Safety Mindfulness Methodology

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Future Sky Safety is a Joint Research Programme (JRP) on Safety, initiated by EREA, the association of European Research Establishments in Aeronautics. The Programme contains two streams of activities: 1) coordination of the safety research programmes of the EREA institutes and 2) collaborative research projects on European safety priorities.

This deliverable is produced by the Project P5 'Resolving the Organisational Accidents'. The main objective is to specify the Safety Mindfulness concept and present a model able to improve organizational mindfulness – creating a purposeful flow of information that actively supports people's capability to remain mindful of safety when carrying out their activities.

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Acronyms

Acronym	Definition
AZ	Alitalia
CAQDAS	Computer-Assisted Qualitative Data Analysis Software
MUAC	Maastricht Upper Area Control Center
QCA	Qualitative Content Analysis

EXECUTIVE SUMMARY

Problem Area

Future Sky Safety WP5.2 "Safety Mindfulness" has the objective to develop and demonstrate a concrete and practical method of maintaining safety mindfulness in operational situations. The idea is that if operational staff are aware of the possible threats that can occur in their day-to-day activities, they can anticipate (most of) them. While operational staff are certainly aware of most of the risks, there are two sources of risk for which they may not have current information. The first is risk information that is taken from a wider pool of information than the operational layer (including supervisors) traditionally has access to. This may be risks identified by looking across several organisations or even across an industry. Such information is relevant but may take a long time to filter back down to operational staff in organisations. The second source of risk information concerns new risks that may have been noticed by one or two individuals during their daily work, but have not yet been passed up the chain and identified as risks that operational staff need to be concerned about. Such risks may be passed on from one individual to another, but this will be an ad hoc process rather than formal, and may not reach the person who really needs it in time. Both these types of risk information may eventually reach the right people, but this can take too much time, and an incident can occur before existing processes have identified, analysed and processed such information, and disseminated it to the collective workforce.

Description of Work

This document presents the FSS Safety Mindfulness methodology, which has been designed to apply the mindfulness principles/dimensions included in the Safety Mindfulness concept advanced in Year 1, and collect requirements to draw a model able to support/leverage change in organizations aspiring to be 'more mindful'.

A multiple case study method has been used to support the investigation of the safety mindfulness concept as a social process in its organizational environment, and collect requirements to specify/operationalise the model. A multiple case study design was used to produce detailed descriptions of the mindfulness phenomenon using theoretical statements and research questions to guide the collection and analysis of data in each case study. Qualitative Content Analysis was used to support the design and application of a systematic process from the research design into the replication of results (i.e. relying on replication logic to provide external validation to the findings). The use of multiple sources of evidence supported data triangulation and consistency of results. Data recording and analysis was supported by NVivo (© QSR International) (Bazeley, 2007).

The case studies were applied in an ATC organization in The Netherlands (Maastricht Upper Area Control Centre) and an Italian airline (Alitalia). The two case studies followed the same protocol for data collection, but tested two different implementation approaches.

Note that these case studies are documented in a confidential Annex to FSS Deliverable D5.6.

The case studies supported the collection of requirements to specify and operationalise the Safety Mindfulness model. Metrics have been advanced to evaluate the extent to which the model can actually increase mindfulness in organisations.

Results & Conclusions

Overall, In MUAC there is an opportunity to enhance timely feedback of risk related information back into the operation, creating opportunities to share information, stimulating active awareness and learning. In Alitalia there is no clear process for managing problem solving and improvement in an accountable way.

In the next phase of the project, proposals to apply the Safety Mindfulness model will be advanced to both MUAC and Alitalia. In year 2, two contrasting case studies have been advanced – contrasting in terms of the operational focus (and type of process), the strengths and weaknesses of the safety management approach, and the focus on implementation. The MUAC case study set the framework for the 'as-is' evaluation, which was then applied to the Alitalia case. In year three the Alitalia case is expected to make good progress in terms of implementation, testing the model as a template for implementing Mindful Self-Regulation. At the same time the prospects for implementation will be explored in detail in MUAC, again testing, in principle, the applicability of the model and learning from experience in Alitalia. This creates a powerful multiple case study approach in which the two case studies can be compared and contrasted in two phases. Analytic generalisation of the different contexts in which the model has been tested will reinforce the external validity of the model, defining more clearly the domain to which the findings can be generalised.

