic to the table:

> "Once, I felt that in a flight deck resilience wasn't terribly good, because I couldn't sense what phase the guy was going through." This perspective meets the Training Manager's comment on how resilience thrives in active, mutual communication.

After the researchers brought anticipation into the conversation, CRMI 3 summarised the entire group's thoughts:

> Anticipation increases resilience, but if you don't leave any room for the possibility that something completely unexpected could happen now, your gloves may fall off. I think that's why perfectionists don't do well or aren't good in the flight deck because nothing can go wrong.

This comment reflected the consensus that there will always be total surprises, things that cannot be anticipated. But on the other hand, anticipation can build resilience. It also underlines adaptability and flexibility as aspects of resilience. When questioned where the anticipation of pilots comes from, the view of this group was that the seeds of anticipation are planted in the basic flight training of pilots and by the time, they become a prevalent character trait of a pilot. And that anticipation and taking threats into account in advance is part of a pilot's everyday work. CRMI 3 said that anticipation is not only limited to professional work, but instead it applies to everything, even to life in general.

It was mentioned that even though it is very human to think about positive things and where we want to go, one should always try to find these side effects and think how situations might escalate. "You try to form an overall picture of all the little signals you get from paper, from the sky, how this thing might go, and if there are any risks. Isn't that exactly what a pilot's job is?" (CRMI 4). CRMI 3 made an interesting connection between complexity and anticipation: "As experience, crew, and technology increase, the environment only becomes more complex, requiring system management, including anticipation." This comment directly reminds us of Klein's (2011) last of the three anticipation forms, 'convergence', and demonstrates its necessity in aviation.

From the focus group discussion with CRM instructors, the researchers derived the following set of categories associated with anticipatory behaviour:

- Communicating proactively
- Relating past experience into the current situation
- Contingency planning
- What if- thinking
- TEM-based briefings
- Seeing the big picture (prioritizing)
- Acknowledging future complexity
- Out of the box- thinking
- Preparing for alternative operating models
- Reading small signals
- Thinking ahead

Type Rating Instructors

In the discussion among the type rating instructors, it became clear that resilience was a hot topic, but they have not been given a solid or uniform definition of it.

> "It has never been discussed between instructors or examiners in any meeting what resilience is concretely" (TRI 2).
>
> "What I miss in our company would be this kind of resilience training" (TRI 1).
>
> "Training should give us tools as pilots to find our own ways to develop our own resilience" (TRI 1).
>
> "It seems that we don't really have any concrete definition in the company, that is how we see resilience" (TRI 2).

Many descriptions were heard, and resilience was even seen as an ambiguous term with no concreteness. However, those descriptions that were given mostly reflected the 'bounce back' type of resilience, just like with the training manager and with the CRM instructors. But there were differences too. Where the CRM instructors had a relatively strong reductionist starting point, emphasising the individual, the TRIs made more comments where resilience was understood to apply at the crew or the systemic level as well. TRI 2 concluded, "A system, team or individual is error-tolerant, i.e., resilient, when it falls outside the normal range and is able to get back to the normal range. The starting point is the ability to bounce back."

Another comment from TRI 4 highlighted the difference from the CRM instructor group, who emphasised 'resilience-ability', "I see resilience at the personal and operational level of the crew as learned through experience, not purely theoretical or an innate skill of the individual." Experience was mentioned several times as a resilience builder: "There are many things in the operational environment that can only be anticipated through experience."

However, training was given credit as well. The TRIs saw it largely through the lens of EBT (Evidence Based Training). Much of the talk at the table touched on the subject, just as with the Training Manager. TRI 2 commented, "As a concept, resilience has come along with the EBT concept. Resilience is guaranteeing the safety of operational activities, that all components are resilient." One of the interviewees suggested that anticipation would fall under the scope of situational awareness, which is one of the EBT competencies.

> The situations that undermine our resilience and remove us from the normal range are so diverse that no one can define them in advance. That is why we have come to the idea that by developing certain competencies we can get back to the normal range, no matter what happens. This is the idea of the EBT. (TRI 3)

How could resilience be seen or observed, then? TRI 1 connected it to monitoring: "Resilience can be seen in normal operation, for example as the monitoring of FMA modes," and TRI 4 to vigilance and communication, "Resilience can be seen in normal operation as vigilance and completion, as good communication.” But the view that resilience is – after all – invisible, something “inside someone’s head” was also presented.

> Resilience is a strongly experienced thing. Perhaps results would be achieved by self-evaluation. It is difficult for an outsider to say directly, he sees the concrete things, but you cannot see what is happening inside the head. Perhaps a professional can see gestures and expressions, but not with us. (TRI 1)

The TRIs did not support assessing resilience, partly because they experienced it as being invisible or hard to observe, but also because of the lack of standards. TRI 2 said: “We don’t use this assessment because we don’t have a common standard.” Resilience was seen more as a non-observable outcome of observable EBT competencies. “I think resilience is the outcome. It’s the outcome of those competencies, things that are evaluated” (TRI 4).

Anticipation as a resilience builder was recognised when the researchers brought it up to the table. The discussion of anticipation led into a discussion of Threat and Error Management (TEM). TRI 3 noted that they are related topics, “We are now training briefings using the threat and error management model... thinking in advance about the highlights that we want to deal with in advance and how to do it.”

From the focus group discussion with type rating instructors, the researchers derived the following set of categories associated with anticipatory behaviour:

- Implementing tentative decision-making protocols
- TEM-based briefings
- Relating past experience into the current situation
- What if- thinking
- Acting ahead of the situation
- Identifying potential threat and error factors
- Presenting threats in advance
- Contingency planning

Observations

During the observations, the researchers employed a set of indicators (Table 3) to identify instances of anticipation in the flight deck. These were derived from the interviews and focus group discussions, where coding was utilised to identify common categories. These indicators formed the foundation for observing the behaviour of the crews in the simulator. It is worth noting that the indicators were allowed to overlap, meaning that part of the communication or certain actions could be connected to multiple indications simultaneously.

Table 3

Indicators of anticipation

Monitoring system status
Acting ahead of the situation
Communicating proactively
Using automation to be able to focus on essential
Relating past experience into the current situation
Preparing for alternative operating models
TEM-based briefings
Seeing the big picture
What if -thinking
Out-of-the-box -thinking
Implementing tentative decision making protocols
Identifying potential threat and error factors
Contingency planning
Acknowledging future complexity

As simulations progressed and the researchers' understanding of the crews' behaviour deepened, they began to notice both similarities and differences between the crews. Additionally, disparities between original expectations and the actual observations made started to become visible. (Table 4).

The table displaying the observed anticipatory behaviour (Table 4) provides a comprehensive list of indications noted during the simulator sessions. It is worth noting that the listed, pre-compiled indications (Table 3) differ somewhat from the actually observed behaviour of the crews. While some of the expected indications were repeatedly observed in the crews' actions, others remained entirely absent. Also, such anticipatory behaviour was observed which the researchers were not expecting based on the earlier data collection.

For example, the indication 'Prepares for alternative operating models' was consistently observed across all crews. This behaviour was shown when the crews prepared for potential laser pointer activity by avoiding simultaneous observation (one crew) and discussed designating a sole crew member to control the aircraft in case of glare (one crew). Additionally, two crews prepared for possible laser by adjusting the cockpit lighting, while all crews discussed avoiding direct gaze towards the light source. Other indications included engaging autopilot earlier (three crews) and maintaining active communication between crew members regarding the issue at hand (one crew).

On the other hand, the indication "Discussion of future complexity" was not directly encountered during the observation. Although contingency planning closely resembled the aforementioned behaviour, it failed to address the complexity factor due to workload and some operational issues.

