How reliance on resilient performance 'hides' or even contributes to system brittleness

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Abstract

Aviation is known to be safe, partly due to highly specialized pilots who undergo extensive training to fulfill and maintain their function at the sharp end.

More demands are placed on the pilots as complexity continues to grow in aviation. This is due to more technology, more rules of compliance, more diversity in operations, and less time to do it all in the aggressive competitive world of aviation. Alongside this grows the increase in demands on the pilot's adaptive capacities to balance safety and productivity. But is work designed to support and assist resilient performance and consider the well-being of the humans in the system? What constraints influence the adaptive capacities, and what does this mean to the overall performance of a system? More resilient or more brittle?

This thesis explores these questions by incorporating perspectives from a group of pilots (micro-level), a safety department (meso-level), and a group of CAA flight inspectors (macro-level). This is done to better understand what it means to work in an airline and explore whether a ‘dark’ side to the resilient performance potentially influences the system’s overall performance.

This study reveals a gap between work-as-imagined based on the dominant safety paradigm prevalent in aviation, and work-as-done, based on value rationality. For pilots to meet multiple conflicting goals simultaneously, they develop their own adaptive strategies, resources, and artifacts. They do this to sustain the daily operation to an extent of adaptive saturation, influencing the resilient performance of a system that goes unnoticed and unaddressed.

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1. Introduction

1.1 Background

“In the beginning, you can feel very alone in the left seat.[1]”

Historically, aviation has been known to be safe, defined by the low number of occurrences leading to incidents and accidents (ICAO, 2020). Part of this success has been assigned to “well-trained and well-qualified pilots” (Bailey et al., 2017) working in an airline due to the intensive training they receive throughout an aviation career to fulfil the functions in a safety-critical environment.

Rules and procedures form the foundation of these work functions, and proficiency checks in simulators ensure that a certain performance standard is achieved. Crew Resource Management (CRM) provides means for ‘soft’ areas such as utilizing “all available resources to mitigate and prevent errors” from happening (Lauber, 1984). Safety Management Systems (SMS) are in place to identify hazards and mitigate identified hazards by measuring and documenting performance indicators (ICAO Annex 19), which are carefully filed and serve as indicators of how safe the system is. This provides the basis for audits performed by an appropriate Civil Aviation Authority (CAA) to meet the overall goal of being EASA compliant.

Identified hazards, findings from audits and/or incidents and accidents happening in the industry form the basis for modifications in the training to learn from. This could, for example, be new procedures, new ‘call-outs’, new ways of flying the aircraft according to the manufacturers, or new topics to discuss during CRM training to shape the desired behaviour to fulfil the work functions. Training constitutes a significant part of system safety and is argued to constitute the basis for the frontline personnel in how they carry out the functions in the socio-technical system.

[1] Statement from one of the respondents in the research.

From my perspective, after working in the industry for many years, it makes sense that work structures and work functions must be in place in a safety-critical industry. The initial and recurrent training must prepare the frontline personnel in the work functions suited to the reality they meet out on the line.

I became a captain in 2007, after going through the standard process in the airline. Besides many flight hours as a first officer in the right seat, this meant knowing the rules, manuals, and procedures, and demonstrating flying skills under various predetermined conditions. The rationale was that this would prepare me to fulfill the work functions in the left seat. However, meeting the realities out on the line left me in various situations that were not covered by rules or procedures. Fully aware of the expectations that come with the job, I was left to figure out for myself how to deal with the challenges in everyday operation. Challenges that were not written down in any manuals or accounted for in training but just emerge as messy details in everyday operation. However, filed away in a cabinet in the airline was the documentation entrusting me with the responsibility to perform anytime and anywhere from the captain's seat, in accordance with the rules required by the appropriate authority, stating that the airline had done their part through extensive training. Although it did not ease my anxiety in fulfilling the role, it did plant the conscious thought of the responsibility resting with me. To cope with the messy details of everyday operations and meet the airline's demands, I started developing my own strategies.

One may question how well the current form of training prepares pilots to do their jobs safely, and what might emerge in the interface of how pilots are trained, and how work is actually done. Is it possible that the current form of training is not compatible with a complex socio-technical system, leaving the frontline personnel to figure it out by themselves? What sort of underlying mechanisms might influence the way that work is done? And most importantly, what might emerge from that?

Today's aviation training is based on a logic of reductionism that implies that to understand the system, "you need to reduce it to its individual components" (Heylighen et al., 2007, p.120). In this case, the function required to fly in the left seat is decomposed into training

elements of line training, simulator training, check of knowledge in rules, and adherence to procedures to prepare frontline personnel to navigate the real-world environment and achieve the desired outcome.

This logic is also prevalent in CRM training, the field I have been teaching for a couple of years in various airlines. In this training, the emphasis is on the importance of training the pilots to be assertive and resilient to prevent errors from happening, implying that the responsibility ultimately rests upon the humans in ensuring safe operation.

This rationale is founded on the assumption that the system is well designed, and if the frontline personnel behave as they are trained, the system is basically safe (Hollnagel, 2014, Dekker, 2011).

Out of this rationale follows that when things go wrong, the logic implies that decomposition can tell which component of the system failed. Traditionally, the failure is assigned to "human error" (Woods et al., 2010) or other labels expressing a deficiency of the human operator. A remedy in place to deal with this is either extra simulator training, degradation, or termination of employment to counter the deficiencies of the human and restore safety equilibrium.

Working in the aviation industry for about 20 years, primarily as a pilot but also as a CRM trainer, has often left me frustrated with how the system works. My own experience and the many stories entrusted to me as a colleague and through training have left me with the feeling of something not adding up in how training and work are conducted. This feeling has increasingly grown over the last couple of years.

On the one hand, I bought into the aviation rationale in the CRM training: That human errors are the cause of up to 80% of accidents (Rankin, 2007), and the logic that encourages behaviour shaping training by telling pilots to be more vigilant, more assertive, and more resilient, to prevent incidents and accidents from happening. After all, that is what the experts of EASA tell us to do (AMC1 ORO.FC.115), and as an industry of compliance, we comply (EU965).

On the other hand, the stories from the pilots resonated with my own experience to a degree that raised questions about the fairness and purpose of placing the responsibility with the pilots. Something just did not make sense. The stories told by the pilots did not match the rationale that humans are a liability to the system. On the contrary, the stories I heard circled around how often the pilots stretched and went to great lengths to make the big puzzle fit in a messy work environment. Stories that had less to do with the pilots and more to do with deficiencies in the system. Deficiencies that no amount of assertiveness, resilience, or good CRM could prevent. However, these stories do not fit the aviation rationale of an inherently perfect system; a perfect system where the trouble lies in frontline personnel's behaviour that needs to be shaped through training to prevent bad things from happening, also known as Safety I (Hollnagel, 2014) or First Stories (Woods et al., 2010).

However, according to Safety Science, there is a "second" story (Dekker 2011, Woods et al., 2010) that tells that the system is not inherently safe and that this form of training may not be suited for working in a complex socio-technical system as aviation. The system cannot be understood by 'structural decomposition' (Rasmussen, 1997, Dekker, 2011) but must be understood through the web of dynamic interactions going on across scale that shapes and influences the performance of the system and where unaccounted system properties emerge daily. Emergent properties are here understood as unexpected behaviours from the interaction between the components and the environment (Johnson, 2006). These emergent properties can be beneficial, for example, if pilots adapt in ways to support tasks that designers never intended. However, they may also turn out harmful "if they undermine important safety requirements" (Johnson, 2006, p. 1476).

From the perspective of acknowledging the complexity of the socio-technical system, the light shines differently on the human operator. In this light, the human operators are seen as the source providing adaptive capacities, adjusting their performance to patch up an imperfect system to balance safety and productivity. A view that resonates with the stories I heard from the pilots.

Out of this "second story" also grows a consciousness that the system is not well designed and that the training of following procedures and rules cannot encapsulate work in a socio-technical system. The aviation system is far more complex. It consists of a web of interrelations and interdependencies that cannot be predicted in advance and cannot be reduced to 'following procedures' (Dekker, 2011). This perspective is recognized in, for example, concepts such as Safety II (Hollnagel, 2014) and Resilience Engineering (Dekker et al., 2008, Hollnagel et al., 2011). They see humans working in the system not as a liability but as a resource that provides "an enormous contribution to safety" (Holbrook et al., 2019) unrecognized in the aviation domain.

This implies that the current aviation training is not suited for the complex world of aviation, and safety is achieved by something more than what the frontline personnel is trained for that contributes to the resilient performance of a system. But what does this contribution to the resilient performance look like, and how is it achieved? What sort of drivers lay underneath the sustainment of daily operations and safety of a system? Is the contribution exercised by the frontline personnel of infinite capacity, or are emergent properties associated with this contribution? Do unintended consequences exist in the system that is unrecognized and/or unspoken of. And do these unintended consequences 'hide' areas of brittleness in the system?

This thesis seeks to explore if a 'dark' side exists in the system that is expressed as unintended consequences to resilient performance and is tied to the interrelations and interdependencies across the scale of the micro (pilots), meso (safety department), and macro (the CAA).

The thesis question for the research is:

'How does reliance on resilient performance 'hide' or even contribute to system brittleness?'

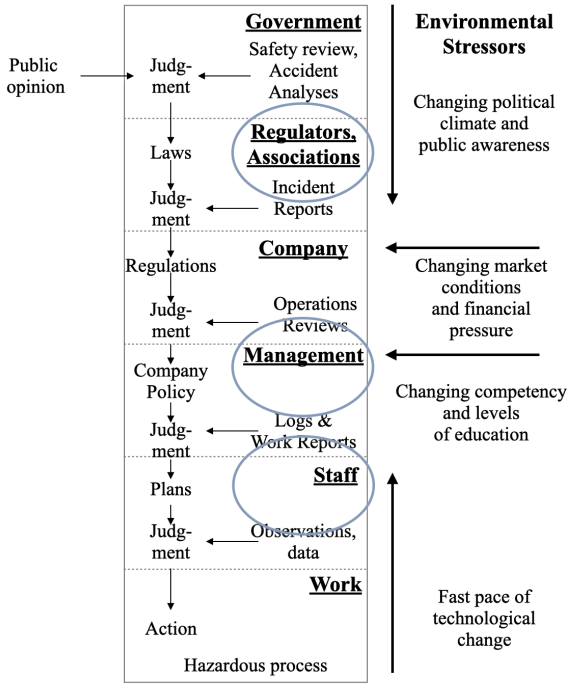
1.2 Research focus and Objectives

The research will take its point of departure in the practices and strategies of adaptive capacities exercised by the frontline personnel (micro-level) to understand how and why these adaptive strategies are played out in the aviation system. To understand system features of interrelations and interdependencies from a broader perspective, meso-level (safety

department) of the same airline and macro-level (Civil Aviation Authority) will give their perspective on how the adaptive capacities play out in the system.

As illustrated in the Rasmussen socio-technical system model below, the system of interest becomes the relations and interactions between Regulators (CAA), Management (Safety department), and Staff (the pilots) and how they influence each other with a basis in the lived experience of the staff.

The socio-technical system involved in risk management



(Adapted from Rasmussen 1997, p. 185)

This research aims to understand the resilient performance of a system, discover potential emergent properties associated with adaptive capacities, and explore what this means in the overall system. The understanding takes its starting point in the stories told at the micro-level and connects these to the perspective of the meso and macro level.

The objective of this research is to:

1. Identify and discuss different features of resilient performance at the micro-level,

2. Critically evaluate different system features influencing resilient performance through the lenses of micro, meso, and macro,

3. Analyze if and how unintended consequences are emerging from resilient performance and, if so, how such unintended consequences affect system performance and behaviour.

These objectives are clearly intertwined but are stated to give focus on the research task, and thereby, by meeting these objectives, the overall research aim will be achieved.

2. Literature review

2.1 Introduction

In recent years, Resilience as an EASA training objective for frontline personnel has entered the world of aviation. But what does resilience mean when looking through the lenses of different safety paradigms? And will training of resilience guarantee a safer system or a riskier one? Could there potentially exist an unspoken 'dark' side to resilience? This literature review will focus on providing insights into previous work by locating this research project in its context (Blaxter, 2006). The review will identify and evaluate what I see are the most pertinent sources of information in the further process of the research.

2.2 Resilience development in aviation: A product of a safety paradigm?

After the Germanwings crash in 2015, the European Commissioner for Transport issued an EASA Action Plan requesting a Task Force lead by EASA to come up with recommendations, which would prevent such a disaster from happening again. In the EASA Action Plan, it is stated that: "The Germanwings tragedy reminded the international aviation community that the medical and psychological conditions of flight crews, if not detected, can lead to a catastrophic outcome" (2015, p. 3), implying we can go back to having a safer system after this implementation. The following year, a new topic was implemented in the CRM training syllabus, 'Resilience development' (AMC1 ORO.FC.115). The Guiding material (GM) on how to train 'resilience development' to frontline personnel stated to include the following:

- Mental flexibility,
- Reflect on own judgment and adjust to the unique situation,
- Avoid fixed prejudices and over-reliance on standard solutions, and
- Remain open to changing assumptions and perceptions.

According to Bergström (2020), this regulatory formulation suggests that resilience is a human trait that can be trained and developed “at the level of pilot mental processes and behaviours” (p.178).

To be compliant, CRM training is to a great extent based on the EASA Guiding material, which seems to be founded on the assumption that training resilience as an individual trait would prevent disasters like the Germanwings from happening again, and the system would return to a safer state. Furthermore, it provides a new label for pilot performance measurement to assess whether the pilots are resilient enough.

Labels to categorize human behaviour in aviation are widely used in training and assessing frontline personnel. Looking back in aviation history, the work of James Reason seems to have played an especially significant role in how safety is managed in aviation today. Reason’s seminal work (1990, 1997) provided aviation with taxonomies that describe how unsafe acts of people can be categorized into errors, violations, and mistakes. The Swiss Cheese Model has been widely used in training to illustrate how organizational factors can lie latent and suddenly be triggered into what culminates in an accident that forms the basis for risk assessment and accident investigations today by, for example, looking for root causes.

In the field of CRM training, a certain psychological path laid the grounds for the training that addressed the prevention of errors at the level of the frontline personnel (Helmreich et. al., 1999). CRM training has gone through several generations of evolution. For example, the error troika states that “it's human to err” and has stayed ‘true’ to its original idea that accidents can be prevented by behaviour shaping mechanisms of the unreliable human in the system. Still today, we see the exact same CRM definition stated in the regulations that emerged in 1984, where the objective of training frontline personnel springs from “utilizing all available resources to promote safety and enhance the efficiency of flight operation” (Lauber, 1984).