This will also have benefits in the development of Mindfulness metrics.

Applicability

Within Future Sky Safety P5 "Resolving the Organisational Accident", the Safety Mindfulness concept is applied particularly at the level of operational staff, supervisors and includes management across the range of aviation organisations (e.g. airlines, airports, ATM, etc.). It is designed to support and integrate with the overall P5 concepts in applying solutions to organizational safety across the whole organization in normal and non-normal operations.

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1 INTRODUCTION

1.1. The Programme

FUTURE SKY SAFETY is an EU-funded transport research programme in the field of European aviation safety, with an estimated initial budget of about € 30 million, which brings together 32 European partners to develop new tools and new approaches to aeronautics safety, initially over a four-year period starting in January 2015. The Programme research focuses on four main topics:

- Building ultra-resilient vehicles and improving the cabin safety
- Reducing risk of accidents
- Improving processes and technologies to achieve near-total control over the safety risks
- Improving safety performance under unexpected circumstances

The Programme will also help coordinate the research and innovation agendas of several countries and institutions, as well as create synergies with other EU initiatives in the field (e.g. SESAR, Clean Sky 2). Future Sky Safety is set up with four years duration, and started on the 1st of January 2015.

FUTURE SKY SAFETY contributes to the EC Work Programme Topic MG.1.4-2014 Coordinated research and innovation actions targeting the highest levels of safety for European aviation in Call/Area Mobility for Growth – Aviation of Horizon 2020 Societal Challenge Smart, Green and Integrated Transport. FUTURE SKY SAFETY addresses the Safety challenges of the ACARE Strategic Research and Innovation Agenda (SRIA).

1.2. The Project

TCD is leading the strand related to the 'Safety Mindfulness' within Project P5 'Resolving the Organisational Accident'. P5 has the high-level objective to reduce the likelihood of organisational accidents in aviation through the development and implementation of a Safe Performance System. Safety focus has traditionally been on technical failures and human error as they occur in operations. New and promising approaches consider the overall socio-technical system in the full operational and organizational context. The research FSS P5 is advancing addresses effects of organizational structures, processes and cultural phenomena on safety performance in aviation organizations.

Specifically, TCD is responsible for developing and demonstrating a concrete and practical method/approach to maintain safety mindfulness in operational situations. In Year 1 an extensive literature review regarding the original concept developed by Weick and colleagues has been provided, and an integrated FSS Safety Mindfulness concept was advanced to address the weak areas of the original concept. The proposed approach comprises different aspects which will support both the operational, supervisory and middle management layers to better understand the system they work in, and share safety knowledge-based information. In Year 2 the concept has been tested in two distinctive cases to support the specification of the concept and collect requirements to define a 'Safety Mindfulness model', able to support the definition of mindful organisations and leverage of change.

1.3. Project context

The proposed concept has been tested/applied in two different ATS organisations from the aviation sector: an (1) ATC company based in The Netherlands, and an (2) airline company based in Italy. The specific case studies were analysed in the multiple case study approach advanced by Yin (2009, 2012).

1.4. Research objectives

The high-level objectives of the field research conducted in Year 2 were to provide a methodology description of the safety mindfulness concept, by testing the theoretical statements of the concept, and to collect requirements to specify the model. The over-riding research questions have been the following:

- How can we support the implementation of an "organizational/collective" Safety Mindfulness system?
- How can we support the sharing and retrieval of useful information and data to successfully mitigate/avoid incidents and accidents within ATS organizations?

Each case study specified the research questions from the problem area identified with the management.