Table 4

Observed crew actions and anticipatory behaviour

	CREW 1	CREW 2	CREW 3
Crew experience	Capt: 20 yrs / 14 yrs as captain Cop: 4 years	Capt: 12 yrs / 1 mo. as captain Cop: 6 years	Capt: 17 yrs / 1 year as captain Cop: 13 yrs
Laser pointer	Turn right away ■ File a report if occurs ■▲ No lookout simultaneously ▲● A/C control to functioning vision ▲	Increase of cockpit lighting ▲● Avoid looking directly ▲▲	Avoid looking directly ▲● Radios to other pilot ▲ Use of autopilot ■
Thunder cloud	Weather radar on and "eyes open" Eye on the outside conditions Use of autopilot ■ One last look to the horizon Engine failure path ▲● Use of TOGA thrust ■ Earlier turn towards the route ■ Idea of wind shear ▲●	Weather radar on Earlier turn after departure ■	Use of TOGA thrust ■ Wind check Procedure for windshear rehearsal ▲●
Fuel indication	Review of fuel at eng start Fuel calculation (FOB + used) Possibility of system reset ▲ Probability of sensor failure ■ Requirements for the rest of flight ■▲ Estimating arriving traffic flow ■▲ Selection of lower cost index ▲ Maintenance consulting QRH for abnormal procedures ▲ MEL consulted Tentative FORDEC ● Alt airports along the route + weather ■▲●	Fuel quantity looks "rational" ■ Unchanged amount extra fuel	Fuel amount at departure Sum of indicted and fuel used Extra eye on fuel at each waypoint Review of the system pages ■ Review of weather ▲
Avionics smoke	Memory items or OEB´s? ▲ System pages ■ Maintenance consulted Failure relation ▲ Call to the chief of cabin ■ Review of alternate airport + wx ■▲▲● Actions on ground if smoke ▲▲	No smoke or unusual smell ● Logbook for previous warnings ■	No unusual smell ● Review of system pages ■ Status of circuit breakers Traces of smoke across panels ● Emergency actions review ▲● Alternate airport review wx + friction ▲● Option to declare mayday ▲
Passenger	Consultation of MEDLINK Analysis of the flight time ■▲	Speed related to emergency	Inquiry of conciousness state ■ Possibility to announce doctor ▲ Status of alternate airports ▲ Approach charts of alternates opened ▲
Descend profile	Discussion about military airspace ■▲ Inquiry of profile from ATC ■ Reduction of airspeed ■	Possibility for L/G lowering for drag ▲ Half the speed brake available	NOTAM review ▲ Discussing extra fuel for holding ▲▲■ Review of actions if steep descent ▲ Possibility of L/G lowering for drag ▲

			Possibility to ask for extra miles ▲(blue) Speed brake partially available
Risk of g/a	Speed reduction Longer use of automation ■(green)▲(green) Inquiry of the reason for previous g/a ■(red) Review of go-around actions ■(gold)▲(gold)▲(green) Discussion of fuel reserves ■(red)▲(red)	Discussion of drone hazard ■(red)●(gold) Possible concequences of drones ■(red)■(purple) Alternate airport review ▲(red)▲(blue) Use of automation for possible g/a ■(green) Inquiry of the reason for previous g/a ■(red)	Full flap selection Inquiry of the reason for previous g/a ■(red) Review of go-around actions ■(gold)▲(gold)▲(green) Longer use of automation ■(green)

	CREW 4	**CREW 5**
Crew experience	Capt: 21 yrs / 14 yrs as captain Cop: 12 years	Capt: 20 yrs / 14 yrs as captain Cop: 6 years
Laser pointer	Keep eyes inside ▲(blue) Internal lights bright mode ▲(blue) Earlier use of automation ■(green)	Use of automation ■(green) Report to ATC, if occurs ■(red)▲(green) Keep eyes inside ▲(blue)
Thunder cloud	Weather radar on Use of TOGA thrust ■(gold) Possible circumnavigation path ▲(blue) Informing cabin crew ■(blue) Option for other direction takeoff ▲(purple) Earlier turn towards the route ■(gold)	Weather radar on Earlier turn after departure ■(gold) Possible circumnavigation path ▲(blue) Discussion of windshear possibility ▲(blue)
Fuel indication	Fuel calculation (FOB + used) Possibility of system reset Possible reappearance ▲(green) QRH system reset Review of system pages ■(blue) Several fuel checks during flight ▲(red)	Fuel calculation (FOB + used) Possible options to land ▲(blue)●(red) QRH ready and available ▲(blue) Estimate of fuel consumption ■(blue) Maintenance consultation
Avionics smoke	Review of suitable alternates ▲(red) Discuss of possible lighting strike ▲(red)▲(purple) Status of circuit breakers ■(blue) Review of QRH ▲(green) Maintenance consultation Possible fire discussed▲(green)▲(purple) Landing capability check ▲(red)	Consider using oxygen masks ▲(blue) Review of avionic smoke procedure ▲(green)●(red) Cabin contacted. all ok? ■(red) Worst case actions discussed ▲(red)●(red)▲(green) Maintenance consultation
Passenger	Possible need for ambulance ▲(green) Updated inquiries (2) from cabin ■(red)	Speed related to emergency
Descend profile	Possible different landing rwy ▲(purple) Landing lights = "minibrakes"▲(purple) To ask ATC about drones ■(red) One has constant lookout ▲(blue)	Discuss ways to catch profile ▲(blue) Several reviews of the profile ■(red) Wind direction considered ■(gold)
Risk of g/a	Plan for drone encounter ■(gold)●(gold) Inquiry of the reason for previous g/a ■(red) Discussion of possible drone impacts ■(red)■(purple)▲(red)	Reduction of speed ■(gold) Inquiry of the reason for previous g/a ■(red)

- ■(blue) **Monitoring system status**
- ■(gold) **Acting ahead of the situation**
- ■(red) **Communicating proactively**
- ■(green) **Using automation to be able to focus on essential**
- ■(purple) **Relating past experience into the current situation**
- ▲(blue) **Preparing for alternative operating models**
- ▲(gold) **TEM-based briefings**
- ▲(red) **Seeing the big picture**
- ▲(green) **What if -thinking**
- ▲(purple) **Out-of-the-box -thinking**
- ●(blue) **Implementing tentative decision making protocols**
- ●(gold) **Identifying potential threat and error factors**
- ●(red) **Contingency planning**
- ●(green) **Acknowledging future complexity**

Detailed description

Crew 1. Crew 1 was relatively experienced, especially the captain, who had 20 years of flying experience and 14 years as a Captain. The first officer had 4 years of flying experience.

Crew 1 did not react to the NOTAM mentioning laser activity during the flight preparation, so the first signal went unnoticed. When the ATC mentioned the issue, the crew stated that they would, in case they observed any green light, turn their sight away. They agreed that they would report to ATC about the attack and take further care not to look outside simultaneously. They also stated that in case either of the pilots encountered vision problems, aircraft control would be taken and maintained by the pilot with functioning vision.

The first signal of the thunderstorm activity, the rattling noise, also went unnoticed. The second signal, the weather information on the thunderstorm in the vicinity, drew their attention and triggered some anticipation during the departure briefing. The pilots decided to keep the weather radar on and "eyes open". They also decided to keep an extra eye on the conditions outside. The captain, who was the pilot flying, had a plan to fly the initial climb manually, but after reading the weather information, he said he would choose to use autopilot earlier, if any hazardous weather was observed. In any case, one last look at the weather and its effect on takeoff would be taken at the departure point.

During line-up into the runway and when they saw the actual thunderstorm, they analysed the situation and concluded that the departure route would turn left towards the route well before the thunderstorm. The co-pilot noted that the flight path in the engine failure procedure would go straight ahead towards the storm, whereupon the captain replied that in case of engine failure they would deviate from the engine failure path and follow the all-engine departure route. Just before takeoff, the captain also announced that to increase the safety margin, he would use full thrust (TOGA) in the takeoff, instead of 'FLEX' (reduced) thrust, which was the original plan.

After takeoff, the crew had a short discussion on the minimum allowed turning altitude and decided to ask the air traffic control for an earlier turn towards the route. It was unclear whether this was due to economic reasons or to increase distance from the thunderstorm. Afterwards, on the route, the crew still discussed the usefulness of including the wind shear situation in the take-off briefing.

After the momentary malfunction of the fuel quantity indication, the crew did a lot of troubleshooting and situational analysis. They calculated and verified the fuel quantity, comparing it to the fuel before the engine start and to the used fuel indication. They analysed the indications of the FUEL system page and found all correct. They discussed the possibility of a system reset, and how probable a sensor failure would be. They had a comprehensive discussion on the fuel requirements for the rest of the flight, including estimates of the arriving traffic, possible delays, and anticipated arrival route in Helsinki.

In addition, they selected a lower cost index into the flight management system to save fuel. This was done on a "just in case" -basis because they had no doubts about an erroneous indication. The crew reported the event to the maintenance with ACARS and examined the QRH (quick reference handbook) for possible related abnormal procedures, which did not exist. They also looked into the MEL (Minimum equipment list) for possible further information. They initiated a decision-making process ('FORDEC') and analysed the possible alternate airports along the route and checked their weather. This analysis was interrupted by the next momentary malfunction.

Regarding the momentary AVIONICS SMOKE warning: having seen the failure appear and disappear, the crew ensured that no 'memory items' or OEBs (Operational Engineering Bulletins) were associated with the AVIONICS SMOKE warning, though they were not mandated to do so since memory items and OEBs are only performed in case of an active failure. The crew also went through several systems pages to find any possible indications which could be related. They consulted the maintenance over the radio and asked whether the two failures could be related to each other. They also discussed if any smell of smoke could be observed and made a call to the chief of cabin to inquire about the same. Again, they reviewed their possible alternate airports and their latest weather. Finally, they had a discussion on possible actions on the ground after landing if there was smoke in the aircraft.

Upon receiving the call of the worsening condition of a passenger, the crew did not initiate any action but they decided that if the condition worsened, they could call for medical consultation with a satellite phone. They also made a short analysis of the flight time to destination, which was approximately 30 minutes.