It may, therefore, not come as a surprise that the focus on the human in the system is also prevalent in the recent European Plan for Aviation Safety (EPAS) 2020-2024. In it, the

strategic priorities are described as: "… the latest accidents and serious incidents underline the complex nature of aviation safety and the significance of addressing human and organizational factor aspect", with an emphasis on human factors described like: "this term focusses on why human beings function in the way they do. The term incorporates both mental and physical processes and the interdependency between the two" (EPAS, 3.1.1.2). There seems to be a particular interest in explaining safety as dependent upon the internal environment of the human and training as the remedy for correcting unsafe behaviours of the frontline personnel in an otherwise safe system. One could suggest that the search for "supposed psychological error mechanisms inside an operator's head" (Woods et al., 2010, p. xvii) continues.

This logic is nested in a certain safety paradigm of centralized control (Provan et al., 2020), where the system is believed to be well designed and maintained by procedures and training because frontline personnel "behave as they are expected to - and more important as they have been taught or trained to do" (Hollnagel, 2012, p. 6). From this rationale, resilience can only be placed at the level of the human, in exhibiting "mental flexibility, avoidance of over-reliance on standard solutions, remaining open to changing assumptions and perceptions" (AMC1 ORO.FC.115) – how could it be anything else? From this perspective, it comes as no surprise that resilience is seen as an individual trait, and if the frontline personnel behave as they are trained (e.g., are resilient enough), future disasters can be prevented. This safety paradigm goes under the name Safety I (Hollnagel, 2014), "Old View" (Dekker, 2011) or "First Stories" (Woods et al. 2010).

2.3 A contrasting Safety paradigm: The systems perspective

However, what the aviation world seemed to miss along the way, or perhaps chose to disregard, was the growing field of Safety Science. Around the same time as CRM emerged in the 1980s, another perspective emerged, where 'the inner environment of the human' was not the focus of interest, but where behaviour is seen as a reflection of "an unkind work environment." (Rasmussen, 1986, p.150).

"A thinking human being is an adaptive system… To the extent that he is effectively adaptive, his behaviour will reflect characteristics largely of the outer environment… and will reveal only a few limiting properties of his inner environment…" (Rasmussen, 1986, p.63).

Rasmussen introduced a new perspective from his observation of real-world work environments. Rasmussen founded the school, which suggests that bad outcomes could not be found by labeling human behaviour, but rather it should be considered "that an error can only be found if a standard of judgment exists and whether or not an act is judged an error depends on the perspective and reference for judgment chosen" (Rasmussen, 1997, p.205). Accidents could thereby not be explained at the human level but as "the effect of a systematic migration of organizational behaviour under the influence of pressure towards cost-effectiveness in an aggressive, competitive environment" (Rasmussen and Svedung, 2000, p.14).

The work of Rasmussen is seminal in the field of Safety Science. His work represents pillars in the emergence of a new perspective, acknowledging that a socio-technical system is complex and consists of social and technical elements that must be understood in the interactions of interrelations and interdependencies in influencing one another (Rasmussen, 1990, Adriaensen et al., 2019). This means that the component (e.g., the human operator) of a system cannot be viewed separately (Rasmussen, 1997, Dekker, 2011, Woods et al., 2010) but must be viewed from a holistic system view (Wilson, 2012) where interactions and interrelations are intertwined in a non-linear complex web, and the whole is usually greater than the sum of its parts (Wilson, 2013). Complexity is understood as a variety of emergent properties (Woods, 2006) and where the emergent properties cannot be reduced to the properties of the parts (Heylighen et al., 2007).

From this perspective, frontline personnel is considered as representing the "*presence* of something" (Dekker et al., 2008, p.2) in the overall system. They contribute to safety in how they manage to fill the gaps of a flawed, complex system by matching and adjusting their performance through adaptive capacities, contributing to overall resilient performance in the system. This safety paradigm is based on guided adaptability (Provan et al., 2020) and also known as Safety II (Hollnagel, 2014), or Resilience Engineering (Hollnagel et al., 2011).

Out of this perspective grows the consciousness that the current form of centralized control in training design founded in Safety I (Hollnagel, 2014) may be insufficient and inappropriate for the complex socio-technical system. However, it is nevertheless still very much alive in aviation (Holbrook, 2019). The differences between Safety I and Safety II are illustrated in the table below. Secondly, the failure to fully consider and recognize the contribution made by the human adaptive capacity in the aviation system goes unrecognized and leaves a gap in understanding the interrelations and interdependencies and how they influence the system's resilient performance.

This thesis does not rest on a belief that Safety II should replace Safety I, but more as a means to illustrate how they are currently contrasting.

	Safety I	**Safety II**
Definition of safety	That as few things as possible go wrong	That as many things as possible go right
Safety management principle	Reactive, respond when something happens	Proactive, try to anticipate developments and events
Explanations of accidents	Accidents are caused by failures and malfunctions	Things basically happen in the same way, regardless of the outcome
View of human factor	Liability	Resource

Adapted from Hollnagel, 2012, p.12.

2.4 Features of resilient performance in a system

In the previous sections, I discussed the different safety paradigms, as it is important to understand which paradigm is underpinning when we talk about resilience. Safety II and Resilience Engineering represent a shift in the paradigm. Instead of looking for what goes wrong (e.g., Safety I), attention is shifted towards what is going right (Hollnagel et al., 2011).

One of the fundamentals in the new safety paradigm is acknowledging that the system is not inherently safe and that people need to patch up the imperfections (e.g., competition pressure, meeting conflicting goals, limited resources available) (Dekker, 2019).

Resilience Engineering (Dekker et al., 2008, Hollnagel et al., 2011) is described as the adaptive capacity exercised by the frontline personnel to navigate goal conflicts through trade-offs and workarounds to sustain the daily operation. This resilience has been celebrated as the success criteria of how operations are sustained by frontline personnel matching and adjusting the variable performance demands. Resilience can also be seen as how a system "gracefully extends" its performance when surprising events challenge its boundaries (Woods, 2015, 2018), along the same lines of seeing it from a systems perspective, where resilience is described as: "a system's abilities to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operation in both expected and unexpected conditions" (Hollnagel et al., 2011, p. xxxvi).

Since work is messy (Nemeth et. al., 2004), we may need to understand resilience is emerging in the process. Bergstöm & Dekker (2014) describe it like this: "Rooted in complexity theory is the idea that resilience is a system property, emerging from interactions and relations at local levels" (p. 1). This suggests that what is going on at the local level may influence the system as a whole. This is also mentioned by Woods (2006) in what he calls cross-scale interactions to understand the higher-level emergent properties. Hollnagel describes it as how anticipation differs across scales and cannot be distributed equally in the larger system. "The global system may anticipate occurrences that are too rare to be even thought of at local scale, while local operators will anticipate situations that are much too detailed to be tackled at a larger scale" (Pariés, 2011, p. 4).

Nested in Resilience Engineering, this thesis wants to understand how frontline personnel engineer "adaptive capacities into their system so the system keeps functioning under varying circumstances" (Bergström & Dekker, 2019, p. 391) and what this means in the overall system through the cross-scale interactions.

Therefore, resilient performance could be seen in the light of understanding how resilience emerges in adaptive capacities by examining how the frontline personnel adjusts their performance in everyday activities according to the different system constraints imposed at the local level. How they make sense, interpret and match the performance to the work conditions, and how they intervene before situations escalate (Hollnagel, 2014). However, adaptive capacity is finite (Woods, 2015, 2018), and although this cannot be drawn as a hard boundary, the seeking of patterns of resilience and brittleness, may tell us about system feature influences that can be drawn from the local into the global system. This means that to understand resilient performance, we must also understand system brittleness of "how the system in question performs when it is pushed near boundaries of how it has been designed to operate" (Woods, 2006).

As described above, the definition of resilience is an ongoing discussion within Safety Science (Bergström et al., 2015). For this thesis, resilience is understood as an emergent system property (Dekker & Bergström, 2014, Woods, 2018), viewed from the perspective of how sustained adaptability gracefully extends the system (Woods, 2015, 2018) and keeps within the envelope of performance. By sustained adaptability, I am referring to " the ability to continue to adapt to changing environments, stakeholders, context and constraints" (Woods, 2018, p. 433). The interest of this thesis especially goes to understanding the relationships and interactions between micro, meso, and macro-level and how resilience as sustained adaptability (Woods, 2015, 2018) emerges from that. Additionally, I am interested in exploring if and how saturation occurs, exhausting the range of adaptive capacity (Woods, 2018) leaving the system more brittle. Woods (2018) argues that graceful extensibility, which encapsulates sustained adaptability, is the opposite of brittleness. Brittleness in this context is therefore understood as " insufficient graceful extensibility to manage the risk of saturation of adaptive capacity" (Woods, 2018, p. 442).

Although Safety II and Resilience engineering emerged with a focus on "what is going right", the research of this thesis wishes to explore whether unintended consequences to adaptive capacities of making "things go right" exists, obscured in possible organizational over-reliance on people to fill the gaps of the imperfect system (Woods, 2006). As the demands for

adaptive capacities increase with the growth in system complexity, one may wonder whether the emergent property of resilience may 'hide' system brittleness?" It follows that the same characteristics of a system that produce the bright side will regularly provoke the dark side from time to time" (Vaughan, 1999, p. 274).

Following the lines of Vaughan wakes the curiosity towards understanding the social interactions in the system happening behind the curtains. "Unanticipated consequences of purposive social action can be differentiated into consequences to the actor(s) and consequences to others that are mediated through social structure, culture and civilization" (Vaughan, 1999, p. 272). These 'invisible' mechanisms may be hard to detect but could potentially influence the resilient performance that affects the organization as a whole over time. Secondly, when things are "going solid", these adaptive strategies might 'hide' the tight coupling happening unrecognized by management, resulting in a "flirting with the margin of acceptable performance" due to the solid system having little available 'slack' (Cook and Rasmussen, 2005).

This thesis, therefore, will explore whether the achievement of resilient performance in how frontline personnel adapts multiple conflicting goals at the same time results in a "flirting with a margin of acceptable performance" due to effective strategies exercised at the local level, that eventually might contribute to a "drift into failure" (Hollnagel, 2014, Dekker, 2001, Woods and Cook, 2003, Dekker, 2011). Is sustained adaptability (Woods, 2018) associated with the tragedy that obscures how close a system might be to failure? (Wears and Hettinger, 2013).

The Safety Science literature about resilience is extensive since the introduction of Resilience Engineering in 2004 (Dekker et.al., 2008, Bergström, 2019) and Safety II (Hollnagel, 2014). These concepts represent a much-needed safety paradigm shift in focusing on "what goes right" as expressed by the adaptive capacities of the people in the sharp end, and much focus has been on emphasizing the contribution to safety and productivity from frontline personnel. However, not much literature reveals whether a price is attached to approaching the limits of adaptive capacity (Woods, 2018) and what sort of emergent properties could be associated

with unknown and 'hidden' features of resilient performance. This may represent a gap in the literature that asks for more empirical research.

3. Research Methodology

3.1 Introduction

As noted in the previous chapter, there is an abundance of Safety Science literature on Resilience Engineering and Safety II, focusing on "things that go right". In contrast, there is little research on the potential unintended consequences of ‘making things go right’ and what that means in the overall system.

This thesis aims to understand how practices and adaptive strategies at the micro-level are performed to understand how these emerge through interactions at the micro, meso, and macro level. By taking the point of departure in the stories told by the pilots (micro-level), I believe that insight can be achieved into how work is done by understanding how they adapt and make sense of their work functions, which reveal insights into the power relations between the levels.

According to Kaplan, "methodology is to help us understand, in the broadest possible terms, not the product of scientific inquiry but the process itself" (1964, p. 23).
In order to study work in a socio-technical system, the underpinning idea of how the world works around us is necessary, meaning that “something that reaches into the assumptions about reality that we bring to our work” (Crotty, p. 2). This means that the ontological considerations rest in the ‘horizon of meanings’ (Flyvbjerg, 2019). Many realities of a concrete phenomenon exist, based upon social constructions and values surrounding and influencing an emerging context.

This thesis is inspired by several ideas that form the underlying methodology of this paper. One of the main inspirations for this thesis work has been phronetic research (Flyvbjerg, 2019). Phronetic research is context-dependent and concerned with “a sense or a tacit skill for doing the ethically practical” (Flyvbjerg, 2006, p. 372) seen in the light of experience. Phronetic research focuses on specific values and interests in the context of particular power relations (Flyvbjerg, 2006). For this thesis, I seek to understand the relationship between rationality and power in the horizon of meanings at the micro, meso, and macro-level. By

understanding the practical wisdom (phronesis) in, practices and strategies exercised at the micro-level, I wish to explore to what extent they are shaped and influenced by the power relationship at meso and macro. Moreover, I also seek to understand what emerges from this local logic of phronesis at the micro-level, and how the emergent properties influence the system as a whole. The relationships are then explained through value-rational questions (Flyvbjerg, 2019).

Although the foundation of the analysis takes its point of departure in practices and strategies exercised at the micro-level, the idea is not to focus on the individuals in the system. The idea is to understand how they modify existing structures and practices to make the system function through relations and dependencies that connect to system features (Pettersen et al., 2010).

From this point of view, I seek to understand the relations between agency/structure (Flyvbjerg, 2019, Pettersen et al., 2010) to understand one dimension of the socio-technical system where neither agency nor structure can provide explanations, but where the explanations lie in a reality that can be found 'out there' in the interconnectedness between the two. This is expressed by how frontline personnel deal with and modify existing structures in a socio-technical system to make the system function, shaped and formed by 'the relationship from design to operations' (Pettersen et al., 2010). Meso (safety department) and macro (CAA) perspectives on practices and structures are incorporated to explore this relationship. They will provide a more rich picture of how these relationships play out that allows for pluralism in meanings and interpretations by understanding the horizon of meanings and possible power relations (Flyvbjerg, 2019) in a search for not one voice of the 'final truth', but a polyphony of voices (Flyvbjerg, 2019, p. 139). Therefore, I find that critical realism, as stated by Bhaskar's theory (Pettersen et al., 2010) and Phronetic research (flyvbjerg, 2019) overlap in areas that inspire this methodology.

3. 2 Research Strategy

3.2.1 Choosing the method

A qualitative approach was used for this research, as "it tends to focus on exploring, in as much detail as possible, smaller numbers of instances or examples, which are seen as being interesting or illuminating, and aims to achieve 'depth' rather than 'breadth'" (Blaxter, 2006, p. 64). This type of approach seems suitable since the underpinning paradigm of this research is concerned with discovering and exploring rich data and understanding the system's interrelations and interdependencies through the pilots' stories.