1.5. Field Research methodology

To test and validate the Safety Mindfulness concept a multiple case study research has been developed. This has been proven to bring more compelling evidence, and the overall study is regarded as more robust (Herriot & Firestone, 1983). In particular, a multiple case design approach has been followed. The rationale for a multiple-case design refers to the kind of replication to be studied. The cases will be represented by ATS organisations. Each case study will follow the same protocol for data collection and respond to the same general/overriding research questions.

The first case study regarded an air traffic control company – i.e. Maastricht Upper Area Control Centre (MUAC). First an introduction of the problem area will be provided, and the allied research questions will be outlined. Then the field research will be presented, and the results discussed.

The second case study in the Alitalia (AZ) airline company aims at verifying Safety Mindfulness levels by enhancing organizational capability and performance in the internal safety reporting systems and processes. The benefit of a proposed process/organizational change is expected to increase a positive context to get an organizational emergence of safety mindfulness following improvement initiatives foreseen by TCD year 3 (2017) of the FSS Project. Such changes would target the systems in place for safety information flows, management and learning. This case study defines a project for a systemic change initiative in AZ between 2016 and 2017. The safety mindfulness concept reveals to be key factor to engage in this wider change initiatives, supporting it and strengthening the potential of a wider organizational improvement path.

Note that these case studies are documented in a confidential Annex to FSS Deliverable D5.6.

1.6. Current Status of Research

In Year 2 an in-depth field research has been undertaken to apply the Safety Mindfulness principles in real-world cases. This has led to the specification of requirements and definition of a Safety Mindfulness model. Metrics associated to the model have been designed. In Year 3 the model and the metrics will be tested in a different case study, to consolidate the Safety Mindfulness model and associated measures to test the extent to which this leverages transformation into more mindful organisations.

1.7. Overview of Document

This document divides into several different sections:

- **Section 2** presents an overview of literature that provides a background for the safety mindfulness concept which was advanced in Year 1
- **Section 3** presents the 'Case Study' method to draw on a framework able to describe and specify the properties of the FSS Safety Mindfulness concept, and consequently model it. Further, it provides the background methodological approach to data collection, recording and analysis to ensuring validity and reliability of the findings.
- **Section 4** constitutes the bridge from the Safety Mindfulness concept advanced in Year 1 into a model drawing on the multiple case study analytic replication
- **Section 5** presents the Safety Mindfulness model
- **Section 6** presents the metrics proposed to measure safety mindfulness.
- **Section 7** presents the conclusions and recommendations

In addition, several appendices are provided along with a list of references.

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2 SAFETY MINDFULNESS IN ORGANIZATIONS

2.1. Introduction

This section presents an overview of literature that provides a background for the safety mindfulness concept which was advanced in Year 1.

Section 2.2 introduces the organizational context of (air transport) operations, and individual and organizational mindfulness herein. Section 2.3 provides the highlights of the safety mindfulness concept developed in the earlier FSS-D5.2 report (McDonald, Callari, Baranzini, Woltjer, & Johansson, 2015). Section 2.4 presents background on situation awareness modelling and it introduces risk situation awareness and risk mental models as concepts for studying safety mindfulness.

2.2. Mindfulness in an organizational context

2.2.1. Organizational context

Safety mindfulness is a concept for reasoning about safety in an organizational context. An organization is a planned, coordinated and purposeful action of human beings to construct or compile common tangible or intangible products (Giddens, 2006). Figure 1 shows a schematic diagram of an archetypical organization with three organizational layers. The lowest level is the operational level where the (tangible or intangible) products are actually produced by the complex interplay of human operators and technical systems working in an operational context. In the context of air traffic, the operational level can include air traffic controllers delivering ATM services, airline pilots controlling aircraft movements, or technicians working at ATM providers or airlines. Safety mindfulness primarily concerns the safety at this operational level.

The middle layer concerns middle management, which is managing part of the operations and wherein the middle managers are typically in regular contact with the human operators at the operational level. The middle management also interacts with upper management towards achievement of the overall organizational objectives and the translation of the means and requirements at the operational level. The upper management typically interacts with the middle management layer, but may also interact with the operational layer, e.g. for learning and appreciation of details in the conduct of operations.