During cruise and before starting descent, the crew discussed the altitude reservations by the military, which might affect the descent profile. In other words, the weak signals of profile challenges led to anticipation. During descent, the crew practised more forward-looking activity as they asked the air traffic controller about what their expected altitude at waypoint LUSEP would be. Finally, when the air traffic control announced that further descent would be delayed, the crew decided to reduce their airspeed as a proactive measure to facilitate re-establishing the optimal profile with a corresponding speed increase.

When the crew heard the announcement of the go-around of the previous aircraft, they immediately started to reduce their speed to minimum approach speed to allow time and space for possible go-around -inducing constraints ahead. The captain, who was PF, announced that, contrary to his previous plan, he intended to keep the autopilot and autothrust connected much closer to the landing runway to facilitate the possible go-around. The crew also inquired the air traffic control for the reason for the go-around of 'Finnair six' and reviewed the go-around actions. They also practised anticipation by analysing that it was likely that the situation would be clear early, so that a very low altitude go-around should not be expected. Moreover, they briefly discussed their fuel quantity and reserves, keeping an eye on the situation after a possible go-around. Despite the NOTAMs which reported possible drone activity, and therefore hinted at the reason for go-arounds, the researchers did not note any discussion related to the possible drone activity.

The researchers noted that the crew practised anticipation and threat and error management in other ways as well. The co-pilot mentioned that a close family member of his had recently died and therefore his mental vigilance might not be optimal, and advised the captain to be aware of this. This crew also inserted a 'secondary' flight plan into the Flight Management System during the preparation phase. This was to make a possible quick return to the departure airport easier, in case of any unexpected situation After both momentary technical faults, the crew discussed the usage of autopilot in the case that the faults reappeared. For the approach, they armed the "APPROACH" mode of the autopilot quite late on purpose, to prevent possible faulty localiser beam captures.

The crew themselves judged that they were generally well ahead of the situation. The researchers noted that the level of discussion, analysis, and anticipation on the flight deck was very intense throughout the entire operation. The captain agreed and commented, "For a moment I thought that hopefully we're not missing any standard stuff – if there are too many words and such an overload." In their own words, they tried 'FORDEC' (a mental model for decision-making that Finnair uses) a little bit in everything, so that it forced them to stop and think about different options. When asked about the differences between real life performance and simulator performance, they stated that "simulator performance is overall better because in normal life more things may remain unsaid. In real life, on the other hand, there may be more 'oxygen' to do things."

When asked about the origins of their anticipatory behaviour, they replied, "Experience, training (other than resilience training particularly), lived experiences." The whole trick of flying is that you're more there, that your hustle isn't about reacting. That we are ahead of the machine." The crew stated: "During the operation, during sim or real life, you will know if you have performed well or worse, and based on that, you will be able to perform better the next time." This strengthens the assumption that anticipation and resilience improve with experience.

Crew 2. Crew 2's experience was mostly on the first officer's side. The captain had just started his duty as a commander, having only one month of experience in the captain's seat, but had worked as a first officer for 12 years previously. The first officer had 6,5 years of flying experience.

During flight preparation, crew 2 read the NOTAM about laser pointing aloud, but it did not lead to any anticipation. When the Air Traffic Control noted the issue, they mentioned that they would increase the flight deck's internal lighting to a bright setting, and if a laser was observed, they would avoid looking directly at it.

Concerning the thunderstorm in the vicinity, the crew did not react to the first signal, the rattling noise. However, in the interview after the flight, the captain mentioned that he had heard it but had not communicated it. In the flight preparation, the crew took the possibility of thunderstorms very lightly. Later, they made a few notes about the issue, and mentioned that they would keep the weather radar on, which is a Finnair procedure and always on by default. When they lined up the runway and saw the cloud, the captain said that the cloud was pretty far away and that no precautions were necessary at that point. The co-pilot suggested an earlier turn after departure, to which the captain concurred, but said it would be enough to request it from the air traffic control when airborne. Overall, the weather triggered relatively little anticipation.

The co-pilot noted the momentary malfunction of the fuel quantity indication first and mentioned it, which the captain shortly acknowledged. When the indication was resumed, the crew noted that too, and the captain made a brief note that the fuel quantity looked "rational" based on the unchanged amount of extra fuel. After this, the crew seemed satisfied with the situation and did not analyse it further or prepare for it to happen again.

Having seen the warning of avionics smoke, the captain reacted with the command "ECAM actions", but once the fault disappeared, they only briefly discussed that there was no smoke visible nor any unusual smell on the flight deck and concluded that it had been a nuisance warning. They checked the logbook for any notes of previous warnings but agreed that they would return to this issue later if they had time after approach preparation. Overall, there was no anticipation of consequences.

Upon receiving the information of the passenger's worsening condition, the captain ordered the cabin crew member to inform them "if something else happens" and told him that the flight time would be approximately 30 minutes. Later, during the approach briefing the co-pilot very briefly mentioned the current speed restriction of 250 kts below FL100 which was programmed to the FMS as default "to remember, if there is going to be a rush with the passenger".

There was no discussion arising from the first weak signal, the CIS note about military airspace restriction near Helsinki. During descent, when the Air Traffic Control told them that further descent below FL240 would be delayed, the crew had some discussion about their further actions: to use landing gear to steepen the descent, and to ask for extra miles from air traffic control, if needed. They also asked the air traffic control if there would be holding expected in Helsinki, to anticipate the need for these measures. At some point the co-pilot raised the point that in A320 only half of the speed brake would be extended if the autopilot was on, and that the full brake would be available only if the autopilot was disconnected. To the researchers this appeared as an anticipatory reminder to the captain, who was pilot flying. However, during descent the captain used the full speed brake with autopilot on, without further communication.

The crew had a lot of discussion about the drone hazard. They included it in their approach briefing, and after that discussed the need to reduce speed because of the drone hazard. They rehearsed the altitude that was mentioned in the NOTAM (below 3000 feet) and other information that had been given. During approach they discussed the possible consequences of drones over an airport, and briefed that if Helsinki were to be closed, they would proceed towards alternate Tallinn. This hazard therefore created a lot of anticipatory thinking.

Upon hearing about the previous aircraft going around, the captain mentioned that if a go-around occurred, he would keep the autopilot and autothrust on. The co-pilot asked the air traffic control for the reason for the go-around of the previous aircraft.

To summarise: the preflight planning of crew 2 was rather straightforward. Concerning the weather information between departure and destination airports, the crew paid special attention to the large difference in barometric air pressure between the airports. The researchers considered this a sensitivity of situational awareness, low threshold of communication, and an indication of the level of situational awareness related to the knowledge of the general behaviour of barometric air pressure. Without having that aspect explicitly be part of the signals, researchers considered that as an observation of a "weak signal". Short taxi time was mentioned but it was not particularly communicated to the cabin crew.

The crew was not so concerned about technical problems during flight but considered the faults to be more of a nuisance by nature. During descent, the copilot reminded the captain about birds when they were talking about descent speed and that was considered by limiting the descent speed.

After the session the crew became aware of the crack of thunder during preflight briefing but neither one of the crew members communicated about it, thus it did not activate any actions at that point. The researchers considered the captain‘s limited experience as part of the reason for less anticipation and communication during the flight, since he had only sparse (1 month) previous experience in his new role.

The crew also deemed that "the ability to anticipate is born rather through the mother's milk as anticipation is practised even in normal life outside of work". "The skill to anticipate comes partly through training, as observation and our own and shared experience confirms that many things, even critical ones, are easier and clearer by anticipation, thus making the decision process faster." This emphasises the importance of experience, including normal life, in anticipation.

Crew 3. Crew 3 was rather experienced. Even though the captain did not have more than one year of commander experience, he had 17 years of experience as first officer. Thus, with the first officer's experience, the accumulated experience in the flight deck was more than 30 years.

Crew 3 noted the first signal, the NOTAM about laser pointers. They discussed it in the preflight briefing, and this discussion included anticipatory actions: if laser seen, avoid looking at it, immediately communicate to the other pilot if one's vision is affected, put the autopilot on immediately after takeoff, and ensure that the aircraft will always be controlled. As this discussion was comprehensive, the crew did not make any further notes when the air traffic controller advised them about the same issue at the taxi phase.

Regarding the thunderstorm and weak signals about it, crew 2 did not take that much action. They noted the report of thunderstorms in the vicinity when reading the preflight briefing material, but did not demonstrate anticipatory behaviour. When they were taxiing onto the departure runway and saw the storm, they did a relatively quick preparatory discussion, considered takeoff with TOGA (full) thrust, checked the wind, and quickly memorised the callouts and most important actions in a possible windshear occurrence. The researchers' opinion was that this was done in a hurried manner, which was possibly caused by the fact that they had not anticipated this possibility earlier.