Since I have access to the different micro, meso, and macro-level groups through my work, focus group interviews (Krueger and Casey, 2014) were the obvious choice as the method. I knew it would provide me with rich data that could help me explore and discover subtle interactions between micro, meso, and macro that could help tell how their worldview is shaped and what it means (Vaughan, 1996).

One of the advantages of focus group interviews, compared to individual interviews, is that they allow the respondents to share their sense-making through specific stories told of how work is done. Sharing this as a group tells about commonalities in challenges of lived experiences and may reveal patterns of system features such as underpinning assumptions and cultural aspects that act as social forces of how work is done.

This approach is also susceptible to several limitations. Besides the fact that it is a ‘one-shot’ case study (Krueger and Casey, 2014), there is also a risk of groupthink (Janis, 1991). Since the respondents know each other (and I knew some of the respondents), elements of social desirability biases can influence the trajectory of talk.

Focus group interviews can be conducted from two different strategies: topic guide or questioning route (Krueger and Casey, 2014). For this research, I chose the questioning route strategy, as I tried to narrow down the distinct purpose of each question through a sequence of questions that would later help me derive themes for further analysis.

3.2.2 Designing the research

Early on in the thesis process I knew, I wanted to pursue an understanding of the broader picture that would encapsulate the social forces influencing work in aviation and what underlying assumptions were involved in understanding challenges and risks associated. This allows for a deeper understanding of resilient performance as the object of research, in how to work at the sharp end is connected through relations and interactions in and between levels in the overall system.

The sequence of the focus group was important, as I wanted rich stories from the pilots' everyday work to establish a scope of resilient performance that could provide me with an idea of the graceful extensibility (Woods, 2015) of adaptive strategies and how these played out locally. Furthermore, I was interested in exploring whether there were any unintended consequences associated with the sustained adaptability (Woods, 2018) by understanding their perspective on underlying mechanisms that influenced their behaviour, which could help me understand power relations through the interactions across levels.

With the pilots' statements in mind, the safety department (meso) was the next focus group interview to be conducted. Without revealing anything from the first focus group interview, I was curious to find commonalities and differences in the safety department's statements that may help me discover system features of the relations that provided explanations for what was going on at the micro-level. They might also help me explore to which degree the meso group recognized what is required to sustain the daily operation. Essentially, what kind of assumptions exist about safety and work-as-done (Hollnagel, 2014) and paying attention to what is said and *not* said to connect this to power relations (Flyvbjerg, 2019).

This provided me with a rich picture of work in an airline, which I brought to the focus group of the CAA[2]. Insights and identity of the airlines were not revealed to the CAA, as I was there searching for a more general perspective of the airlines in the industry. What trends and patterns did the CAA inspectors see as challenging for the frontline personnel, through their eyes of rules, regulations, and audits and what emerges from that? I believe that the three

[2] CAA: Civil Aviation Authority

different perspectives could provide me with a deeper understanding of the relations that connect and are intertwined in the interplay between frontline behaviour and system features. And that would help me understand more about the resilient performance of a system, and ultimately safety and risk, through the horizon of meanings (Flyvbjerg, 2019).
Since I had access to representatives of micro, meso, and macro, there seemed to be an opportunity to do so.

3.2.3 Selection of respondents

The respondents were selected by approaching an airline that agreed to participate with pilots in connection with a recurrent CRM course and a separate meeting a few weeks later with the safety department. It was, however, emphasized by the airline that they wished to be anonymous in the research. In connection with a training course I delivered for the CAA, they agreed to participate as well.

Focus group 1 - pilots (micro)

I planned it so I could start with a focus group of pilots (micro), as I found it important to establish a baseline of real-life stories. This group consisted of nine pilots and were a mix of captains and first officers, representing a wide range of experience. All pilots were Scandinavians.

Gender	Position (FC or FO)	Flight hours
Male	Flight Commander	18000
Male	Flight Commander	12000
Male	Flight Commander	10000
Male	Flight Commander	8800
Male	First Officer	8900
Male	First Officer	8600
Male	First Officer	7000
Male	First Officer	3000
Male	First Officer	1500

Focus group 2 - Safety Department (meso)

The second focus group consisted of the safety department in the same airline, which consisted of three Scandinavian pilots.

Gender	Position	Years in position	Flight hours
Male	Head of Safety/ Flight Commander	1,5/20	8500
Male	Safety officer/Flight Commander	9/18	8300
Male	Safety officer/Flight Commander	5/40	5500

Focus group 3 - Civil aviation authority (macro)

The third focus group was conducted with a Scandinavian CAA.

Gender	Position	Years in position	Flight hours
Male	Chief inspector	0,5	14000
Male	Chief inspector	11	12000
Male	Chief inspector	0,5	11000
Male	Chief inspector	0,5	3500
Male	Chief inspector	3,5	250
Male	Chief inspector	13	200

3.2.4 Data collection

Three focus group interviews (Krueger and Casey, 2014) were conducted in February 2020, based on a semi-structured approach. Inspired by the Critical Decision Method (Klein et al., 1989), four questions were developed in cooperation with my supervisor to dig into interviewees' stories and tap into areas of experience and expertise. I would make the interviewees recall situations and reflect on the strategies used and the meaning they connect

to the situation. This also allowed me to observe the group dynamics going on in the room through the interactions that are said and that which is not said and observe the small signals exchanged among the participants during the discussions.

I initially gave the groups 25 minutes to discuss the questions before the facilitation. My teaching experience has taught me that participants are more motivated to share their stories if they have had time to reflect on the questions and share their experiences in small groups before sharing in plenum. This also allowed me to pick up on keywords to use in the following facilitation and observe the group dynamics. During the facilitation, further open-ended sub-questions were asked, taking into account the trajectory of the talk and the co-construction between interviewer and interviewees. Based on asking them to come up with situations that they found challenging and/or difficult in the daily operation, I could probe deeper into their stories of tacit knowledge.

I used a digital recorder after permission from the interviewees. During the group work, I wrote down keywords I picked up from the groups to use in the facilitation afterward, as it was difficult to clarify what was said in the groups on the digital recorder. Due to the number of interviewees, the pilots were divided into two groups called ‘Red team’ and ‘Blue team’. During the facilitation, I used red and blue whiteboard markers to distinguish between the two groups and simplify my data. The flip overs and initial thoughts written down after the workshop are part of the data collection.

Table 1. below shows the questions posed based on Critical Decision Method (Klein et al., 1989).

Question	Purpose	Link to thesis statement
1) "Discuss 1-2 situations that you find difficult/challenging in the daily operation."	For the interviewees to link resilience to their experiences. To establish resilience through stories told.	How resilience can be seen in the daily operation.
2) "What sort of resources do you find necessary to cope and adapt in these situations? "	To see what they see as the elements of resilience. What is required of the human to exercise resilience?	Identification of resilience and the resources embedded. Is there a 'good' and 'dark' side of resilience?
3) "What effect do these adaptations have on the daily operations? "	How resilience sustains and absorbs daily disruptions and change.	Linked to how resilience sustains daily operation.
4) "In your judgment, are there situations where the crew adapts and absorbs too much?"	To get into whether they find that there is a 'dark' side to resilience.	To look into if resilience might contribute to system brittleness?

All groups were asked the same four questions with small corrections (See table 1.). For example, in focus groups 2 and 3 (meso and macro), question one was rephrased to: "Discuss 1-2 situations that you think the crew finds difficult/challenging in the daily operation."

3. 3 Framework for data analysis

The analysis is inspired by Cognitive Task Analysis (CTA) (Crandall et al., 2006). From the micro group, collected data tells about actual events where people had to make sense of the situation and figure out what to do and how to do it. Understanding cognition in context means understanding both the cognition and the context that surrounds it. This is tied to specific cues, factors, and goals (Crandall et al., 2006).

Concept maps for knowledge elicitation have been used for all the groups micro, meso, and macro to derive themes for further analysis. The framework was therefore based on the following principles of CTA (Crandall et al., 2006)

3.3.1 Steps of analysis

The first step of the process started during the transcription, which was done immediately after the focus group interviews. In this phase, areas or cues of interest were underlined or marked in the transcript. Since the data was collected early in the phase of this study, there was a gap of a few months before the data was revisited by listening to the recorded tapes again and reading the transcripts several times.

The second step was to identify findings based on initial interpretations of what story I felt the data was telling across scale and discussions with the supervisor. From here, initial themes were derived. Statements from the participants were grouped in each theme written on big posters for further reflection. Concept maps of knowledge elicitation were made for all three groups and went through two cycles each.

The third step in the analytical process was to discover meaning by asking questions like: What are they thinking about? What are they worried about? What are they certain about? What information are they seeking, and from what source? This process was to a great extent diving into the transcripts, again and again, to discover meanings in the words, phrases, silences, or dialogues happening during the interviews. Based on the initial themes, the connection between the three groups started to emerge. The fourth and final step of the process was knowledge representation using concept maps and ultimately synthesized in an overall description of emergent patterns of resilience and brittleness.

3.3.2 The initial themes

Although not shaped perfectly in my head, some initial rough themes turned up in the days after transcribing the focus group interview. I chose to do this manually, as I felt that this process would help me get further into the data and allow themes to emerge. Combined with my hand-notes from the interviews, I highlighted areas of interest in the transcripts. After transcribing, reading the transcript a couple of times, and listening to the recordings again, I looked at the overall data to get an idea of emerging themes that would connect micro, meso, and macro through the interactions. In collaboration with my supervisor, I arrived at seven initial themes:

- Responsibilization
- The role wanderer
- Competing goals
- Secrecy of adaptation
- Different priorities
- Drivers of adaptation
- Normalisation of adaptation

These initial themes were written on posters, and statements from each focus group were place in the different themes, and I placed the posters on a wall to look and reflect upon. I soon found myself a bit challenged in connecting the three different groups, so I decided to dig deeper into the data by making concept maps for further knowledge elicitation that could guide me in the process of creating meaning and a wider picture. This became an abductive process of coding, where I allowed an openness for surprises in the data by cycling back and forth in data (e.g., transcripts and tapes) and theory (further reading and exploring from the safety literature).