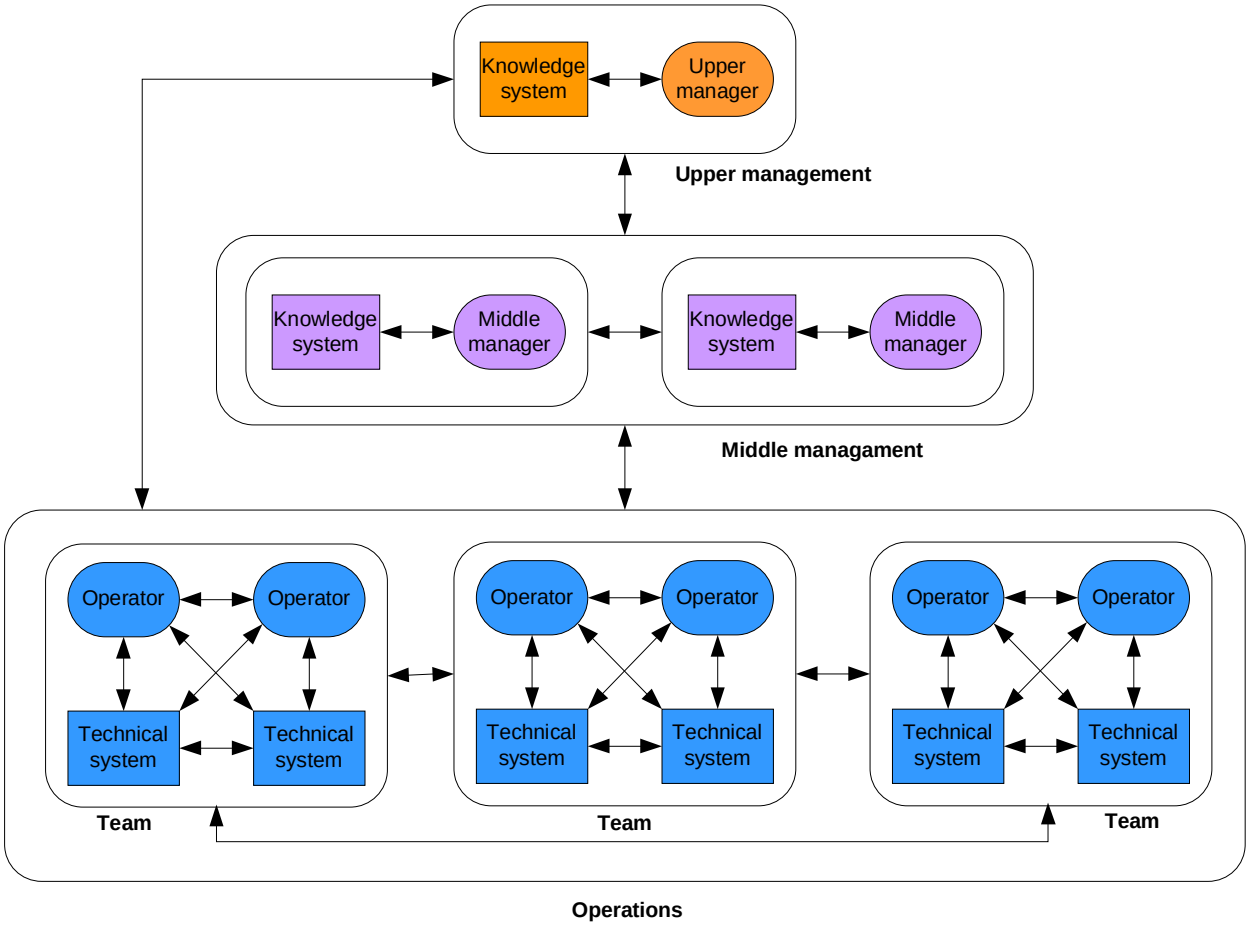


Figure 1: Schematic diagram of an archetypical organization with three organizational layers: operations, middle management and upper management

Organizations interact with other organizations, as depicted schematically in Figure 2 below. These inter-organizational interactions may exist at all layers. Organizations in air transport include airlines, ATM service providers and airports. Safety in air transport operations depends on the ways that the human operators of these various organizations interact: working attitudes and interactions between pilots, air traffic controllers, airport operators, etc. influence the safety of the operations. Inter-organizational interactions at middle and upper management can support safety management and the overall management of the operations in recognition of the reciprocal interests of the organizations.