After the momentary failure of the fuel quantity indication, crew 3 rehearsed the fuel amount at departure, and compared it to the sum of remaining indicated fuel and the fuel used indication. They agreed to keep an extra eye on fuel at every waypoint ahead and discussed how much extra fuel they should expect to see at each waypoint. They ran a check on the system pages, and made a short statement that the weather was generally good. They also saw a little sluggishness in altitude indication, which was actually an unarranged simulator issue, but they pondered whether this was connected to the loss of fuel quantity indication. Anticipatory behaviour was not or very little observed.

On the momentary avionics smoke failure, crew 3 practised extensive troubleshooting and analysis. The researchers noted an interesting work distribution. The troubleshooting of the warning itself was mostly performed or led by the co-pilot, whereas the anticipatory thinking was – at the same time – performed by the captain. The crew examined possible smells on the flight deck and in the cabin, went through several system pages, discussed the connection between the failures they had seen, checked the status of circuit breakers, and looked for any traces of smoke around all panels in the flight deck. With the captain's lead, they anticipated what would happen next in case of emergency, what was the best option for an alternate airport if needed, what was the status of the latest weather and NOTAMs, and what was the quality of the rescue and fire-fighting services. They agreed that if something happened immediately, they would proceed to Tampere, whereas after a while, the best option would be to continue to Helsinki at a high speed, declaring MAYDAY (distress signal) to the air traffic control. To summarise, this signal – momentary failure – spawned a significant amount of anticipatory behaviour, which was especially observed from the captain.

When Crew 3 received information about the worsening condition of the passenger, the captain asked the cabin crew if the passenger was conscious (yes) and advised to call again in case of any emerging trouble. They also reminded them of the possibility to ask for a doctor onboard with a PA announcement. Within the flight deck, they again discussed alternative airports in case of emergency, and noted Tampere as the best option, in terms of weather, NOTAMs, and fuel. The captain loaded the approach charts of Tampere ready into his EFB.

Preflight, the crew shortly rehearsed the NOTAM concerning the military exercise near Helsinki and its possible effect on the descent profile. They agreed that the profile might become a little steep and that there could be a high traffic load in the Helsinki area, and as a result, decided to take some extra fuel for possible holding. During flight, when the air traffic controller announced the delayed descent below FL240, they had a discussion about possible actions in case of a steep descent: the use of landing gear, and the possibility to ask ATC for extra miles. The co-pilot gave a reminder that the A320 speed brake opens only partially with the autopilot on. This conversation can be seen as anticipatory behaviour.

When the crew heard about the go-around of the previous aircraft during the final approach, the co-pilot (PF) immediately asked the captain (PM) to select full flaps. The researchers considered that the idea was to decelerate expeditiously and have some extra time to be better prepared, though this was not verbally communicated. The captain asked the air traffic control for the reason of this go-around, after which the crew rehearsed the go-around actions. The co-pilot announced that he would keep the autopilot on until just before landing, to reduce workload in case of a go-around.

During the session, the crew also anticipated events unplanned by the researchers, such as informing the cabin of a short taxi time beforehand. The crew also picked up NOTAM related to drone activity in the destination area without further actions at this point. This was rehearsed again during the approach briefing. Group dynamics worked smoothly among the crew. The crew's communication was calm and matter-of-fact, sometimes even seasoned with humour. There was no overlapping communication. Communication was forward-looking in nature and the crew was constantly creating a plan going forward.

After the flight, the co-pilot brought out the influence of one's own personality on the risk management mindset, together with its influence on normal life situations as well. The crew also stated that habitual anticipation in life overall also carries over to the work front. "You notice that you are in the right field". "If you learn the procedures well, it doesn't matter how many challenges you face during the flight, but you take the safe option on average, you stay on course through the slalom track."

The crew thought that, in general, the more anticipation and preparation, the safer the operation. The effect of experience on managing situations was brought to the fore: "Mindset' for managing situations comes from training, more specifically from CRM training, but also from things experienced in simulator training and from one's own experiences across the day to day line operation." The amount of experience appeared to be directly proportional to the quantity and quality of anticipation. "The profession has taught me how to choose the right operating model when faced with a problem situation, maybe not always the best, but on average a good model that leads to the goal."

It is also a skill to know how to disregard those things that no longer affect the operation and thus burden the future operation. There is such a thing as over-briefing. If we start to brief on events, the probability of which is infinitesimally small, we might forget more important things. There will even be a defensive reaction to over-briefing. "There should be relevant things, relevant NOTAMs on the board. I get lazy if there are thousands of things in it." When it comes to training, the co-pilot also said that he would like an approach where the 'optimal' amount of brainwork (briefing and anticipation) was somehow taught.

Crew 4. Crew 4 can be described as an experienced crew. The captain had 21 years of experience, including 14 years as captain, whereas the first officer's experience was 12 years. The cumulative experience of the crew was 33 years.

Crew 4 indicated the first signals about the laser pointers when reading the NOTAMs during preflight briefing. The co-pilot commented as an anticipatory action that "the eyes should be kept inside" if laser pointers are encountered. Later, during line up to the runway, the co-pilot reminded about the laser pointers and suggested switching the flight deck's internal lights to the bright mode in case laser pointers were encountered during takeoff. After takeoff, the captain mitigated the potential interference from the laser pointers by turning on the autopilot earlier than he would normally have.

Crew 4 noted the weather report of thunderstorms in the vicinity but did not anticipate any actions during preflight briefing. Later, during flight preparation the co-pilot heard the rattling sound in the loudspeakers and informed the captain that thunderstorms were present. The captain looked to the left from the window and said that some thunderstorm clouds were visible. At the departure briefing, the crew listed possible thunderstorms as a threat and agreed that they would mitigate it by having the weather radar on and clouds visible in the radar display. They also considered takeoff with TOGA (full) thrust, making flight path avoidances if needed to navigate round the clouds, and informing the cabin crew that turbulence was possible and that the seat belt signs would be kept on longer than normally.

When lining up the runway and when the clouds were visible on the radar, the copilot suggested if takeoff in the other direction was an option and with that in mind requested the latest wind conditions from air traffic control. The captain reminded that the actual routing would pass the clouds but that they would anyway be in close proximity to the clouds. Negotiations about immediate left turn after departure were also made and finally after a couple of minutes of thinking takeoff commenced.

After the momentary fuel quantity indication failure, the crew considered the initial fuel quantity before takeoff and the fuel used relative to the remaining fuel quantity. The captain pondered whether the failure condition would reappear and remembered that the quick reference handbook contained some fuel system-related resets and started looking through the manual. The co-pilot went through the system pages to check if the error situation had remained elsewhere in the system, and for a possible reason for an event. Several times during cruise and approach the fuel quantity indication was checked to ensure that the indications were sufficient.

When the momentary warning of avionics smoke occurred, the first action from the captain was to check for the most suitable alternate airport, which he did briefly without further analysis of weather or NOTAMs. They did a relatively large amount of troubleshooting: the co-pilot wondered if these two failures were due to a lightning strike. Together they checked the status of the circuit breakers, the QRH, and asked the maintenance over the radio about possible failure indications that the aircraft might have sent. The co-pilot pondered if a possible fire could have hindered the warning indications. After the troubleshooting they moved on to the forward-looking part: checking the weathers at Jyväskylä (alternate along the route) and Helsinki. The captain communicated that if the failures affected the avionics and the landing capability, the weather was so good that it would allow landing in all cases.

Upon receiving the call of the worsening condition of the passenger, crew 4 asked the cabin crew whether an ambulance was needed in Helsinki after landing and asked them to report any changes in the passenger's condition. Later during the approach, the captain called (twice) and asked the cabin crew for new updates on the passenger. The researchers did not, however, interpret this communication as anticipatory behaviour.

Regarding the descent profile, crew 4 held a moderately limited amount of discussion. When they were instructed to maintain FL240 and told further descent would be a lot later, the captain asked the co-pilot to ask for a different landing runway in Helsinki which would have let them approach the airport from a different direction and possibly avoid remaining high in profile. The captain mentioned he would put on the landing lights, calling them "mini-brakes", but that was more humour than intention. To summarise, the crew did not anticipate their actions ahead very much, in terms of the descent profile. It was unclear whether their experience influenced the fact that the crew was not worried about being high on the profile.

When the previous aircraft performed a go-around in the short final approach, the co-pilot asked the ATC for the reason for the event. They did not anticipate go-around actions or start any other communication related to the issue.

What they did anticipate very thoroughly was the risk of drones, which was mentioned in the preflight NOTAM. During the entire descent and approach, they had a lot of discussion and anticipation of possible drones. They shared their own experience of sighting drones. They asked the Helsinki ATC whether drones had recently been observed. They agreed that one of them (the Pilot Monitoring) would keep a constant look outside during approach, to enable him to see possible drones. They discussed drones in general, and their ability to move away if an aircraft was crossing their flight path. All in all, this crew put a lot of anticipatory effort into the danger of drones, much more than the other crews did.