Table 2. Concept map for the pilots

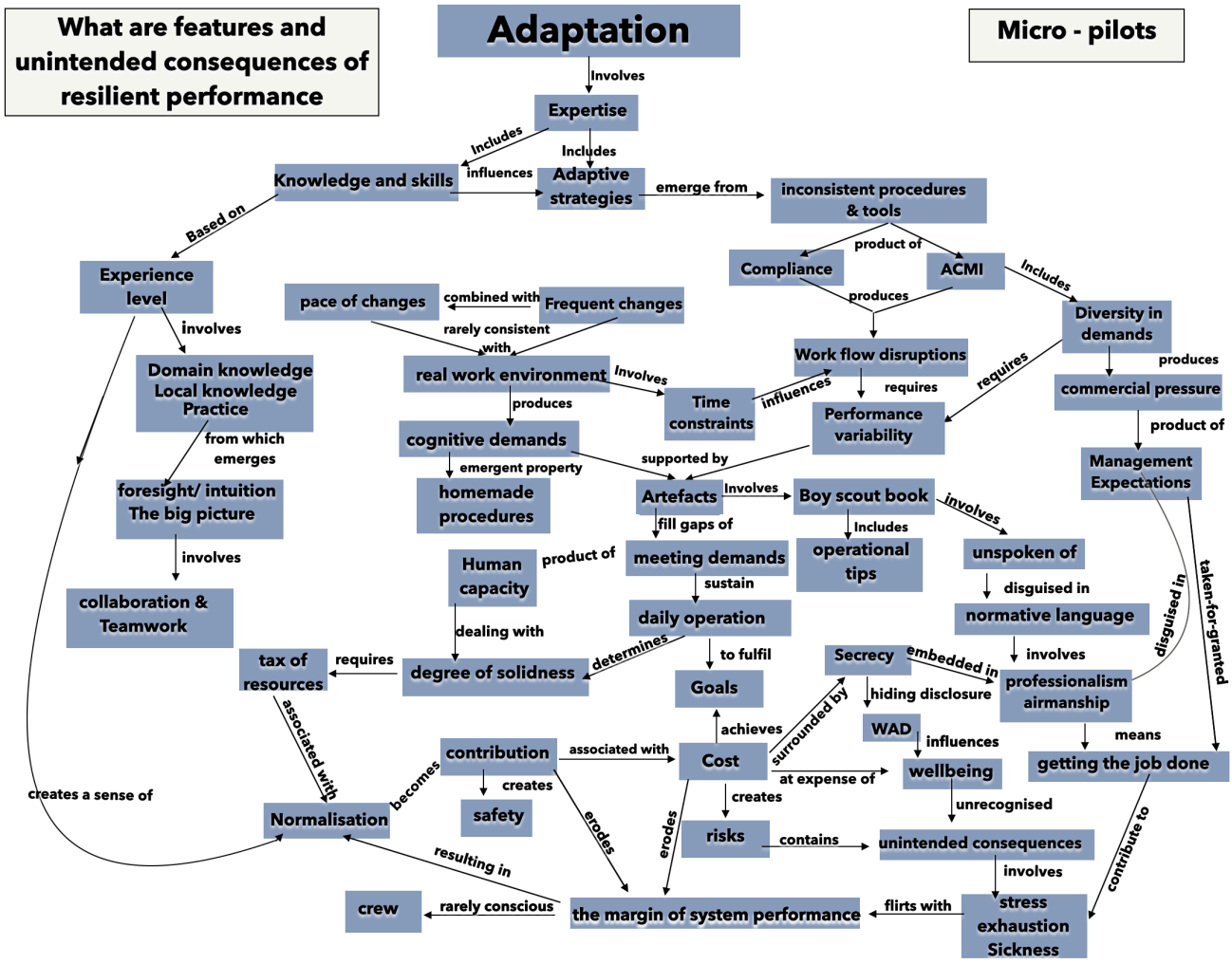


Table 3. Concept map for the Safety department

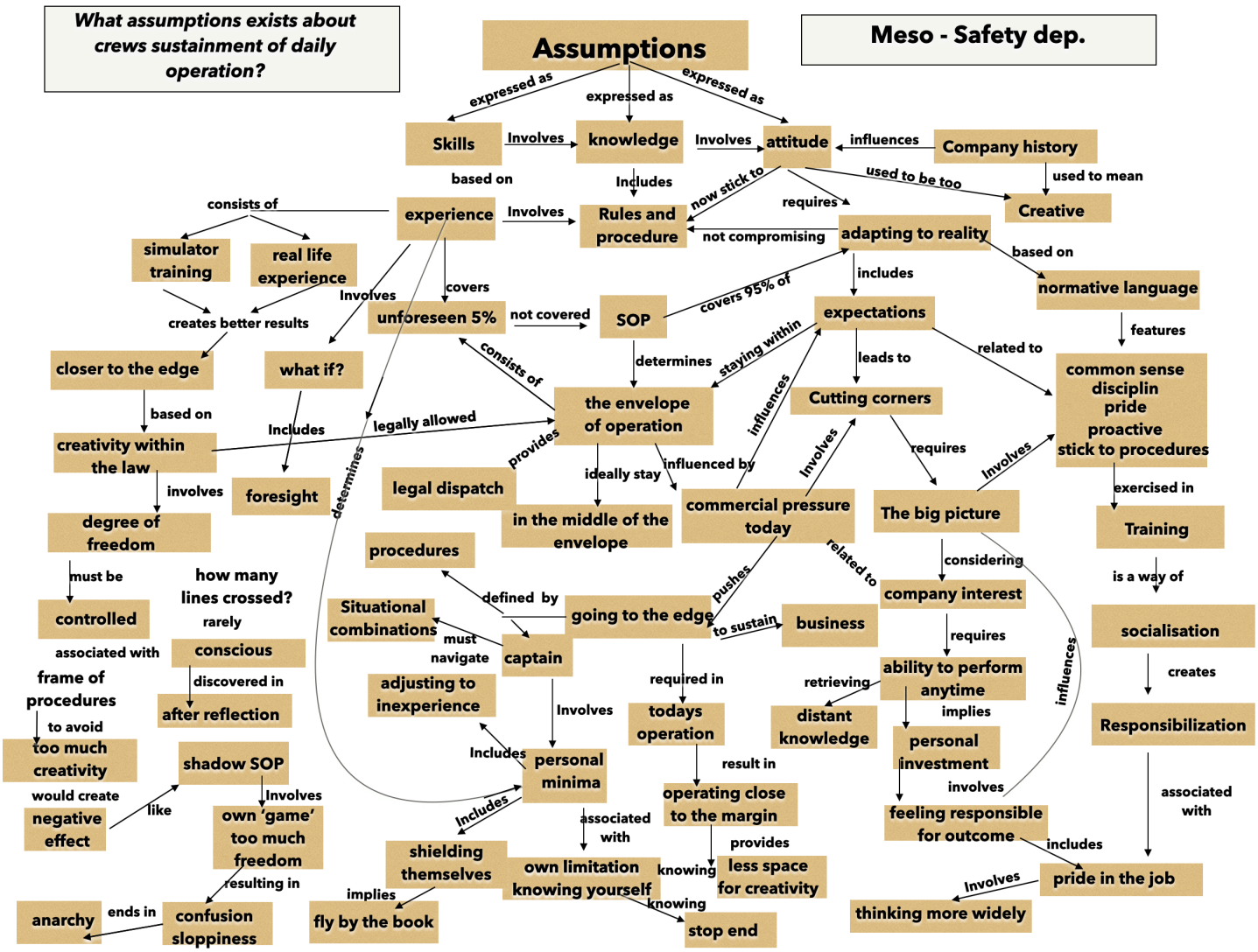
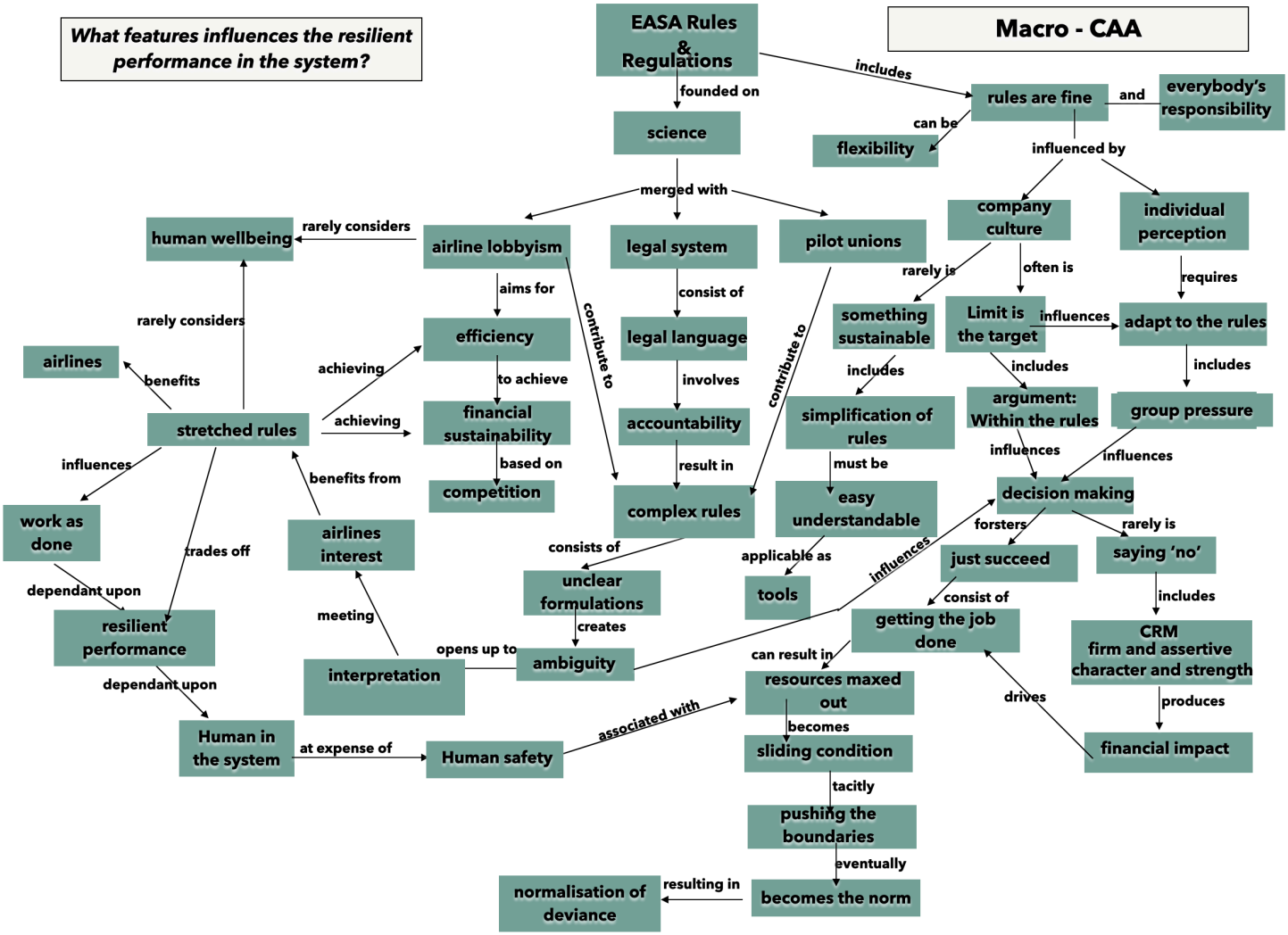


Table 4. Concept map for the Civil Aviation Authority



The coding process consisted of iteratively moving between transcripts and concept maps, and some of the initial themes became more salient for exploration in the analysis.

The foundation of the research is based on adaptation and sense-making as functions of macro cognition at a micro-level and what this means in the wider system. With the thesis question in mind and the research object being resilient performance, I arrived at three themes for my analysis.

Theme 1: Responsibilization

This theme goes to how the frontline personnel is made responsible through different invisible system mechanisms. This theme caught my attention, as it seemed to appear in various forms in the different focus group statements.

Theme 2: Using experience to solve the double binds

The initial analysis started with the theme, Normalization of adaptation. However, during the analysis and in collaboration with my supervisor, it became clear that experience seemed to be a more central theme in the data. Experience seemed to reappear as a central element across levels and appeared to solve the double binds. In connection with my thesis question and my previous flight experience, this theme resonated with my curiosity about resilient performance and potential conflicts across levels.

Theme 3: Hidden and unintended sacrifices of adaptation

Initially, the theme revolved around the kind of secrecy I sensed in the micro-level focus group, in the way that the pilots adapt in everyday operation. However, analyzing across levels revealed sacrifices of adaptation connected to secrecy that seemed more relevant to explore. My curiosity about this theme goes to the hidden and potential sacrifices that emerge from adaptation.

Although these themes overlap, several of the initial themes appear in the analysis as well. I believe that these are the themes that are best suited to help me answer my thesis question.

3.4 Ethical considerations

Ethical considerations concerning the participants in the research are guided by Lund University Research Ethics (https://www.researchethics.lu.se/).
Consulting this reveals that the research is not considered legally binding, and therefore does not have to undergo an ethical review in accordance with the Act on the Ethical Review of Research Involving Humans. Nevertheless, good research ethics will be sustained for this research.

In December 2019, an inquiry was sent to the airline who agreed to participate with a team of pilots and their safety department (micro and meso). A course was already booked for the CAA (macro), who also agreed to participate. An agreement to return with the result of the research after graduation was made with both organizations. Three separate dates were set for the airline and CAA in February 2020 to conduct the interviews.

When I arrived for the first interview with the pilots, it turned out that only one had been informed by the airline about the invitation letter and its purpose. I asked everybody present if they wished to participate voluntarily, to which they agreed. In the CAA focus group, one chose not to participate.

The interviews started with a short introduction informing the interviewees of the intent of the research. I emphasized that this research is solely for the purpose of my thesis and that no corporate interest was involved in the process. The interviewees were informed about confidentiality, clarifying the anonymity of the airline and the geographical position, including names and certain positions mentioned during the interviews. During the transcription process, all names and certain sensitive positions are represented by numerical codes to protect the interviewees from harms or wrongs (Swedish Research Council).
The interviewees signed an Informed Consent Form containing the following information:

- The overall plan for the research
- The purpose of the research
- The methods that will be used
- The consequences and risks that the research may entail

- The person responsible for the research
- That participation in the research is voluntary, and
- that the research volunteer has the right to terminate his or her participation at any time.

Signed Informed Consent Forms were copied or mailed afterward to the participants.

In the research, I am an outsider since I am not employed by either organization. However, I used to be a part of the airline and therefore possess insight and tacit understanding about how the airline works, which might possess certain biases. During the focus group interviews and analysis, I was aware that biases and preconceptions as part of the process were to be trimmed.

4. Results and Analysis

This chapter aims to go beyond the knowledge elicitation illustrated in the concept maps and described in the previous chapter. Also, it aims to get a sense of how the relations and interactions play out in the system by analyzing the data through the three themes: Responsibilization, Using experience to solve the double binds, and Hidden and unintended sacrifices of adaptation. To meet this objective, data extracts related to the three themes will be analyzed, discussed, and synthesized in relation to the thesis question and the literature reviewed in chapter 2.

The three groups (pilots, safety department, and CAA) are in this chapter referenced by using a code consisting of a letter and a designated number in the group. For the pilots (micro-level), the letter 'P' followed by a number was used (P1, P2, P3, P4, P5, P6, P7, P8, P9). There were three participants in the Safety Department (meso-level) denoted as S1, S2, or S3. The CAA group (macro-level) consisted of 6 participants denoted as C1, C2, C3, C4, C5, C6. Finally, 'SR' refers to me as a student researcher.

4.1 Theme 1: Responsibization

"In reality, however, power often ignores or designs knowledge at its convenience" (Flyvbjerg, 2019, p. 143)

For pilots, who represent the micro-level in the analysis, frequent changing procedures and adaptation to the different operations posed challenges in the daily activities.
Especially the work as ACMI[3] suppliers are associated with many different constraints, e.g., familiarising with many different destinations, demanding destinations of operation, several different carriers' procedures and ways of working, and different demands of on-time performance. These constraints represent dramatic changes in the characteristics of the working environment creating constant new demands for coordination (Cook and Rasmussen, 2005), as the pilots are not equipped with the same software tools as the airline for which they fly.

[3] ACMI: An agreement between two airlines, where the lessor agrees to provide an aircraft, crew, maintenance and insurance (ACMI) to the lessee - in return for payment on the number of block hours operated.

In one specific ACMI operation, the pilots were especially concerned by time pressure, through, for example, having to deal with many last-minute changes that require recalculation of the load sheet; a task that can easily turn out to be time-consuming and causing delays:

> In our own operation, we are allowed 5 min. delay before we have to write anything (e.g., delay code in the flight log). However, in 'X' it is 2 minutes. We were told that our company have weekly meetings with 'X', and if we can not explain the 2 minutes delay in reasonable terms beyond our influence, like no handling etc., they will take the payment. (Respondent P6).

Another respondent (P2) addressed the conflict like this:

> We are subcontracting for many different suppliers, and they all have different ways of doing it. So, when you are under time pressure, then the procedures start to slide… the procedures cover one scenario, it does not take into account these outer factors.

These statements suggest a work environment of variability, where rules and compliance cannot encapsulate the many variable operations. In this interaction between the general rules of compliance and the concrete situations of messy work (Flyvbjerg, 2019), the pilots are required to use judgment and choice based on their experience in meeting the organizational demands of on-time performance. This is done by developing strategies and adjusting their performance in getting the job done. Although this makes sense at the local level, it may be perceived differently for those not immersed in the daily work.

In the meso level group, representing the safety department of the same airline, the perspective was slightly different when talking about complying with procedures. The initial talk was not so much a question of understanding the operational constraints, but more a question of preventing the pilots from 'cutting corners' by emphasizing to 'stick to the procedures'. This was seen as a cultural issue that had long existed among the pilots and which, according to the respondents, was a consequence of former management and had been addressed by top management. One of the respondents (S3) said:

> We have seen several examples of people cutting corners out of good intentions because they thought they were doing the company a favour. And they did, right then and there, but not in the long run, because suddenly we may end up in a corner where things go wrong.

This statement implies a certain epistemological stance at the meso level, that suggests an underlying ‘truth’ of ideals (Flyvbjerg, 2019), where not ‘cutting corners’ and ‘sticking to procedures’ would prevent things from going wrong. It could seem that these “ideals block the view to reality” (Flyvbjerg, 2019, p. 143), as the reality as experienced by the pilots shows another rationality.

In the CAA group which represents the macro level of abstraction, this cultural aspect was addressed, and from this perspective, it went to the company culture and dilemmas faced by pilots. Particular focus went to being able to say 'no' before the limit was reached. Respondent (C4) said: “that you are backed up and able to say 'listen, I cannot fly anymore, I am totally crushed,' and that it is accepted in the company.” This statement may suggest that according to the respondent, a certain perspective prevails within aviation, revealing that unless you are in a position of violating the rules, then it might be difficult to justify your reasons for saying ‘no’. The respondent (C4) further elaborated: "Also, that it is used as an argument, it is within the rules so that you can do that “, implying that organizations use the rules as a benchmark for work and less consideration is taken to the humans doing the work.