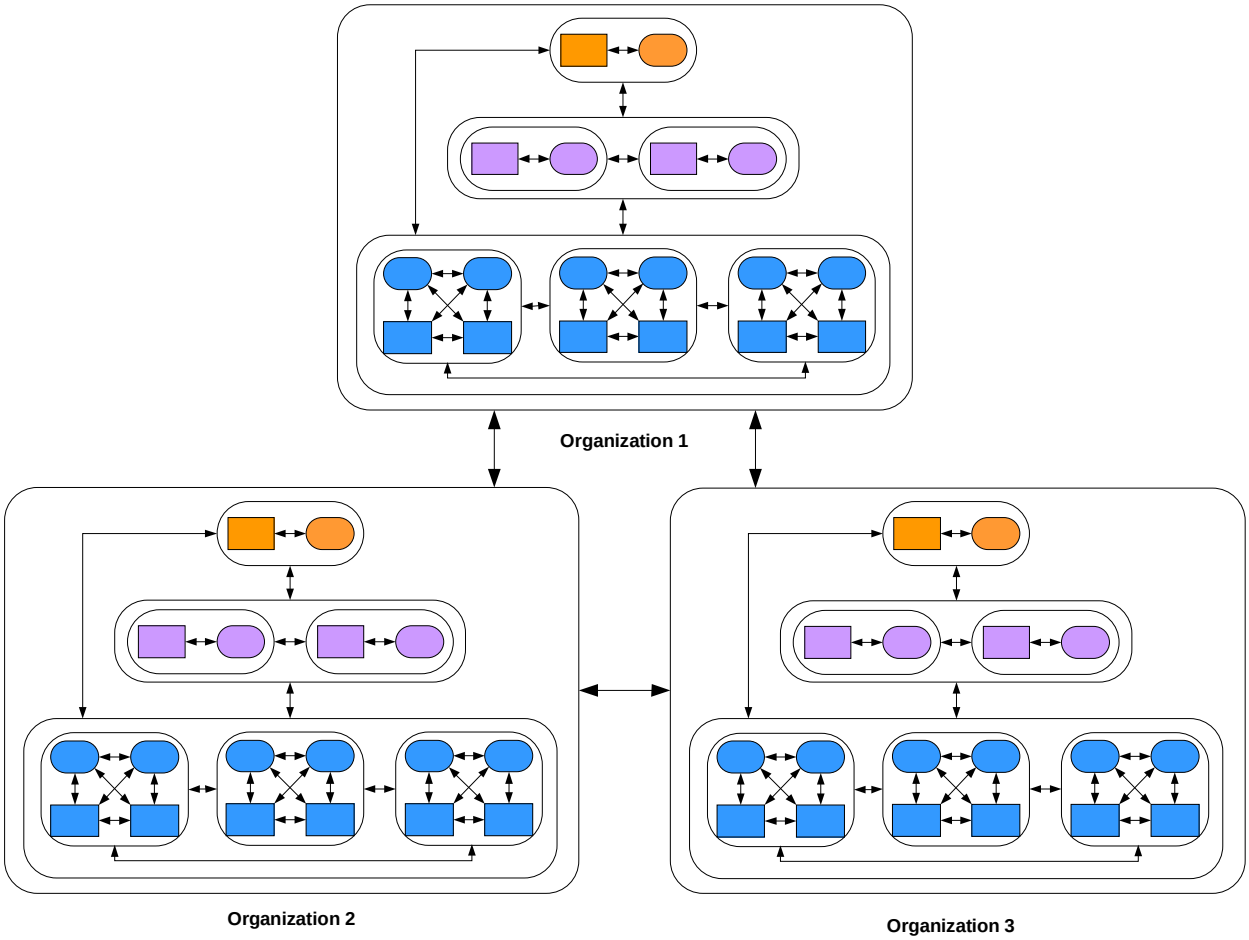


Figure 2: Schematic diagram of interactions between multiple organizations (see also Figure 1)