In the interview after the flight, crew 4 said that the flight in the simulator is not fully comparable to a flight in reality, since in reality one is more relaxed and more able to function in surprising situations. One does not 'freeze' in real life whereas in the simulator the pretence hampers one's performance. However, they added that the EBT concept has taken the simulator evaluations' atmosphere in a more relaxed direction. As to the question of where their ability to anticipate had come from, they mentioned experience and training, specifically CRM training where they had heard of previous cases and accumulated their own 'data bank'. As our own experience is somewhat limited and gathering it takes time and effort, this jointly collected experience was seen as being of great value. "The more you have experienced the more capable you are to anticipate."

However, the crew saw a connection between gathering experience and being able to utilise it in day-to-day operation: "In the beginning, the accumulation of experience took up most of the capacity before reaching a situation where the experience and accumulated capacity could be put to good use in anticipating and preparing for future situations and circumstances."

The co-pilot mentioned navigating with a visual flight map in basic training as one specific exercise which enhanced anticipation: "What do you expect to see next?" In addition, they mentioned personality as one factor. "A pilot must be a constantly worried type of person, in a way. Not too satisfied." To the question if there can be too much preparedness or anticipation, they again responded that the relaxedness that prevails on a normal day usually makes for better performance. "In a normal, relaxed atmosphere, things go better."

Crew 5. Crew 5 was not the most experienced but still had a good number of working years. The captain had 20 years of experience, of which 14 years was as captain. The first officer's experience was 6 years. The cumulative experience of crew 5 was 26 years.

Crew 5 read the NOTAM concerning laser pointers at the briefing material but did not comment about it. Later, in the taxi phase, when they were advised about the laser pointers by the ATC, the crew discussed that in case visibility was impaired due to the laser, they would put and keep the autopilot on and try to look inside. They also agreed that they would report the event to ATC if able.

When reading the ATIS weather broadcast before engine start, nearby thunderstorms were mentioned, and the captain looked behind right from the window and announced that he had seen some (storm) clouds. They quite briefly agreed to maintain a look on the weather radar and circumvent the storm if possible. When they were lining up the runway and saw the storm again, they made a quick analysis that the departure route should keep them away from the storm, but that they would ask for a quicker turn after departure anyway to ensure that they kept clear of clouds. The co-pilot mentioned that "a windshear may happen", but they did not anticipate that (or any required actions) any further.

Upon the momentary loss of fuel indication, they performed a comprehensive analysis of how much fuel they should have had, and how much they did have according to the indication that returned after the momentary loss. In that discussion, they integrated the possible options to land, in case they were to lose the indication completely, and mentioned that they were "kind of making a FORDEC (Finnair's structural decision-making model)" already. They made the QRH ready for use, in case of total loss of indication, and again made an estimate of the amount of fuel, and checked the FCOM to see what the fuel consumption per hour should be in the cruise phase. They also agreed to call maintenance via radio a little bit later at cruise altitude. All in all, the crew seemed to anticipate and prepare for the indication to be lost for the rest of the flight. So, the 'ratty signal' triggered quite a lot of anticipation in this case.

When the momentary avionics smoke warning appeared, the co-pilot briefly suggested the use of oxygen masks, but did not get response from the captain and seemed to abandon this plan himself a little later as the warning ended. The captain checked the FCOM for the avionics smoke procedure, after which they called the cabin to check that everything was normal on that side. After this they made a relatively comprehensive situational analysis in terms of possible alternate landing airports. They also updated this as time went by, and at some point closer to Helsinki, they agreed that if smoke were to appear they would put on the oxygen masks, change the controlling of the aircraft to the captain, as for a direct clearance to the final approach in Helsinki, and fly there at high speed. They also made a call to maintenance over the radio, to check if they saw any active failures in their aircraft through their system. So anticipation of the actions in case the problem persisted was made.

The crew reacted only minimally to the message of the worsening condition of the passenger in the cabin: they thanked the cabin crew for the information, and later made a quick mention of the passenger and that "nothing further was heard so probably all was ok."

When crew 5 received the information that their descent clearance was delayed, they had quite a lot of communication on how to catch the profile from above, including playing with airspeed and asking for extra track miles from the ATC if needed. They updated their awareness of the profile a few times during the descent, and the co-pilot observed that the wind had turned advantageously for them, and would facilitate the descent profile handling.

During the final approach, having heard about the previous aircraft going around, crew 5 asked the air traffic control if they were aware of the reason, but did not make any further discussion or planning on their ensuing actions or actions during a possible go-around. The first officer seemed to reduce the final approach speed in a determined way, but it was not clear if it was related to the specific go-around risk.

When interviewed after the flight, the crew felt that the flight had been short and there had been no time to address the challenges as deeply as they wanted. But still, they had a feeling of good performance and even the feeling of a normal short scheduled flight. They said that getting high on profile did not create any major worries, since as experienced Airbus pilots they knew the performance of the aircraft and were convinced that they would reach the profile with the measures they were using. In the researchers' view this highlighted the connection between resilience and experience. When asked where they had learned to anticipate or where the ability comes from, they mentioned training, specifically simulator training, where they had encountered similar situations. "Mostly from the simulator training comes the idea that you have to be ahead of the aircraft." This, again, highlighted the aspect of experience to the researchers.

Using the FORDEC decision-making model, which has come to the fore in recent years and has been put into use, was seen to facilitate foresight by creating space for considering alternatives and preventing rushing into quick, non-rational decision-making. Crew 5 used the so-called tentative FORDEC in a smoke alarm situation to give rise to a tentative decision. Later they returned to the decision-making process to complete it with additional threat factor analysis.

Discussion

Our meticulous research into the scientific literature paints a picture of resilience which is much more than a reaction to an unexpected event. Several scholars (e.g. Hollnagel, 2011, Klein, 2011, Rerup, 2001, Snowden et al., 2007) emphasise a conception of resilience that includes an anticipatory perspective of future events, changes and threats. Of course, the views between scholars are not identical, and the scientific field is therefore incoherent, too. However, we can argue that there is significant recognition of anticipation as a component of resilience development within science.

In our review of the literature and the data collection we have demonstrated that resilience can be understood in a much broader way than how the EASA spreads it into the whole domain. Anticipation is a visible example of a concept which EASA, and in our experience, many other entities in aviation do not recognise as part of resilience. At least, it is not emphasised. However, the importance of anticipation as a cornerstone of resilience has been underlined in many safety science and human factors publications. Thus, it seems relevant and important to research anticipation in the aviation domain.

Through our data collection, it became clear that the understanding of resilience throughout the airline organisation, including the training manager, the instructors and the pilots, was incoherent. The training manager regarded it mainly as a capability to 'bounce back' whereas the mainstream of company instructors during discussions described a colourful portfolio of definitions and ideas. The question arose as to why there are these differences? In the light of our research question, it was also significant how few remarks were made of anticipation as a component of resilience. Its role was acknowledged, but usually only after we specifically asked for it.

Pilots do anticipate, as demonstrated in the observations. Anticipation, however, is guided by other background factors than systematic, goal-oriented resilience training. Anticipation is seen as a marker of good airmanship, and something that is learned from older, experienced colleagues. Some pilots said that training includes ideas of anticipation, but it remains flimsy what training it was, and how. Anticipation was, however, remarkably different between observed crews and individual pilots. There is certain evidence that experience could foster anticipatory behaviour at individual level. The question arises, how could anticipation turn into enhanced systemic resilience.

The EASA Regulation

When we talk about aviation as a system, we must turn our attention to regulations. Aviation is a domain with a history of strong regulation and compliance. Dekker (2014) warns about the disadvantages of the bureaucratisation of safety and reminds us that safety structures that are developed bureaucratically at a distance from operations might not represent risk well or manage it in practice (p. 350).

The EASA regulation has been critiqued by Bergström & Dekker (2019) for falling into a 'moral trap'. Bergström & Dekker (2019) note that the regulatory formulation sees operational resilience as being located at the level of pilot mental processes (mental flexibility) and behaviour (performance adaptation). In other words, it takes a behaviourist approach to resilience, which receives little support in academic traditions (p. 421), making the sharp end operators responsible for the safety and risks of airline operations. Thus, lack of resilience could become another characterisation of 'human error' (p. 422).

Bergström & Dekker (2019) also mention 'a reductionist trap', meaning "a view in which resilience is constructed in a reductionist manner in which the target of operational resilience becomes the sharp-end (micro-level) operator" (p. 419). One can find the regulation holding resilience to be the property of an individual, and therefore it has a flavour of reductionism, too. Bergström & Dekker (2019) conclude that the fundamental principle of complexity theory is that the macro behaviour of a system cannot be reduced to micro-level behaviour (p. 418).