These interactions suggest a certain kind of responsibilization. What at the micro level seems to be a necessity of sustaining daily operations and adapting to ever-changing operational and procedural constraints are at the meso level perceived as wilful acts (Reason, 1990) of ‘cutting corners’ that could lead to things going wrong. And at the macro level, it was noted that the rules state that you can say ‘no’, but that the social context of a culture can make it difficult to do so. Although representing different rationalities, they all have one thing in common: the focus goes to the responsibility as placed in the hands of the pilots.

To understand the pilots' rationality in dealing with these constraints, we may have to visit a place "out there" where social context and individual action overlap (Snook, 2000, p. 206). The "out there" may serve to explain possible reasons for behaviour-shaping constraints disguised in talk, communication, and language interpreted by the pilots. One of them seemed in this operation to be organizational expectations of 'on-time performance'. Another respondent (P9) addressed the culture:

> It's like the company makes an agreement, where we just have to adapt to time constraints, and that contributes to a change in the culture… company-wise… as there no longer is a wish for us to take the time necessary…

This relationship seems to emerge in that which is said and that which is not said (Flyvbjerg, 2019). According to the pilots, management chooses to tell the pilots that delays are associated with penalties in operation. Requirements of documenting why delays occur create social pressure among the pilots and serve as means to achieve the end: on-time-performance. However, according to the pilots, management also chooses not to tell, as one of the pilots pointed out (P2), "what a good job you did, following the procedures and taking the time needed". This statement implies value rationality among the pilots, suggesting that what counts as a 'good' pilot (e.g., taking the time necessary) vanishes in the relationship with management. However, it should be noted that time constraints and the importance of on-time performance were not explicitly mentioned in the meso level discussions. Instead, this becomes an implicit aspect of being a good pilot, in the eyes of the company; a pilot to be proud of as expressed by respondent S1:

> I think that it is widely known in X that we actually have some employees that we are proud of and who feel a responsibility in getting everything to match up, to get the big puzzle to fit and not just seeing their work from their cockpit…

This relationship could draw lines to the "financial awareness" stated in the CAA group, which exists in an organization as a social context (Vaughan, 1996), influencing the pilots'

behaviours. The CAA group (C2) elaborated on financial awareness: "because you have an opportunity to choose and say, we will not be able to fly all the way home or we could… you could just make it happen". This interaction reveals a common thread of financial awareness across levels that suggest social mechanisms influencing and responsibilizing the behaviour of the pilots.

In all three focus groups, familiar words from the aviation discourse were used, such as "professionalism" and "airmanship", with an underlying indication that there existed a collectively agreed-upon meaning of words and concepts that would enable the achievement of standard behaviour. "Airmanship" and "professionalism" represent words in the aviation discourse and are pillars in aviation training as formulated by EASA, like, for example, Crew Resource Management (CRM). In the micro-level focus group, "airmanship" was described like this:

> Good airmanship is working proactively. That you do not just say 'this is not my problem,' or 'I do not know how to do this,' accepting that all in the crew are part of the process, that eventually succeed in the best possible way. Knowing that we all make mistakes and it's about catching those mistakes. Being capable of working as a unit and arriving at the possible result with the things available; and if things are not available, then good airmanship is getting those things available. That's good airmanship! (Respondent P6)

When we look at the stories told so far by the pilots, they seem to reveal different layers of meaning, or rather a gap between how they describe their real work environment and their stories of how to exercise 'airmanship' as part of being 'professional'. The real work environment stories are described in detail and richness. In contrast, the stories of how to exercise 'airmanship' as part of being 'professional' lack the detail and richness of actual work (Shorrock, 2016). Stories from real work reveal complexities that include multiple organizational constraints such as time pressure and not having the tools available to do the job. However, 'airmanship' and 'professionalism' shift the talk to the human level and are suddenly simplified human remedies to fix the issues, such as how the pilots' statements

involved 'creating the time necessary' and 'getting things available'. Using this form of language reveals a normative understanding of how it is appropriate to behave in the context of what the organization requires (Pettersen et al., 2010) but does not explain the social context produced by social processes in the organization that shapes this behaviour.

In the safety department, getting the big puzzle to fit seemed to go more to what was legally accepted. I noticed how specific words to explore turned up in the discussion several times. This was, for example, "going to the edge", "crossing the line" and "the envelope". As respondent (S3) said: "If you ask me, the bottom line is that you do not cut any corners, but you can go to the edge because it is actually legal to go to the edge."

However, I was curious to see if the 'line' or 'edge' was a well-defined one for the pilots to recognize. Using a previous drawing from one of the respondents, illustrating that aviation is already close to the lines due to commercial pressure today, I drew two crosses, one in the middle of the box and one close to the edge.

Dialogue:
SR: "If I use the box that S2 was talking about before as an example, and when we are getting the big puzzle to fit, are we here (x in the middle of the box) ? or are we out here (x close to the edge of the box) ?"
S1: "It can be both… because the puzzle is already planned to fit together. So, if everything works, then we are all able to fly in the middle, on a given day, to make the puzzle fit."
SR: "How often does that happen?"
S1: "It never happens (laughter). Somehow, the x is moving around."
S2: "It does, you know… but… but… "
S3: "Well, I think we are relatively further away from the edge than the last x you put there."
SR: "Oh, okay. Where do you want me to put the x?"
S3: "What I mean is, we do not get THAT close to the edge."
SR: "Okay, so is the edge a well-defined one?"
S2: "No…"

S1: “Not always… but basically, our procedures define the edge, but it may not be a hard line like that one.”
SR: “Who defines the edge, in your opinion?”
S3: “Our procedures and everything written in OM-A and on the technical side… whatever is written.”
SR: “Do the procedures cover all scenarios?”
Silence
S3: “Basically… but you of course… yeah…”
SR: “What do the rest of you think?”
S1: “No, they do not cover all scenarios, to give you a straight answer! … They do not! ... There will always be combinations on the day that put you in situations… where they do not cover.”
SR: “So, who defines the edge in that situation?”
S1: “The captain does! On a flight, it will always be the captain who defines the edge. He has to a great extent the tools, which are the procedures as a predetermined edge, that are applicable by far, to most conditions… but there will always be combinations where you get in a situation…”

This 'line' or ‘edge’ is associated with risk, but there seems to exist ambiguity around this 'line', as something that apparently exists 'out there', but it is not a hard 'line'. This 'line' is constructed as a last resort by the captain according to the respondents (S1). “You are hired as a captain to be able to distinguish and make decisions about when it is necessary to deviate from the procedures.” What this also implies is that the responsibility to see the 'line', lies with the captain, but one could, however, imagine, that the interpretation of this 'line' could differ in how a captain would construct the 'line', and how for example, a safety department would construct that 'line' in hindsight.

Obscured in the discourse lies a rationality that seems to go to other motives underlying why the 'line' or 'edge' may not be so well defined. It serves as an abstract phenomenon 'out there' that on the one hand creates an invisible 'line' that provides enough 'freedom' to the pilots’ choice, but on the other hand serves to be used in the aftermath of an event, as a clear 'line' of

violations. The 'line' then suddenly changes character into one of legal character and seems to play a major role in the worldview of the Safety Department. It seemed that the word ‘legal’ found its way into the aviation discourse, serving the purpose at its convenience, circling around the main focus of attention - the pilots.

Most prevalent was the power of the word ‘legal’, especially at the meso and macro levels, suggesting a focus on what is legally accepted rather than socially accepted. It became apparent that a power effect existed that exercises its force and influences across levels. And that this power seems to originate in the state apparatus of the EU and can be seen through power effects imposed on the industry in the written rules and compliance.

> There is something in the OM-A that has changed over the years from being more practical to being sort of a manual where you are covered… It has changed because lawyers have entered the picture, and you are now held accountable in an airline, so that is why it is a totally different writing and phrasing today. (Respondent C6).

Another respondent elaborated on how the rules had become complex over time and that in the process, “we forget reality” (C5). The consciousness at the meso and macro level around legal boundaries and aspects may suggest that less attention is placed on a different ‘reality’, as “the structure of regulatory relations systematically undermine the attempt to know and interpret situations in all organizations” (Vaughan, 1996, p. 238). In other words, the power effect becomes how EU rules are legally formulated in terms and language that do not reflect the messy details of reality in everyday operation. Nevertheless, organizations must demonstrate compliance while sustaining an operation that entails a ‘reality of messy details. ‘Reality’ becomes part of a “Structural secrecy” (Vaughan, 1996).

In order to address ‘reality’, the pilots emphasized the importance of different strategies like knowledge sharing to adjust and adapt in the different ACMI operations with, for example, many new destinations where the crew become dependent upon the local knowledge obtained by their colleagues or, as emerged during the focus group interview, how all the respondents

individually have created their own note-system to deal with the many different aspects of the ACMI operations:

> I mean sharing, and once we have flown there for 6 months, then we get the hang of it, but then the contract ends… and we start all over again. But you eventually get very good at working like that, once you have tried it many times before… You know in advance that nobody knows anything, so…. I have made my own little black notebook, where I write everything down, it becomes sort of a homemade SOP[4]. (Respondent P6).

This quote provides several really interesting insights into the lived experience of work from a pilot perspective. Every pilot in the room expressed that they had their own 'system' in note-books to deal with the challenges in the ACMI operations, which they named the 'boy scout book'. The quote reveals how artefacts of 'shadow SOP' are necessary for dealing with the operational demands, an issue illustrated by Perry and Wears in their studies of underground adaptations from Healthcare. The study showed that staff in a hospital emergency department developed 'shadow charts', " a dynamic paper artefacts with increasingly more details and elaborated personal notes" (2012, p. 254). In the pilots' 'shadow SOP', all from how to get in and out of unfamiliar airports, to how much fuel the aircraft *really* uses, and how much go into thin air is written down and used as cognitive resources. Respondent P6 further elaborated how this artefact worked as a 'walking stick', with which you can walk a bit better, implying that the flow of work runs more smoothly when those notebooks support them.

The pilots' statements also reveal values that motivate action in the job. Through their own artifact system, they eventually become very good at adapting to new operations. In this way, they create value by adapting to the particular and ensuring the flow of work.

In exploring the interactions and relationships across scale (micro,meso, macro), different rationalities appeared. The normative language used and reference to the boundaries of work in legal terms, at meso and macro level, suggested a certain responsibilization of the frontline

[4] SOP: Standard Operating Procedures.

personnel. Their arguments were wrapped up in context-independent norms (e.g., professionalism, ”do not cross the line”, “you can say ‘no’ according to the rules”). However, at the same time, these norms seem to influence the values of the sharp end people, who are facing the particular context. Socially enforced through expectations, these norms influence the behaviour and practices of the sharp end people, who “follows a taken-for-granted understanding that dictates” (Vaughan, 1996, p. 399), making it happen by going to the line.

Less attention thereby goes to the social context produced by the organizational and regulatory system, which lacks the language and power to address the everyday messy details that influence the system's resilient performance. It seems that power has designed knowledge at its convenience (Flyvbjerg, 2019) in how the rules are formulated, interpreted by the airlines, and manifested through training, which places the main responsibility not with the organization but in the hands of the sharp end people.

4.2 Theme 2: Using experience to solve the double binds

“ ‘God is in the detail’ the proverb says ‘So is the devil’ “ (Flyvbjerg, 2019, p. 133).

The interactions between the levels reveal different rationalities and present a polyphony of voices (Flyvbjerg, 2019, p. 139). In the work landscape where adaptive strategies are required to sustain the daily operation, these adaptive strategies seem to become normalized and may serve to solve double binds.

In the micro-level focus group, most pilots possess a great deal of experience, which seems to be a key element in adjusting their performance by adapting to the daily operational challenges. One pilot (P6) expressed it like this: "It is a huge advantage that most of the pilots are old experienced guys, who do not get easily pushed over the edge.”

Experience is a crucial element in phronesis (Flyvbjerg, 2019). ”Phronesis is that intellectual activity most relevant to praxis. Phronesis requires an interaction between the general and the concrete; it requires consideration, judgment, and choice. More than anything else, phronesis

requires experience“ (Flyvbjerg, 2019, p. 57). During the talk with the pilots, I noticed how elements of phronesis entered their stories.

To be able to meet organizational goals, the pilots start preparing the day before the flight. This means reading weather, wind charts, NOTAMs[5] alternative routing that has to be considered regarding fuelling, initial calculations for operating on a short runway during winter operation, and reading up on procedures for the different ACMI operations.
This preparation illustrates an anticipation that helps create mental models of different possible scenarios to consider, which incorporates wider operational considerations.

> You cannot sit the night before and go through it all because you do not know if you are accelerated stop distance-limited with 70 tons on a 2 km runway. You really do not know if you are able to stop in time; you just cannot incorporate all. But you know as a sort of rule of thumb or ‘fingerspitzgefühl’ something, for example, you know if you are not going to be able to fly all the way down without fuel stop, so where do we fuel? And then you can call OP[6] and give them a worst-case scenario… and say: this is what I need tomorrow. (Respondent P3).

This statement suggests an intuitive understanding based on experience of the operational work. Moreover, it reveals how phronesis (e.g. ethics, values, intuition) and techne (e.g. craft, know-how, techniques) are joint in the interactions expressed, as the pilot goes beyond the concrete task at hand and incorporates more general operational considerations based on practical knowledge (Flyvbjerg, 2019, p. 57). This illustrates how dependency on deep domain knowledge, preplanning, intuition and experience becomes a prerequisite to adapting to the messy details on the day. Furthermore, this example illustrates tacit knowledge gained through extensive experience, where ‘rule of thumb’s’ represents techniques, developed adaptive strategies and resources upon which the pilots draw, as this is not written in any

[5] NOTAMSs: Notices to Airman containing information about flight operations concerning the establishment, condition or change in any aeronautical facility, service, procedures or hazard

[6] OP is Operations, the department that assists with all concerning the flight operations such as crew, flight plans, ground handling etc.

procedures. This suggests that experience becomes a means that contains the practical insights to navigate the messy details of work to sustain the daily operation.

During the meso level interview, it became apparent that with growing experience, it was expected that the pilots developed adaptive skills, almost as a 'taken-for-granted' thing. Respondent (S3) said: "you arrive at a better result when people get more skilled at solving these special situations, right? So, when people have learned to adapt to many different situations, you arrive at a better result." Implied in this statement lies an expectation that suggests that adaptive skills eventually mean dealing with situations that go beyond normal operation for the operation to arrive at better results.

Also, in the meso focus group, the discussion turned to the importance of experience as an adaptation element, recognizing the difficulties in training the pilots to fulfill their role. This recognition reveals that the safety department, to some extent, is aware of the messy details that the pilots have to deal with daily. Although one of the respondents argued that simulator training would help the pilots dealing with the realities of the work, another one (S2) disagreed that training the "craft" (Flyvbjerg, 2019) would encapsulate what is required to do the work:

> I think there is a challenge in that. It just takes ten years to get ten years of experience, right? You may think that all sort of … decision-making scenarios, tools like DODAR[7], and what have you… but it just takes ten years, because you never get into the situation you practised in the decision-making scenario, it never happens, but you will experience hundreds of other scenarios.