In our document analysis of the EASA regulation, we concluded that the critique from Bergström & Dekker (2019) seems valid. Whether you look at the EASA regulation on CRM training or EBT, they offer a relatively narrow idea of resilience, treating it as a reactive capability and addressing the individual as a resilience unit. What should be brought up instead is the systemic nature and non-normativeness of resilience, along with anticipation, of course. We also learned from the subject matter expert that the EASA regulation on CRM was formulated under external constraints and ended up "leaving 90 % of [the] Hollnagel definition out". He mentioned that a recent evaluation did not amend or renew the parts related to resilience or anticipation in any relevant way.

We note that the company instructors emphatically called for more training in resilience and stated that there is no common, concrete definition in the company. We also note that the company training manager was troubled by the abstractness of the concept of resilience given by the EASA regulation, and by the lack of a proper definition. We strongly question how the training can adequately equip pilots at the sharp end with a robust understanding of resilience or develop their resilience if the regulatory framework at the highest level of the domain fails to establish a strong foundation.

We acknowledge that the appearance of resilience as an individual characteristic in the EASA regulation arises from its mandate to oversee the qualification standards of individual license holders. However, does this adequately justify the significant deviation from the scientific perspective? What about the operators who are given considerable freedom in determining the "how" – should they try to embrace a more holistic, systemic understanding of resilience? Unfortunately, this appears challenging, as highlighted by Dekker (2014) in his commentary on safety bureaucratization: "People in positions of accountability may not feel empowered to think critically about technical questions (even those related to safety), and this can impede innovation and initiative" (p. 352). In this context, it is understandable that regulatory requirements are often adopted as they are by operator organizations. We argue that the regulatory framework plays a pivotal role in incorporating resilience within the domain and requires improvement. If the regulator views resilience as a part of an individual´s character, even though there is no solid scientific backing for this idea, it could steer the entire domain in the wrong direction and weaken its approach to systemic safety.

Challenges in Training Resilience and Anticipation

How to describe the existing understanding of resilience within the airline organization, in the light of our study? As noted in the Findings chapter, the Training Manager's view was largely based on resilience being the ability to 'bounce back' from unexpected or surprising events. At the same time, the Training Manager acknowledged difficulties in getting support for promoting resilience through the EASA regulation, whose definition we earlier found narrow and abstract. On the other hand, he recognized that the nature of the regulation was non-prescriptive and performance-based, which meant that a lot of freedom to interpretation is given to operators on purpose. The Training Manager said that, in addition to the regulation text, the resilience views had been discussed, to some extent, with other airlines and collectives such as aircraft manufacturer Airbus. But mostly, he leaned into the EBT training concept, which has been given a lot of emphasis in resilience development in the airline.

Instructors find resilience a complicated concept to explain, as it contains different functionalities, practices, and definitions. Due to the complexity of the operations, the appearance and manifestation of resilience varies greatly. Dekker and Lundström (2007) agree on the uniqueness and complexity of operations and the possibility of predicting events: "The limits on our ability to prepare crews in detail for the precise operational problems they may encounter come from the intersection between our finite knowledge and the infinite configurations of problems-to-be-solved in any complex, dynamic domain" (p. 1). This is probably why instructors find recognizing resilience difficult. TRI 2 said, "When we talk about situational awareness and communication, resilience is there in the background, but it's kind of invisible, big, a bit vague, like nebulous." TRI 4 suggested resilience being an outcome of competencies, things that are actually evaluated. We argue that this approach allows for the potential for a more systemic resilience view.

The difference between the views of the Training Manager and the instructors is that whereas the training manager is aware and guided by the EASA regulation text through compliance responsibility, the instructors have not familiarized themselves with the regulation text related to CRM and thus are not aware of what it says about resilience. This became clear in the discussions between the CRM instructors. They knew the 'bounce back,' the reactive definition which was used in discussions within the training organization, but their various and creative ideas of resilience that they expressed in the focus group discussions originated from other sources such as literature which they had become acquainted with.

How would we define this (resilience) so that everyone would see it the same way? We all see it in slightly different colours, in different aspects. In comparison, for example, EBT competencies seem to be rather well standardized. Resilience sounds like a new 'competence', but as it is not yet understood in a uniform way, its training is also incoherent (TRI 2).

Then, how can resilience and anticipation be trained? According to instructors, teaching starts with strengthening one's own competence. Only then the instructor can pass information on. TRI 1: "Some kind of training would be great from a psychological point of view, to develop and to give those tools to us (instructors)." Also, a uniform way of teaching, consistent requirements, and certain attributes were perceived as essential starting points for good resilience training.

We have learned that mental models and ways to handle difficult situations comes with experience. Developing this expertise and learning mental models takes time and is somewhat challenging. "If we cannot teach people to think like experts, perhaps we can teach them to learn like experts" (Klein, 2017, p.169). This challenges training departments because experienced experts have learnt to see things that are invisible to others, including things that do not happen (negative cues) (Klein, 2017, p.151). This is what makes a significant difference between novices and experts. Only through expectancies can someone notice whether something did not happen (Klein, 2017, p.149).

According to CRM instructors, going through cases is a very good way to teach because people learn from other people's past experiences. "It makes you think about what I would have done myself in that exact same situation" (CRMI4). They also agreed that anticipation takes many forms. Anticipation can be seen as the ability to see future possible scenarios of a situation based on one's own previous experience or experiences learned from others. The more experienced crews are, the more anticipatory behaviour seems to happen. Issues are discussed, and threatening points of view are brought up in discussion. Such communication was observed in the simulator observations, for example, with crew 1, who had a comprehensive discussion about the fuel system momentary malfunction and all possible consequences, to enhance their preparedness and knowledge. Thus, anticipation is closely related to the ability to communicate openly and effectively. This open way to share experiences in mixed contexts would also be a way to teach anticipation.

When talking about resilience training, a connection with competencies is seen: "It appears as a byproduct through these competencies" (TRI 2). It is also important to name the features that can then be improved. Someone has even called the debriefing session a 'therapy session'. It seems to contain many non-technical aspects. Among the instructors, resilience was seen both on a personal and crew level, not as a purely theoretical or innate skill of the individual, but specifically that everyone is able to improve their resilience through training. The flight instructors gave an example from real life of the impact of experience and learning:

> The UPRT (Upset Recovery Training) training is, among other things, a good example that there are people who have never been in such a situation and then when they are placed in that situation a second time, they are able to handle it in a completely different way. (TRI 2)

Training resilience and anticipation should start by first defining the concepts (resilience and anticipation) and ensuring a common understanding of these. This should also be clearly visible in the contents of the EASA regulation to complete the understanding down from EASA all the way to line operation. The training should concentrate more on a proactive approach to operations and on the implementation of anticipation in everyday work.

Anticipation and Evidence Based Training (EBT)

When discussing resilience development with pilots, one cannot ignore EBT (Evidence-based Training), which was referred to several times by all interviewees. The evidence-based training project is a global safety improvement initiative in the training environment, supported by the International Civil Aviation Organisation (Skybrary, 2022). EBT training scheme is also regulated by EASA (2021). Finnair is among the airlines that have implemented EBT training fully since the beginning of 2022.

The concept is a new approach to recurrent pilot simulator training where simulator training and evaluation is planned such that – instead of pre-described flight manoeuvres – the key element is to train competencies, many of them non-technical (Finnair, 2022). The scenarios are created using data such as accident and incident reports, flight data analysis, and other operational data that reflects real life and actual training needs. According to ICAO (2013), mastering a finite number of competencies should allow a pilot to manage situations in flight that are unforeseen by the aviation industry and for which the pilot has not been specifically trained. The predefined competencies are

- Application of Procedures, Communication,
- Aircraft Flight Path Management - automation,
- Aircraft Flight Path Management - manual control,
- Leadership and Teamwork,

- Problem Solving and Decision Making,
- Situation Awareness, and
- Workload Management.

Additionally, EASA recognises a ninth competency, 'Application of knowledge', which is not listed by ICAO.

According to the subject matter expert, the training manager, and the instructors, EBT is expected to develop resilience. Let us examine how anticipation is embedded in the EBT concept. We must first note that EBT is standardised by ICAO, and later regulated by EASA. To help instructors train and evaluate competencies, EASA and ICAO have created a list of observable behavioural markers to indicate the existence of each competence. In other words, these markers are what EBT examiners look for in the crew behaviour, and what the EBT instructors seek to induce in the students. Can we find mentions of anticipatory behaviour in the listed markers? First, we must note that the markers listed by ICAO (2013), and the markers listed by EASA (2021), who regulated EBT later, are somewhat different. From both, let us look for behavioural markers which can be attached to anticipatory thinking as described by Hollnagel (2014), Rerup (2001), or Klein et al. (2011).

ICAO (2013), in its EBT Manual, lists a total of 72 observable behavioural markers included in their eight core competencies. Out of these 72, we can find only three markers that are related to anticipation. These are:

- 'Anticipates and responds appropriately to other crew members' needs' (under the competence of Leadership and Teamwork),
- 'Anticipates accurately what could happen, plans and stays ahead of the situation' and
- 'Develops effective contingency plans based upon potential threats' (under Situational Awareness).