This statement reveals the underpinning conflict that emerges in how training is designed and what it takes to do the work (e.g., being experienced).
In the meso level focus group, the talk went to how setting 'personal minimas' is needed for, for example, new captains to deal with the realities of work.

[7] DODAR (Diagnose, Options, Decide, Assign, Review) is a decision-making tool.

> I think that there is something in these personal minima, for example, for a new captain. With those (new captains) I have been training, I have tried to indoctrinate them to create a shield around themselves. It might be that it is possible to be creative, but it may not be a good idea to use your energy there for the first six months as a new captain. Make sure that you fly 'by the book' and only 'by the book'… It has very much to do with experience and the envelope that you stay in the middle and then starts to move along the edges when it is necessary. Knowing where the edges are. All the time, know where the edge is… and that is the interesting part in reality, isn't it? (Respondent S1).

What the meso level participants are addressing here is the dilemma they face regarding how to actually train the pilots in fulfilling the role, when training only reflects a partial and incomplete part of work. How do you get ten years of experience into a new captain? A partial and incomplete work design leaves no other choice for the Safety Department than to rely on the personal traits of the pilots (e.g., setting up 'personal minima') to finish the design (Dekker). This interaction reveals a system property emerging where a balance between agency and structure must be constantly re-negotiated.

Interestingly, the Safety Department provided another perspective on the use of homemade artifacts as assisting in the daily operation. When I asked whether they believed that these adaptations could become too much, one of the respondents (S1) replied:

> You wouldn't want to end up in…, and I'm not saying it has that effect, but it could have that effect, that the crew get used to solving all these challenges themselves, by being a bit too creative all the time because then we would end up in a situation where the result would have a negative effect on the daily operations. Because if you suddenly have an SOP and then also some sort of 'shadow' SOP… If 50 captains out there have their own SOP, then it would extensively so have a negative impact, not at least on the first officers who would feel very confused about what is actually applicable, and that would cause sloppiness among the pilots… if you by adaptations mean that the pilots are given so much freedom that they control their

> own game, that would end up in anarchy… our safety index would go out the window, and no doubt risk in our operation would increase, and worst-case scenario we would end up in an incident… it would be a negative spiral as we would influence each other.

From his position of power (Flyvbjerg, 2019), a statement that is tolerated by upper management, the authorities, and the public eye is the only statement he can officially make, as he is, in a sense, justifying the department's safety work. At the same time, this statement also reveals the degree of freedom he possesses in his function as a safety officer. Directly confronted by what he may already know or suspect is going on among the pilots, his power position may prevent him from publicly addressing these issues. This is, for example, implied in his choice of words (e.g. safety index, risk, and incident) which suggest an epistemological stance of safety being 'zero' incidents and accidents. Additionally, this statement reveals a publicly hidden relationship between the Safety Department and the pilots that serves different rationalities to the degree of freedom. The objectives of the Safety Department are formulated in general terms, but propagated downward to the pilots the degrees of freedom multiply into many different paths of implementing these objectives, where the local context influences the interpretation of these objectives (Rasmussen, 1997).

As was found earlier, the pilots create 'homemade SOP' to assist them on the job, but from their perspective with other motives than creating anarchy and a safety index that goes out the window. On the contrary, the pilots seek to meet organizational expectations. They adapt to the messy work and ensure the sustainment of the daily operation by using these homemade artifacts to free up some resources that make them capable of conducting *safe* flights. The pilots are engineering resilience into the system. However, in the interactions between pilots and the safety department, we may also witness how both God and the devil are present (Flyvbjerg, 2019). "The safety department in this statement implies that a standard can be achieved by following the SOP. However, they also stated how the airline was proud of having employees who felt responsible for making the big puzzle fit. The conflict for the pilots becomes how 'God' whispers into one ear 'be on time. Solve the problem. Use your experience. Use the repertoire of maneuvers that you have learned over the years; this is why

we made you a captain'. And yet, into the other ear, the 'devil' whispers 'stick to the procedures. Stay within the envelope. Never cross the line and do not be too creative'." This relationship may be found in the interconnectedness between the general terms of safety objectives as stated at the meso level. However, embedded within these formulations lies the reliance on getting the job done on time, which on the micro-level is interpreted as finding ways to meet those objectives – one of those ways is creating their own 'shadow' SOP.

Initiated by some of the more experienced captains at the micro-level, the talk turned to how the first officers needed additional artifacts to adjust and adapt to the captain's ways of doing the job. Respondent P2: "Yes, there is great variation in how we do things. So, you not only adapt to the operation but also to whom you are flying with?" A first officer (P8) replied: "You have to ask on the day, how do you do it? What do you usually do? Okay, so that is how we do it today."

This suggests that the first officers are further challenged in dealing with additional constraints on the job by adjusting to the captains' various ways of doing things. This finding suggests that pilots not only have to navigate diverse demanding operations and operational constraints in, for example, lack of tools, different organizational expectations, and the anticipation of the operational development. They also have to adjust their performance and adapt to the person they are flying with. Similar concerns were presented in the safety department when training new captains:

> In the beginning, you can feel very alone in the left seat, because you might fly with someone really skilled, that you trust right away, or you might fly with someone inexperienced, where you do not really know what to expect. And suddenly you feel the shift… where you suddenly are placed in another situation and have to be more skeptical of whether you can actually trust the advice coming from the other side (e.g., the first officer) and then it gets really lonely sitting there… if you do not have the experience. (Respondent S1).

These statements reveal the awareness of some of the unintended consequences associated with the way work is designed. Despite extensive training to become a captain, you may end up feeling very alone in the beginning. This extends into how work is designed and the conflict that emerges dependent upon experience. One may wonder if the current work design only represents partial elements of what it means to work in a socio-technical system? And if so, if it creates unintended consequences of 'loneliness' in the left seat, where homemade procedures become necessary? And does it keep organizations locked in positions of relying on the pilots to figure it out themselves, influenced by the well-intentioned but normative language of being 'professional' and 'staying within the envelope' until they have acquired the experience necessary and it has become normalized to move towards 'the edges'?

At the meso level, little was discussed about the influence of organizational and regulatory constraints. However, a respondent opened a window of opportunity to see some of the social dynamics in play, when dealing with, for example, the EU261[8] concerns of delays:

> It is not unthinkable that it has happened, that you have found some legal way of adapting, on some sort of MEL[9]. But if you had not had the EU261 concerns, you would have said: 'hold the horses, let us stay here and get someone to look at the aircraft'… You may not think that it is an optimal solution, but I am going to do it. (Respondent S2)

This example illustrates how the long arms of the EU law through EASA stretch all the way into the cockpit, which ultimately influences the pilots' behaviour. But it also reveals how 'corners are cut' to meet organisational goals. The respondent here reveals the reality of work and implies the implications of organisational characteristics and regulatory system influencing the social context. In the example of EU261, the regulatory constraints produced emergent ways of adapting to avoid the penalties associated from EU261, into something that made more sense for the pilots to sustain the daily operation. And making sense of the rules may not only refer to the micro level.

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[8] EU261 is an EU rule that requires compensation to passengers when flights are delayed more than 3 hours.

[9] MEL is a minimum equipment list which provides for the operation of aircraft, subject to specified condition, with particular equipment inoperative.

In the CAA group, the rules were discussed as being too complex: (C1) said: " … here, I mean, we also have to point at us… to some degree. That OM-A and manuals need to comply with EASA rules… but in my opinion, it needs to be a tool." Another (C6) added: "Well, I do not think EASA is helping in that regard." Historically, some of the explanations for this may lie in the shift from JAR-rules to the implementation of EASA, especially for commercial aviation in 2012. In this shift, EU law entered the picture, which changed the language and formulations of the rules. One of the respondents (C2) further described the effect of the complexity of the rules:

> It has become, you know… bullshit because the foundation was based on these scientific studies, but then you have lawyers from 28 EU countries that have to write it all up, combined with lobbyism from 25 airlines and 10 pilot unions, and what eventually comes out of this is just… mud! So, they say, 'this is the result', and then we say: 'What? Where the hell did that come from? It makes no sense!"

This statement is of particular interest as it, according to the respondent, reveals how complexity emerges in many interactions in the state apparatus of EASA acting on behalf of the EU. It also reveals what this means to the ones who, nationally, have to oversee and audit the rules' compliance and ultimately to the airlines and operators within. If it does not make sense to the CAA, how can it make sense to airlines or the people at the sharp end? And yet, EASA aims for ideals of a safety standard to be achieved and audited within the EU through compliance with rules and regulations. The means to achieve these ends becomes how work is designed. However, it seems that this work design is based on "ideals that block reality" (Flyvbjerg, 2019), as the resources in an airline go to ultimately sustaining the ideals of EU, and yet, on the other hand, finding ways to deal with the realities of work and ultimately surviving in a competitive environment.

In these power relations, we may begin to understand how experience becomes a crucial factor, as work cannot be sustained on ideals of standards but requires experience and practical wisdom (Flyvbjerg, 2019) in dealing with the complexity of work.

Safety thereby becomes the contribution that the pilots make (Holbrook, 2019) with growing experience that emerges in a fusion of adaptive strategies, practical wisdom, intuition, and deep domain knowledge, which develops over time through locally shared knowledge, and individual experience. However, the unintended consequences of the current work design seem to be the loss of tacit knowledge in the system on how work is done. The focus of the work design lies in work-as-imagined (Hollnagel, 2014) in achieving an EASA standard of safety dictated by the EU.

These findings suggest that the underlying perspective of EU standard upon which EASA audits and the airlines seek to comply rest in an epistemological stance of analytical rationality that is rule-based and context-independent, where the practical wisdom developed through experience is not taken into account. Nevertheless, the findings in this research reveal that an expectation exists of the individual evolving and developing practical wisdom and skill. Hidden in these findings, we may find the existence of "rational fallacy" (Flyvbjerg, 2019, p. 23), suggesting that work design based purely on analytical rationality does not match the performance requirements for the complexity of work. Achieving the level of proficient performance, which is the EASA standard requirement, requires a broader perspective to understand the total spectrum of human activity (Flyvbjerg, 2019). In other words, gaining proficient performance requires a training and work design that incorporates properties such as "context, judgment, practice, trial and error, experience, common sense, intuition, and bodily sensation" (Flyvbjerg, 2019, p. 23).

We may begin to understand how experience serves to solve the double binds, that on one side meets the requirement of the regulations based on rules, procedures, and context-independent training simulations, and on the other side serves to solve the real-world work environment that requires experience of context-dependent practical wisdom in order to sustain operation and survive in a competitive environment.

4.3 Theme 3: Hidden and unintended sacrifices of adaptation

"We must still wonder how subtle interaction of competitive environment, organizational characteristics and regulatory systems operate to influence the actions of people in organizations shaping their world view and their interpretation of information." (Vaughan, 1996, p. 408)

There seems to exist "a hidden social reality in the socio-technical system" (Pettersen et al., 2010, p. 190), not currently addressed in safety work. In the interactions between the levels of micro, meso, and macro there are several relationships that tell about the power existing and influencing the resilient performance of the system.

In the session with the pilots, we eventually moved to a deeper layer of reflection through the stories told, which illustrated to me some areas of vulnerability not often discussed in aviation and worth exploring. Although the pilots had previously told of how adaptations became normalized elements of work, it also seemed that at times unintended consequences emerged when dealing with the many organizational constraints:

> I was under such pressure, where I just absorbed all the shit that just did not work… I just took it in…, and you get so far out… where you get so tired and are just so fed up, and you start to snap at people… and then you are far out… by personally taking in all the deficiencies of the organization. I remember this from last year, where we had a lot of work due to a lot of business opportunities, and we support that but when you go so far… believe me… you have to be good, you have to be really good at saying 'no' to the company… so, instead of just absorbing and carry the commercial pressure on our shoulders, we have to say… 'forget it!' (Respondent P3).

Humans are the most adaptable element in a system, and adaptability is crucial in making things work (Wears and Hettinger, 2013). However, adaptability is finite (Cook and Rasmussen, 2005, Woods, 2018) as illustrated in the statement above, and may possess unforeseen risk. What is interesting to notice is how the underlying relationship is revealed in

the dilemma of compensating for the organization's deficiencies but at the same time feeling a responsibility to support the business opportunities.

Asking the group if others have had similar experiences of exhaustion on the job was followed by silence in the room, telling me that we were getting into an area of vulnerability rarely discussed by the pilots and usually tucked away in their own world of secrecy. One of the respondents said (P6): "It is something we all experience in the daily operation, not every day, but when a month has passed, we have all been there… more or less so." Another (P2) respondent added: "We experience it more often than we should." Although rarely addressed by the pilots, this reveals not just one story of exhaustion but a pattern that seems to exist within the airline. Unintentional consequence potentially becomes exhaustion of the adaptive capacity of the system.

In the session with the Safety Department, similar statements revealed a certain cognizance to the many uncertainties the pilots face in the daily operation, which goes beyond merely following rules and procedures.

> It starts with our point of departure when we check-in and operations are normal, right? - That is our line. Then something happens, okay… then we draw a new line, so now we are here, and we might forget what brought us here, and then something new happens… that is the scenario… and suddenly we have drawn four lines, but there is a tendency to say that the last decision we took was in regards to the last line. I think we sometimes forget to include the whole package.

The respondent is referring to the state that emerges as a result of the interconnectedness of navigating the messy details of work, as the pilots get so immersed in the interaction of unfolding events, which may result in saturation of adaptive capacity. A state that seemed to not be recognizable in the act, as he further added: "I think it is in the after-reflections, where you realize 'wow', I think I went very far… subconsciously." Considering the human in the system, it is, however, crucial to understand that "humans in a socio-technical system rarely

works alone; they are always part of a group or an organization, even though their actions may be separated in time and space“ (Rasmussen, 1997, Adriaensen et al., 2019).

Embedded in the sustained adaptations (Woods, 2018) lie the potential for unintended consequences that invisibly saturates adaptive capacity, as the pilots themselves rarely recognize the limitations of adaptive capacity while immersed in work. ”When situations are volatile, unpredictable and complex, we can get so engrossed in the action that we do not notice small indicators“ (Barton et al., 2020, p. 1). As one of the pilots (P2) said: “…we notice afterward when the FDM[10] tells you, and you get an email about something you did…”Another added (P8): ”We are humans, we want to solve this task, we want to go from A to B, almost at any price.”

Further stories from the pilots in the group revealed how the organisation and EASA rules relationship invisibly imposed constraints on the pilots. The stories told in particular how lack of stand-by personnel in more remote destinations and locations associated with higher performance requirements affects adaptive capacity and makes pilots bow to the underlying pressure from the organization and the legal requirements to perform, well knowing that their physical and mental condition may be exhausted.

P7: “You just know, when you wake up feeling dead or a risk to fly, that there is nobody on stand-by[11]. So, do I call in sick and what might be the consequences for that? In that situation, you just adapt by doing something you should not do (other voices saying: yes) to solve the situation.”
P9: “Yep, that goes for all the small places in ‘Y’[12] as well…”
P7: “Yes, it is hard to get crew in there… and then you just have to… I think, everybody knows what it means…”
P6: “Everybody has EU261 written on their eyelids” (several voices saying: yes).

[10] FDM: Flight Data Monitoring system measuring exceedance of flight parameters.

[11] Stand-by crew to call on duty in case of sickness or unfit to fly.

[12] Specific geographical location in Northern Scandinavia the pilots are referring to, which is held confidential due to the airlines wish for anonymity.

P8: “You know that if you do not do the job, somebody else is called to work. This is not like an office job, where you are able to continue work on Monday… this is different, right? It just has to be done, no matter what!”
SR: “But what does that mean? You go to work and then..?”
P8: “It means the pressure is slightly bigger, but you do not want to burden your colleagues even though you might be…”
P6: “You know yourself (referring to me). You too have been flying when you should not have!”
SR: “Absolutely, I am not trying to judge here. I know these situations all too well….”

The concept of secrecy emerged as a valuable analytical tool based more on what I sensed was going on in the interview room, and *how* things were said. I noticed the silence, exchanging looks, pointing at the digital recorder when something sensitive was said and how the power relations played out in the room, like for example when the chief pilot spoke. The secrecy also became evident in how the pilots used my position and previous experience to ‘justify their answers, for example how one of the participants (P6) said: “ You know yourself. You too have been flying when you should not have! ” implying that I knew what was secretly going on. In this space of secrecy, we may find a pattern among the pilots where they feel that the range of adaptation has gone beyond the saturation point (Woods, 2018) in compensating for a poorly designed and dysfunctional system, where unintended consequences may be severe. Vaughan (1996) addresses “structural secrecy” as a concept due to organizational structure, however the secrecy in this thesis goes more to how the silence among the pilot group, may mirror an organisational silence of what is accepted to address, and how work impacts the people. One might suggest that in the gap between work-as-imagined and work-as-done (Hollnagel, 2014) lies ‘work-as-impacted’: An emergent product of attempting to balance the two worlds. This veiled ‘work-as-impacted’ secretly contain “a reality that is ugly when judged by moral standards” (Flyvbjerg, 2019, p. 135) as by an organization, an authority, or even society, after the fact. At the same time, it “may also be deeply human” (Flyvbjerg, 2019, p. 135) in how the pilots turn up to work exhausted in consideration of colleagues to meet an overarching goal of efficiency and productivity. The consciousness of possible sanctions becomes the dominating factor, as revealing this secrecy

officially could impose sanctions that may be too severe. "Hence, secrecy around work-as-done can be a self-protective measure against the drive to improve efficiency at the expense of other goals (such as safety and well-being)" (Shorrock, 2016). The secrecy in the interview room was an extension of the secrecy of the organization.

In the CAA group, little attention went to the messy details of work and the emergent properties associated with the adaptation required by the sharp end people in sustaining the daily operation. However, their choice of fatigue as most challenging for the sharp end may tell us that there exists some consciousness to the social processes of the system, as an unofficially acknowledged element, revealing a symptom of trouble deeper within the system. Additionally, it was mentioned several times how the rules benefitted the airlines and were "at the expense of humans." However, this consciousness occurred in the statements when the flight inspectors wandered from their present role into being a pilot.

> It's like the boundaries are pushed. Your level of fatigue can seem overwhelming the first couple of times, but subsequently, it becomes more and more a normal condition, a very recognizable condition in which you operate, and in reality, it is a sliding condition, where you sort of being pushed out and where it can be hard to be 'in control'… and I think that is dangerous… It like, becomes the new norm, right? (Respondent C6).

These statements indicate a system of low graceful extensibility where the adaptive capacity is saturated (Woods, 2018) and not noticed during the operation as this has become the norm. This is expressed as the interconnectedness between the pilots adaptive capacity and the number of organizational constraints imposed, but where the responsibility to see this "tight coupling" (Perrow, 1984) and do something about it is placed in the pilots' hands, which may, in fact, lay in the delayed availability of human capacity, revealing unintended consequences of a system.

This "sliding condition" also seem to resonate as reflections in the pilot group also went to how the adaptations may be "hidden in plain sight" (Wears and Hettinger, 2013) to the

management, and the system may appear to be performing better than it actually is (Wears and Hettinger, 2013), as a result.

> We just get the job done at that time and make it work… we do this with the best intentions of helping and so on… but it might also cause that the procedures never get adopted and those who were supposed to see this or do something about it, they do not know anything, because we fixed the problem, we dealt with it, we got the job done. (Respondent P2).

In connection with an honest discussion about complying with minimum fuel procedures, the pilots revealed that none of them complied, and one of the respondents added (P7): ”yes when we do line training”[13] (Laughter in the room) respondent P2 replied to this: ”But then we adapt again!” These statements are of particular interest as it shows the gap between work-as-done (Hollnagel, 2014) and work-as-disclosed (Shorrock, 2016) in the stories told. To meet the overarching goal of on-time performance, the pilots deem it necessary to produce workarounds to meet those demands by trading the procedures. However, these statements also seem to reveal elements of secrecy. The pilots admit that when under observation in training sessions, like line training, they conform and adapt by changing the way they behave, and they are fully aware of the distinction between the two. In other words, the pilots know how to play the game of power, by adjusting their behaviour to the situation. This may be tied with the pilot's”cultural understanding affecting interpretive work, so that people may see their conduct as conforming, even when the behaviour in question is objectively deviant“ (Vaughan, 1999, p. 280).

These reflections illustrate how adaptations become normalized, recognizing that the boundaries are pushed. What perhaps should be addressed in the work design is obscured as these adaptive skills patch up the imperfections and make the system look as though it is performing better than it actually is (Wears and Hettinger, 2013). The saturation of adaptive capacity (Woods, 2018) goes unrecognized in the normalization of adaptations and remains unofficial and unacknowledged in the system. What at first glance could seem like pilots

[13] Line training or line check, is training or yearly check on the line, where the pilots are assessed in following rules, procedures and using correct call-outs according to the SOP.

violating and ‘cutting corners’ in secrecy are to a certain degree known by management, as this secrecy seems to be an emergent property of a tied relationship in the organization’s unofficial expectations of meeting the goals. However, the organizations officially appear to be compliant with what is required as an EU standard to the authorities and public.

4.4 Emergent patterns of resilience and brittleness

In the previous section, a first-order analysis was made based on the three themes: Responsibilization, Using experience to solve the double binds, Hidden and unintended sacrifices of adaptation. Based on the findings in the previous chapter, I will now explore the emergent pattern of resilience and brittleness as a more second-order analysis.

From an airline perspective, we heard the stories told by the pilots on how they adapt to an imperfect system of poorly designed work structures as the characteristics of their working environment changed (Cook and Rasmussen, 2005). Lacking the tools and equipment to perform the job, pilots engineer resilience into the system by developing different strategies that eventually become a bank of resource to be used (e.g., adding weight to the load sheet to compensate for many last-minutes changes. Or not flying with minimum fuel to adapt to the variable reality. Or preparing the day before to be able to deal with the messy work when checking in. Or making their own ‘shadow’ notebook system to compensate for the variable demands (Perry and Wears, 2012). Resilience emerged not as a product of training or rules but in a fusion dependent upon experience, deep domain knowledge, practical wisdom, intuition, and anticipation, supported by strategies and artifacts. These findings suggest that the pilots have found ways of compensating for an incomplete work design, as work design does not reflect the reality they face.

Through talking with the pilots and further analysis, I sensed a deep commitment to fulfilling the expectations from management and their colleagues, which illustrated a pilot sub-culture that entails secrecy through a shared understanding of what it takes to finish the design (Dekker, 2011). In their own way, they find ways of compensating for the lack of equipment and tools and the lack of value consideration in the work design and rules. In this process, they create practices by sharing knowledge, assisting, supporting, and adjusting to each other

and the many variables work entails, which ultimately enhances the adaptive capacity of the system and creates resilience.

However, sustaining the daily operation does indeed seem to draw heavily on adaptive capacity. The pilot's stories of exhaustion happening “more often than it should” reveal a dark side of the resilient performance. As learned from the stories that were told, adaptive capacity of the pilots is finite, and that they all from time to time reach the boundary of acceptable workload (Rasmussen, 1997). Hidden in their own secrecy, the extent to which exhaustion is happening and why rarely goes beyond the micro-level. The tension and affinities associated with work remain invisible (Vaughan, 1990, p. 272). Unintended sacrifices of adaptations thereby become the pilots’ health and well-being as invisible forces exhaust adaptive capacity of the system, leaving it more brittle.

Coupling this with the expectations the pilots felt from management in delivering on-time-performance tells about the influences of organizational factors that create a culture of production (Vaughan, 1996) of ‘getting the job done’ within the group. Moving up the levels to meso and macro, the language changed. In the meso group, it became apparent that there were expectations of ‘going to the edge with the pilots' growing experience because it is actually legal’. The language changed the character into references of legal boundaries of work. In similar lines at a macro level, the legal boundaries became central, but from a rationality that the formulation of the rules have become too complex over time, benefitting the airlines, as the interpretation becomes stretching the rules (e.g., ‘limit becoming the target’) at the expense of the humans working in the system. This suggests a gap where the legal rules are formulated from work-as-imagined (Hollnagel, 2014) on one side, and on the other side, the real-world work environment is full of messy details in work-as-done (Hollnagel, 2014), which cannot be simplified to, for example, pilots saying ‘no’ or knowing where ‘the edge’ is. To bring this into power relations (Flyvbjerg, 2019), the references to legal boundaries of work and aviation discourse represents power by responsibilizing the pilots. Specific words (e.g., ‘professionalism’, ‘airmanship’ and ‘personal investment’) used through, for example, CRM training reveals mechanisms used through the language that serves as social forces influencing work. For the pilots to be seen as, for example,

‘professional’ or ‘having a personal investment’, they must demonstrate adaptive skills that fulfill the organizational goal and expectations (e.g., ‘going to the edge’), while at the same time complying and/or circumnavigating written rules based on imaginative work.

Since the equipment and tools necessary to meet this demanding working environment cannot encapsulate the complexity of work, the result of these interactions is that the pilots engineer their own strategies and artifacts to patch up the imperfections. Similar conclusions have been made from research in other domains, such as Healthcare (Patterson and Wears, 2015, Wears and Hettinger, 2013, Wears and Shawna, 2011).

The pilots do so silently, secretly within the group, as revealing could impose severe sanctions on them (Shorrock, 2016) in hindsight. However, what also seems to be hidden in this process is the range of adaptive capacity available to manage the risk of saturation (Woods, 2018) which seems to go unrecognized when we move beyond the micro-level in the system, as the pilots rarely reveal this. The emergent property of this process becomes exhaustion of adaptive capacity influencing the resilient performance as the system is decompensated (Woods & Branlat, 2011, Ch.10). The system becomes more brittle.

Although not recognizable while immersed in work, the after-reflections of work revealed how the boundaries of safe performance are pushed, as the risk of saturation (Woods, 2018) becomes a normalized element of work, induced and produced systematically, as for example how the long arms of EU rules stretch all the way into the cockpit and serve as subtle mechanisms that influence the behaviour of the sharp end people (e.g., “Everybody has EU261 written on their eyelids”). In this power relation, the only means for the sharp end people to address these complex system issues of concern becomes oversimplified legal terms like ‘fatigue’ that suggest problems with the people and not the system. Convenient remedies become Fatigue Risk Management (AMC1.ORO.FTL.120 (b)(1)) to fix the human, thereby obscuring the system features that produced and induced the breeding condition for this in the first place. The exhaustion of the system's adaptive capacity thereby remains hidden in the dark and could potentially exist as a normalization of deviance (Vaughan, 1996).

Working at cross purposes (Woods & Branlat., 2011, Ch. 10) seems to be one area of brittleness due to the airlines' different rationalities around safety. The homemade SOP created by the sharp end people out of necessity to conduct work safely were at meso level seen as a worst-case scenario, where the "safety index goes out the window". This suggests that the work and effort of the safety department of trying to get the pilot to 'stick to the procedures' do not accommodate the pilot's needs to conduct work. From a systems view, there seems to be a missing link between the two levels of what safety means, leading to working at cross purposes (Woods & Branlat., 2011, Ch. 10) where features of resilience and brittleness get obscured.

The current form of construction of safety in aviation thinking founded in Safety I (Hollnagel, 2014) allows for a dualism. On the one hand, it allows for moral judgments after the fact to determine what 'lines' were crossed based on a standard of, for example, 'professionalism' or 'airmanship', which is stripped for the influencing context and social forces. On the other hand, the dualism encourages the exact same concepts of 'professionalism' and 'airmanship' from an operational aspect that relies on adaptive strategies for sustainment of the daily operation as a taken-for-granted thing. This opens up to the concepts being very 'fluffy' and whatever gets to count as knowledge or 'truth' depends on "who could place the most power behind their interpretation of what was rational" (Flyvbjerg, 2019, p. 147); in other words, from which position of power the interpretations are made.

On the other hand, we also witness a conflict of value rationality present in the Safety Department and how to train new captains to fulfill the role. Despite extensive training, they may end up 'feeling very alone in the left seat'. Intentional means in the training became teaching the new captains to 'shield' themselves by establishing 'personal minimas' since the current work design and discourse represents a partial and incomplete rendering of the job. We may start to understand some of the social forces that induce individual strategies and artifacts to fill up the gaps of a flawed work design based on analytical rationality. An argument further supported when the pilots revealed how they behaved differently when doing line training (e.g., strictly following procedures and accepting delays), seeing this as yet another adaptation, fully aware of the distinction between work-as-imagined and work-as-

done (Hollnagel, 2014). Experience seems to serve to solve the double binds between the two worlds.

In all the three focus groups, it was evident how the airline industry is under pressure, reflected in a high level of competition that requires more efficiency and productivity for survival. In the micro-level group, this was prevalent in the ACMI operations, where especially the time pressure constraint played a role and would lead to financial penalties if not strictly adhered to. From the pilots, we heard how this was achieved by preparing the day before and calling OP (operations) to meet on-time performance. We heard about the different adaptive strategies to cut off the minutes to avoid delays and how homemade 'shadow' SOPs helped to a smoother operation. Although this may be associated with a cost, as macro explained: "efficiency at the expense of human safety".