However, there are 69 other markers in total, including seven markers under 'Situational Awareness' that do not have any observable relation with anticipatory behaviour. EASA's contribution is even smaller. EASA has listed a total of 75 observable behavioural markers, included in nine core competencies. Out of these 75, there is only one marker related to anticipatory behaviour, that is

‘Develops effective contingency plans based upon potential risks associated with threats and errors’ (under the competence of Situational Awareness).

We can conclude that when it comes to both ICAO and EASA, there are only a few markers that represent anticipatory behaviour. The most compatible behavioural marker in the ICAO list, “Anticipates accurately what could happen, plans and stays ahead of the situation”, is not listed by EASA at all. The reason for EASA abandoning this observable behaviour is not known to us. Another detail that drew our attention was that under the competence of Leadership and Decision Making, EASA lists one behavioural marker which mentions resilience: “Demonstrates resilience when encountering an unexpected event”. This wording effectively demonstrates that EASA sees resilience as happening after the unexpected event, reactively. Aiming to recover, not to prepare nor anticipate.

Given that airline operators are tightly bound by EASA regulations, it is questionable whether the EBT concept, though being a good concept in many ways, can truly deliver the level of anticipation as described by researchers such as Hollnagel (2014), Rerup (2001), or Klein et al. (2011).

The Role of Experience

Expertise and experience are indeed interesting factors. What is the role of experience in the ability to recognise small signs or ‘ratty data’ (Rerup, 2001)? Does experience help, when effective and creative anticipation is needed?

Thomas (2004) has researched Threat and Error Management precursors among flight crews and noted that a strong positive contributor to effective threat management was the co-pilot’s experience. Kahneman and Klein (2009) describe how cognitive task analysis has been used to mine cues noticed by experts and used to recognise increasing uncertainty, heightening risk, or signs that trouble might be coming.

Our observation data supports the hypothesis that more experience can result in more anticipation. A good example was during the observation of crew 3, where the co-pilot´s communication was repeatedly focused on troubleshooting the technical status of the aircraft, while the captain took intensive care of the proactive planning and the possible impact of a single event to the flight continuum. This observation is supported by Feltovich et al. (1997) who noted that novices identify relevant cues but are not sure what to do with the knowledge, and that experts (compared to novices) are better at generating more anticipatory actions.

Flight operations are strictly regulated and pre-defined by published procedures and practices. However, according to the interviewed instructors, there are certain things written in the SOPs (Standard Operating Procedures), but there are many things in their operational environment that only come through experience. One instructor says:

> Resilience and anticipation are seen behind practically everything we do, sometimes a bit unclear and clumsy, sometimes even invisible, but nevertheless almost necessary. If you don't have experience and if you don't have vision, you can't really anticipate anything if you don't know what you're expecting. (TRI 2)

The amount of experience varies greatly between flight crews. Accumulating experience takes time and demonstrating resilient behaviour in the very beginning is considered somewhat challenging, as anticipation itself is not taught. TRI 1 said: "We don't teach it (anticipation) directly. Anticipation is learned through absorbing habits and practices from more senior co-workers." But can the organization facilitate this? It could, according to the subject matter expert, who praised learning experiences and courses where pilots are allowed to come together and share their experiences.

According to the training manager, experience in different situations expands the anticipatory capacity:

> With the accumulation of experience, we have been involved in various situations and perhaps know how to anticipate a little more widely, what possible variations there may be in situations, what may possibly happen, and what kind of chain of events can begin from an occurrence.

Woods (2005) supports the idea. "Every event, no matter how dissimilar on the surface, contains information about underlying general patterns that help create foresight about potential risks before failure or harm occurs" (p. 298). Hancock et al. (2022) remind us that a future risk assessment is predicated upon past experience (p. 271). We can also identify similarities with the statements regarding experience and expertise by Klein (2017), Westrum (2009, p. 139) and Feltovich et al. (1997). Considering the abovementioned, we can argue that experience positively correlates with effective anticipation.

Anticipation and Threat and Error Management (TEM)

Threat and error management (TEM) is a contemporary component of pilot licensing regulations, with the aim of equipping crews with the coordinative and cognitive ability to handle both routine and unforeseen surprises and anomalies (Dekker & Lundström, 2007, p. 1).

The training manager considers the TEM model as being related to the dynamic parts of the operation, "Take-off and initial climb and approach, as well as related activities, are operationally the most active sections for which briefing practices have traditionally been created, therefore it is natural that it also emphasises the use of the TEM model." He sees a connection between resilience and the TEM concept and emphasises not only the detection of threats but also their mitigation. "After all, threat and error management includes the fact that those threats are observed or anticipated and then, in the same context, some kind of mitigation or some kind of preparation is built into them."

The training manager's comment that TEM briefings are conducted in certain predefined moments (takeoff, approach, high terrain etc.), raises two questions. The first is related to the times or phases when anticipation happens if it is considered to happen within the TEM framework. Should anticipation be concentrated in certain phases, or happen as a continuous process during the entire flight? The latter receives support from Dekker & Lundström (2007), who state that keeping a discussion about risk alive even when everything looks safe is among the indicators of resilient crews. It is also said that sensemaking is a continuous, anticipatory process of fitting what is observed with what is expected (Klein et al., 2007, as cited by Rankin et al., 2016, p. 625).

Rasmussen (1997) reminds us that "resilience is the ability to steer the activities of the organization so that it may sail close to the area where accidents will happen, but always stays out of that dangerous area" (p. 37). Maintaining this awareness of the margins is a continuous process which is not tied to any predefined moment of anticipation. Hancock (2022, p. 260) defines that "It is important to reiterate and emphasize that unexpected events (UEs) are necessarily embedded in normal operations." This applies to the entire operation from start to finish, not just certain parts of the operation.

The second question relates to the substance. Let us think about the differences between monitoring and anticipation, according to Hollnagel (2009). He describes monitoring as "knowing what to look for" whereas anticipating is "knowing what to expect" (p. 120). He continues, "While monitoring tries to keep an eye on the regular threats, looking for the potential tries to identify the most likely irregular threats" (p. 126). This difference between 'regular' and 'irregular' threats is worth discussing. If we only monitor and observe the regular threats, what does this mean for occasions when such threats are not immediately visible?

According to Klein (2011) there is a difference between situation awareness (making predictions) and anticipatory thinking. He notes that anticipatory thinking is aimed at potential events, including low-probability high-threat events, whereas situation awareness is aimed at the most predictable events. "Anticipatory thinking is functional as it helps to prepare to act, situation awareness just to predict" (p. 236).

Which one does threat and error management represent? Are they 'regular' or 'irregular'? Are they something that exist, or are they a potential for something? Does TEM represent situational awareness, or anticipatory thinking? In TEM briefings, factors that are communicated are usually concrete, isolated, and well-known – such as high terrain, icing conditions or an aircraft malfunction (Merritt & Klinect, 2006, p. 4). However, Klein et al. (2011) describe 'convergence', a type of anticipation which requires us to see the connections between events and which appreciates the implications of different events and their interdependencies. (p. 237). And aviation is a complex domain where interdependencies exist (Dekker et al., 2011, p. 942).

Therefore, we argue that the kind of foresight that the TEM framework promotes, though being a useful and good concept, does not fully correspond with the ideas of anticipation of Hollnagel or Klein. To be more compatible, threat and error management should be a constant process throughout the flight, instead of predefined moments or critical phases. It should broaden its view to more irregular and non-obvious threats and take the complex environment more into account.

Organisational Aspects of Anticipation

Hollnagel (2014) argues that effective work in sociotechnical systems requires continuous adjustments to existing conditions at all levels, from specific task performance to planning and management (p. 298). According to Anderson et al. (2016), resilience is distributed across various system functions and activities. In the light of our research question, it becomes necessary to discuss organisational aspects in fostering active and creative anticipatory behaviour.

Snowden et al. (2007) studied anticipatory thinking in an organisation and its small teams, premised on weak signal detection. To improve anticipation, they recommend:

- encouraging dissent to prevent fixation,
- increasing expertise to improve weak mental models,
- encouraging voicing unpopular concerns, and
- breaking down organisational barriers that can impede the flow of ideas and information.

The ability to perform anticipatory thinking is considered a mark of expertise in various domains (Klein et al., 2011, p. 235). While experience plays a significant role in anticipation, it may not always be available, especially in fresh organizations or with inexperienced crews. Inexperienced individuals can benefit from the experiences and mental models of others, as blending different concepts and stories enhances human intelligence and the capacity to handle uncertainty and ambiguity (Klein et al., 2011, p. 235). According to the instructors, creating an open atmosphere and fostering effective communication with a low threshold can be prerequisites for encouraging anticipatory thinking.