Through the analysis, patterns of resilience leading to brittleness appeared, which tell us about how a system becomes decompensated (Woods & Branlat., 2011, Ch.10) when adaptive capacity is saturated (Woods, 2018) as a product of a poorly designed system, through the organizational constraints and regulatory demands. We have witnessed how training works at cross purposes (Woods & Branlat., 2011, Ch.10), producing patterns of brittleness not recognized to the full extent by management. And we have seen how a certain perspective of analytical rationality (Flyvbjerg, 2019) creates limitations for system safety by a narrow focus that cannot encapsulate work in a socio-technical system. From the state apparatus of EU, power effects of legally binding rules complicate work, and the emergent properties produce a trickle-down effect (Vaughan, 1997) on the industry, manifesting outdated behaviours (Hollnagel et al., 2011) as an underlying foundation of a system, that leaves out the role of the social reality of a socio-technical system (Pettersen et al., 2010).

The research further suggests that the reliance on the level of experience and adaptive capacity means that the ratio between the degree of complexity and adaptive capacity available lies obscured and hidden in the system. And more importantly, so does the ability to manage the risk of saturation of adaptive capacity (Woods, 2018), leaving the system more brittle. Throughout this thesis, it has become apparent that the influencing social forces to a

great extent are left unaddressed as a product of analytical rationality. The values enacted at the micro-level, recognized to a certain degree at meso and macro, seem to be disregarded in the design of work and finished by the sharp end people (Dekker, 2007). The tacit knowledge associated with these values across levels seems to vanish in an analytical rationale that fails to support, assist and improve the training and work design to suit work in a socio-technical system.

5. Discussion

5.1 Reflections

“Power defines what gets to count as knowledge” (Flyvbjerg, 2019, p.155).

This thesis originated in a nagging feeling of something not being right that grew out of my own experience within aviation and the many conversations with colleagues. Observing and increasingly feeling the exhaustion of the job over the last decade led me to this kind of research, as I kept wondering if any considerations were made to the impact work has on the people. In the after-reflections of this research, I realize that what I felt was lacking and what this thesis supports are the ethical considerations on how training and work are designed within aviation.

With an initial mindset of placing the ‘smoking gun’ (Snook, 2000) at a profit-eager airline’s management not considering the human, and the regulatory system living in La La Land, my research started with a biased mind, determined to find the ‘right’ answers in the many concepts of Safety Science! However, I may have to admit that I did not find any ‘right’ answers anywhere, but lots of different explanations based on rationalities that made sense to the people from their work positions. This process is increasingly telling me, that there is no right or wrong, and there is no straight answer that can sum up the work and provide solutions that can serve as an EU standard for what it means to work in aviation, so maybe La La Land does exist?

Throughout this thesis process, it became more and more apparent that aviation is founded on knowledge that leaves little room for value rationality in the design of work and training based on rules and compliance. By values, I am referring to the considerations that “concerns human health and has as its point of departure something both concrete and fundamental concerning human functioning” (Flyvbjerg, 2019, p. 58). Most saliently in the micro-level group, that seemed to be caught in contexts where norm compliance came at the expense of values, but where pilots compensated value rationality in developing their own strategies and

artifacts. Although the meso level group initially asserted the dominance of analytical rationality, their statements also revealed consideration for values, especially in the upgrade training of captains, and the frustrations and doubts associated with training and preparing the new captains sufficiently. Along similar lines, the macro-level group expressed concerns about how the rules "benefitted the airlines" and "at the expense of human safety", which implies that the rules and regulations are based on analytical rationality and lack value rationality. Drawing a line across the three levels reveals that analytical rationality currently has the power to decide what gets to count as knowledge (Flyvbjerg, 2019) as to the compliance of written rules and procedures.

This knowledge seems to underpin the participants' statements of this research and reveals that the accepted knowledge rests primarily in an epistemological stance of analytical thinking (Flyvbjerg, 2019) described as Safety I in the introduction. It reinforces the idea that practice and experience can be gained through ruled-based and context-independent training. However, this research's statements also reveal ethical considerations across scales of doubts, ambiguity, and even frustrations in training and working as pilots in real-world work environments. The lack of context-dependency and value rationality in aviation seems to create conflicts and doubts across levels (micro, meso, and macro). Revealed in statements of adaptive strategies, artifacts, and ways of trying to prepare new captains, the findings in this thesis suggest the need for value rationality, that the people of aviation currently create themselves, out of the very best intentions, to prepare their colleagues for the job and sustain the daily operation. From this perspective, the people within the system create and develop ways for the people to patch up the ethical deficiencies of the system.

My thesis question was this:
'How does reliance on resilient performance hide or even contribute to system brittleness?'

This process has convinced me that the sharp end people do make "an enormous contribution to safety" (Holbrook, 2019) by " sustained adaptability" (Woods, 2018) in adjusting their performance through their adaptive skills, intuition, and experience. But it also taught me that unintended consequences emerge in the process as a result of interactions and interrelations

tied up in a web that influences the system as a whole and which seems to be left unaddressed in aviation. This thesis implies that training structures and work designs contribute to leaving the system more brittle, as it does not encapsulate the complexity of a socio-technical system and is essentially founded on written rules and procedures for work-as-imagined (Hollnagel, 2014). Unintended consequences become a reliance on the personal traits and experience level for resilience in the system, which means it becomes up to the sharp end people to adapt with the risk of sacrificing their own health and well-being. What is associated with aspects of the bright side of the organization (e.g., resilience) is also associated with the dark side (e.g., brittleness) (Vaughan, 1990).

5.2 Value-rational questions

In this section, I will connect the findings of this thesis with the safety paradigms discussed in the introduction through value-rational questions (Flyvbjerg, 2019).

5.2.1 Where are we going, and is it desirable?

In my introduction, I described the safety paradigm through the lens of aviation in where we are and where we are going in the near future. Mental health issues among flight crew have become the new area of focus within aviation. In 2021 all airlines must implement a 'peer support program' based on recommendations from the EASA Task Force initiated after the Germanwings accident in 2015. The 'peer support program' is built on the argument of "… assist and support flight crew in recognizing, coping with, and overcoming any problem which might negatively affect their ability to safely exercise the privileges of their license" (EU965/2012).

The rationale behind this program seems to rely on an analytical rationale, where the solution is once again searching for "psychological mechanisms inside an operator's head" (Woods et al., 2010), and once again, tension and affinities associated with organizational socially constructed circumstances are absent (Vaughan, 1999). Despite fully acknowledging that employees would benefit from a program addressing mental health issues, I believe that this thesis shows that the remedies to do so do not lie in the psychological mechanisms of the human operators. Based on the findings in this thesis, the well-being of the people involved

does not resolve around mental health issues due to personal problems but resolves around exhaustions connected to affinities of work (Vaughan, 1999) as emergent properties of how the work is designed. I, therefore, believe that in order for a Peer Support Program to have any effect, the perspective should be broadened to include and address the systemic issues of sociological mechanisms that go to how work is designed and how this influences and even exhaust the people working within the system.

The concern associated with the currently formulated EASA Peer Support Program is in my opinion how this program could increase unintended sacrifices and continue to saturate adaptive capacities in the system, as the psychological angle in the program could be associated with fear of retribution and stigmatization. In the after-reflections of this thesis, I am left wondering whether mental health issues and remedies like Peer Support Programs address the underlying issues in the system, which may have brought about the mental health discussion in the first place. What might be an unintended consequence of further decades of power-driven analytical rationality? One could suspect that the Peer Support Program may be the result of a power struggle - the bandaid that officially silences the voices of ethics by keeping the discussion on the level of the humans to be fixed and not issues in the system. Based on the findings in this thesis, I seriously question that initiatives like the pilots' mental health issues are the issues to be addressed. I believe that it should be addressed from a more holistic systems view (Wilson, 2012) that could contribute to safety by understanding work-as-done (Hollnagel, 2014) and its impact on the people working within the system. In other words, addressing the conditions around work through the people doing the work may be the first step in that direction.

As illustrated in this thesis, the current form of work design and training structure possesses limitations in preparing the pilots for the complexity the job entails. This eventually creates emergent properties of homemade procedures and unintended sacrifices as a function of this relation. In this research, it became apparent that there is a massive amount of tacit knowledge present in the airline but unexplored due to the current work design and training in aviation. We saw several examples at the micro-level of phronesis and techne (Flyvbjerg, 2019) as intertwined in sustained adaptability (Woods, 2018), although Flyvbjerg argues that the two

cannot be conjoined (2006, 2019), the findings in the thesis suggests, that the two should not be seen as separate virtues, but must be understood as interconnected in real-world work environment.

The practical knowledge based on experience and situational ethics illustrated how the frontline personnel uses their adaptive skills and deep domain knowledge to sustain the daily operation, which cannot be achieved in the same way by being compliant and 'following procedures'. However, phronesis is experience-based, and "In the beginning, you can feel very alone in the left seat," as one of the respondents said. However, it seems that expectations to fulfill the role are built on a standard that does not clarify the boundaries. Instead, on the one hand, it entrusts safety in compliance with rules, and on the other hand, leaves it up to the pilots to define as "that is what you were hired to do". The findings, however, also indicated that the Safety Department expressed concerns about training the pilots in the given training structure, and ultimately personal traits became the means on which to rely for safety. Unintended consequences included in the findings indicated a space of secrecy, where the adaptive strategies flow, based on individual and team perceptions that hide the forces that create safety but also create risk. Connected to this, we also witness how system brittleness emerged as a function of exhausted adaptive capacity and impacted the well-being of the sharp end people. I, therefore, do not believe that the path taken in mental health programs as formulated by EASA is desirable.

5.2.2 What should we do about it?

What we also saw in the research was that despite the pilots being very experienced, exhaustion on the job "happened more often than it should". It was not until the after-reflections that they consciously realized how far they went to meet organizational expectations relying on them to get the job done and inducing responsibilization among the pilots through discourse and references to legal boundaries of work. Retrospectively, this is a flashing signal that tells us that even with extensive experience, saturation occurs exhausting the range of adaptive capacity (Woods, 2018). 'Work-as-impacted' seems to exceed the adaptive capacity available in the system, guided and implicitly encouraged by organizational and regulatory forces, revealing areas of brittleness as emergent properties.

So, instead of implementing more programs and procedures, this research would suggest looking at some of the structures already in place that may just need updates and modifications. In this study, the current form of training has been illustrated as a social force of control that, in its current form, may leave the system more at risk than safe. It seems to be a place where the airlines could benefit from modifying, by gently implementing small steps that provoke a new way of thinking - that is more system thinking (Wilson, 2012). This research suggests that experience, expertise, and practical wisdom (Flyvbjerg, 2019) are important elements in resilient performance and value rationality to adapt to the various environments.

A system thinking perspective would allow for value rationality in an upstream employee voice to be heard, as the focus would move away from appointing blame on the human operator by inviting and encouraging accounts from the real-world work environment, that may tell about what is required for sustained adaptability and the range of adaptive behaviour to manage the risk of saturation of adaptive capacity (Woods, 2018). This would involve constantly exploring the evolving work-as-done (Hollnagel, 2014) as a dynamic process, that might narrow the gap between work-as-imagined and work-as-done (Hollnagel, 2014) by creating a space where the stories of how work impacts are allowed and the understanding of "work" are enhanced. This could, for example, be by departing from traditional CRM training into one, where the focus goes to curiosity about the adaptive strategies exercised on the line to optimize human well-being and overall system performance in providing the thread of commonality (Shorrock and Williams, 2017).

5.2.3 Who gains and who loses?

From our current position in aviation, the prevalent Safety I thinking wins as the power of knowledge that creates an illusion that the system is inherently safe, and the people working within it are unreliable, can be fixed, or thrown out when things go wrong. Based on this perspective, work design is constructed as functional and embedded in legal rules that conveniently omit ethical considerations. However, when the ethical voices try to penetrate the system, they become patched up with the band-aid to silence the voices (e.g., Fatigue Risk

Management programs, Peer support programs, etc.). On a societal level, this thinking makes sense and provides some sort of ease for the users of the system, rested in the legal system that has found its way into aviation as a reflection of these needs (and perhaps with other motives as well), and continuously feeding the Safety I-thinking - seeing the world as either-or, black or white, technical error or human error to return to a system state of equilibrium.

However, what seems to be lost in this form of thinking are opportunities for system learning, growing and changing, as the world changes. Scientific knowledge combined with practical knowledge about what makes a system safe gets lost, in denial of seeing aviation as both technical and social in nature, consisting of many intertwined relationships and interactions. The possibility of creating interconnectedness between the practical world of aviation and Safety Science becomes hard and long and creates frustration and ambiguity for the people working within it, and potentially leaves the system more risky than safe.

Nevertheless, there seems to be light at the end of the tunnel, as concepts such as Safety II (Hollnagel, 2014) are beginning to find their way into aviation. Maybe we should just accept that changes take time, and every small step is a step in the right direction.

6. Conclusion

This research aims to understand better whether resilient performance possesses a ‘dark’ side creating unintended consequences in the system.

By exploring the interactions and interrelations across scale (micro, meso, and macro), this study indicates that the dominating safety paradigm in the aviation industry creates a partial and incomplete work design that does not encapsulate the complexity of work. With an industry of growing complexity, the sharp end people feel left on their own and develop adaptive strategies and resources to compensate for the system deficiency, which happens in local secrecy. The findings coincide with the existing literature by identifying how the sharp end people engineer resilience into the system. The research implies that resilient performance becomes deeply dependent upon the peoples’ experience, intuition, and domain knowledge. The study also found that regulatory and organizational social forces strongly influence and rely on human activities’ actions through discourse, expectations, and references to legal boundaries of work.

In this process, brittleness occurs as a consequence of saturation exhausting adaptive capacity (Woods, 2018) which goes unnoticed and unaddressed in the system. The findings suggest that while immersed in work, signals of reaching the boundary of resilient performance lose their saliency and often appear as ‘after work reflections’. Sustained adaptability (Woods, 2018) creates mental and physical exhaustion for the sharp end people influencing their health and well-being.

The boundary between resilience and brittleness is of dynamic and fluent character.

The research indicates that ethical concerns exist across scale (micro, meso, and macro) as to the consequences of a partial and incomplete work design, driven by the dominating safety paradigm, as organizations and national aviation authorities are kept locked in a power relation with the EU legal system, which lacks considerations for the sociological elements of a system.

The findings of this thesis suggest that regulatory systems and organizations would benefit from investing resources in education that critically reflect upon the safety paradigm used in aviation and the influence on how safety is conducted. Further research into this is therefore necessary.

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