These findings align with the thoughts of the subject matter expert in our interview. The importance of 'chair-flying' and the value of shared experiences and information exchange among pilots were emphasized as means to improve mental models and break down organizational barriers. Thus, the subject matter expert's ideas find support in research. Additionally, the CRMI 2 emphasised the advantages of learning from stories and experiences shared by senior pilots while developing expectations for future events during one's initial visit to a new airport. Edmondson´s (2018) principles of psychological safety emphasise the importance of creating an environment that encourages constructive dissent and the voicing of unpopular concerns, thus making a connection with the recommendations of Snowden et al. (2017).

Resilient organisations are those that are aware of both their internal dynamics and the operating environment, effectively learn from past experiences, and adapt to uncertain futures (Hollnagel, 2017). However, bridging the gap between scientific theory and operational reality poses a challenge. Comfort et al. (2010) suggest that our understanding of resilience is often shaped by hindsight bias, where successes are connected to resilience and failures are seen as its breakdown (p. 178). To overcome this bias, organisations should develop the ability to observe resilience-in-action and anticipation-in-action without relying solely on hindsight.

The current CRM training requirements and EBT training concepts do not endorse anticipation training. However, Hancock et al. (2022) researched pilots´ responses to unexpected events and recommend a more proactive approach to resilience training, focusing on preventing incidents from proliferating toward disaster and occurring originally. This is in contrast with the more common and traditional reactive methods which look to prevent incidents from being repeated (p. 277).

In conclusion, effective anticipation requires a holistic approach that encompasses both individual and organizational dimensions. It is imperative for airline organisations to adopt diverse strategies that foster active and creative anticipatory behaviour among their crews.

Conclusions

In terms of resilience, the current EASA regulation on Crew Resource Management (CRM) appears somewhat vague and has a flavour of a compromise and reductionism. While it outlines the "what," it falls short in explaining the "how." It presents resilience as an individual´s property, without receiving support from human factors and system safety research. The airline training manager's perspective is heavily influenced by compliance with the regulation, shaping how instructors in the organization perceive resilience. As a result, there is no clear and consistent definition of resilience among the individual instructors.

The current regulations and training procedures do not actively promote anticipation. Anticipation is only superficially introduced in the EASA CRM regulation, consequently being excluded from the airline training programmes. The aviation industry, including its related initiatives, seem to lack a cohesive understanding of anticipation.

Although Evidence-Based Training (EBT) is given a significant role in developing resilience, it mainly focuses on a narrow perspective of resilience promoted by the EASA regulation. Anticipation is not integrated into the behavioural markers associated with this concept.

Within the industry, one concept that promotes proactive thinking is Threat and Error Management (TEM). However, it mainly emphasises discussing future threats during specific flight phases, rather than making it an ongoing process. Moreover, it tends to address existing and regular threats, whereas several safety scholars (Hollnagel, 2009; Klein, 2017; Adamski and Westrum, 2003) emphasise anticipation of irregular and non-obvious threats. This implies that some anticipatory potential remains unused.

Experienced pilots seem to exhibit better anticipatory skills, as they can effectively connect weak signals and cues to future events. This creates a link between experience and resilience and highlights the importance of verbally sharing expertise and experiences among pilots for developing anticipation skills.

To summarise, flight crews receive limited and confused training on resilience, with no inclusion of anticipation as a resilience component. The aviation industry provides little assistance to flight crews in developing their anticipatory skills, and resilience training falls short of its objectives. The pilots

demonstrate anticipation to some extent, and it mostly manifests itself as informal communication between the pilots. However, it lacks structure and varies widely among different crews.
Airline organizations should seek ways to encourage constant and creative anticipation in flight decks to enhance system resilience and potentially compensate for inexperience. But most importantly, a revision of the current EASA regulation on CRM and EBT, sharpening the concept of resilience to represent systemic safety and recognising the importance of anticipation, would be necessary in aligning them with modern scientific perspectives and fostering resilient behaviour in airline organizations and their flight crews.

"Our effort here is focused on the adoption of a proactive perspective that looks to anticipate these future threats to aerospace safety in order to counteract their adverse influences as early as is conceivably possible" (Hancock, 2022, p. 256).

Suggestions for Further Research

During the research, we came across the question of whether it is possible to over-anticipate. Throughout our observation sessions, we noticed that certain situations led to a flurry of communication on the flight deck, along with related procedures and actions. At times, the situation management took even longer than expected. In the interviews, some participants made comments suggesting that anticipation can be taken "too far", and that a certain level of appropriate 'relaxedness' can actually enhance crew performance. This leads us to wonder whether excessive anticipation might lead the handling of core operations away from the normal and safe zone. Is there an optimal level for anticipation where, considering the length of the operation and available time, it would yield maximum benefit without veering too far from the main objective – a safe operation – and without creating unnecessary and harmful workload? This area appears worthy of further research.

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Appendix 1

The Question Sets for the Interviews and Focus Groups

The Training manager interview

1. How do you understand ‘resilience’ in flight operations?
2. In a flight deck, how can you distinguish resilience? How does it become visible, in normal operations? Or does it?
3. What is the size of the unit that conducts resilience? Is the unit an individual, or rather a system?
4. Can you train resilience? If yes, how?
5. Is resilience visible in normal operations?
6. Do you see a connection between the TEM concept and resilience?
7. Do you consider anticipation to have an aspect in resilience? Can you describe what kind of aspect?
8. From the point of view of the training manager, are you satisfied with how Finnair's pilots implement anticipation or proactive thinking in the cockpits?
9. Is there anything in which direction you think anticipation should be taken, developed or trained or can it be trained?
10. Is anticipation only related to briefing moments or is it a process or way of thinking that lasts the entire flight?
11. In a flight deck, how can you distinguish resilience? How does it become visible, in normal operations? Or does it?
12. Do you see the connection with anticipation and regulation?
13. In your opinion, how does experience affect resilience?
14. Can we over anticipate?
15. Have you heard from other sources, other universities, airlines, other experts, trade unions, about the implementation of the EASA regulation?

16. Has comparative research been done or has Finnair's interpretation of anticipation and resilience been based on its own sources?
17. How have you implemented the requirements of the EASA regulation into practical inspection and training activities, and by what tool or method?
18. What is the size of the unit that conducts resilience? Is the unit an individual, or rather a system?

The subject matter expert interview

1. What kind of role you have had in the writing of the EASA CRM regulation?
2. Concerning CRM, what kind of picture of resilience EASA wanted to present in the regulation?
3. What sources, or what kind of scientific research was used when creating the EASA regulation that included resilience?
4. Have the requirements for resilience changed on the way to these days?
5. What is your view of resilience?
6. Is resilience an individual or a systemic thing and what is the unit for resilience?
7. How should resilience be seen on a line operation and what should it be like?
8. Do you think that EASA regulation will be changed in the future?
9. How do you see anticipation as a part of resilience development?

Focus group, CRM instructors

1. How do you understand ‘resilience’ in flight operations?
2. In a flight deck, how can you distinguish resilience? How does it become visible, in normal operations? Or does it?
3. What is the size of the unit that conducts resilience? Is the unit an individual, or rather a system?
4. If the unit is more than an individual, what does it consist of?
5. Do you think resilience is a property, or more like an action? Is it ‘something you have’ or ‘something you do’?

6. In your opinion, how does experience affect resilience?
7. Can you train resilience? If yes, how?
8. What helps us overcome surprises or getting startled?
9. Do you consider anticipation to have an aspect in resilience? Can you describe what kind of aspect?
10. Your personal skill to anticipate, where does it originate from?
11. Is anticipation an inborn skill, or can you develop it with training? How?
12. Anticipation in the flight deck – how do you recognize it? How do you see or hear it? How does it become observable?
13. What kind of guidance have you received from the organization for training these themes (resilience and anticipation)?
14. Your thoughts and opinions that you have given here about resilience and anticipation, where have they originated from?

Focus group, Type Rating Instructors

1. How do you understand 'resilience' in flight operations?
2. In a flight deck, how can you distinguish resilience? How does it become visible, in normal operations? Or does it?
3. Can you train resilience? If yes, how?
4. What is the size of the unit that conducts resilience? Is the unit an individual, or rather a system?
5. If the unit is more than an individual, what does it consist of?
6. Your thoughts and opinions that you have given here about resilience and anticipation, where have they originated from?
7. Your personal skill to anticipate, where does it originate from?
8. What kind of guidance have you received from the organization for training these themes (resilience and anticipation)?
9. Do you think resilience is a property, or more like an action? Is it 'something you have' or 'something you do'?

10. Is resilience normative by nature, good or bad?
11. Is it useful to assess resilience?
12. Do you consider anticipation to have an aspect in resilience? Can you describe what kind of aspect?
13. Can we over anticipate?
14. Can you train resilience? If yes, how?
15. Is anticipation an inborn skill, or can you develop it with training? How?
16. Is anticipation dependent on the phase of the flight?