2.2.2. Individual and organizational mindfulness

Individual mindfulness is an information-processing approach, which considers active differentiation and refinement of existing categories, creation of new discontinuous categories out of streams of events, and a more nuanced appreciation of context and alternative ways to deal with it (Vogus and Sutcliffe, 2012). Individual mindfulness has also been defined as an individual learning process, which is characterized by a heightened awareness of the specific circumstances in a given situation (Jordan et al., 2009). Individual safety mindfulness can be seen as an individual's situation awareness of risks related to a work situation, meaning that **the individual is aware of possible threats/risks and is actively thinking about them in a given situation** (McDonald et al., 2015). In the context of Figure 1, such individual safety mindfulness can have different meanings for the various types of individuals. For human operators at the operational level, it refers to the awareness of risks and related mitigating actions for given situations that may occur during their work. For the middle management, it concerns the awareness of the main risks of the operations under their supervision and knowing how the operations can be supported best in mitigating those risks. For the upper management, it refers to the awareness of the main risks in the operations that the

organization fulfils, understanding how these safety risks relate to other risks (e.g. financial, business continuity) and what kinds of changes and investments may be needed to improve the level of safety.

Organizational mindfulness refers to the extent to which an organization captures discriminatory detail about emerging threats and creates a capability to swiftly act in response to these details (Vogus and Sutcliffe, 2012). Organizational mindfulness specifically consists of regularly and robustly discussing potential threats to reliability (preoccupation with failure); developing a nuanced and current understanding of the context by frequently questioning the adequacy of existing assumptions and considering reliable alternatives (reluctance to simplify interpretations); integrating these understandings into an up-to-date big picture (sensitivity to operations); recognizing the inevitability of setbacks and thoroughly analysing, coping with, and learning from them (commitment to resilience); and deferring to expertise rather than authority when making important decisions (Weick & Sutliffe, 2007; Vogus and Sutcliffe, 2012). It can be recognized that organizational mindfulness is focussed on processes that the organization can perform, whereas individual mindfulness refers to a knowledge base (awareness of risks/threats) and to a learning process towards such knowledge base. Part of the organizational mindfulness processes support the strengthening of the individual mindfulness of the people working in the organization.

2.3. FSS Safety Mindfulness concept

The safety mindfulness concept developed by McDonald et al. (2015) includes the mindfulness principles following the work of Weick and Sutcliffe (2007) and Vogus and Sutcliffe (2012), and additional mindfulness aspects, consisting of a situation awareness model, temporal and specificity aspects, and learning cycles.

The safety mindfulness principles proposed in the original concept advanced by Weick and colleagues, and included in the concept proposed in the FSS approach developed in Year 1 (McDonald et al., 2015) are the following:

1. *Preoccupation with failure and success* - Organizational understanding of actual working conditions and the resulting work-as-done in everyday operations to identify recommendations/best practices by learning from all situations/events occurred which led to a failure or a success. This would feed a shared bottom-up system to support the organisational collective mindfulness.
2. *Reluctance to simplify interpretations* - Developing a nuanced understanding of the context so that variation in the environment can be grasped and different interpretations can be given in relation to the specific situation/event presented.
3. *Sensitivity to operations* - Organizations are dynamic and nonlinear in nature. As a result it becomes difficult to know how one area of the organization's operations will act compared to another part. Constant interaction deepens people's understanding of the interdependent workings of the complex system itself. This supports people to cope more effectively with

unexpected surprises. To enable the operational people to understand the changes and the complexity of a novel (unexpected) situation/event, interdisciplinary and inter-departmental activity should be promoted, so that an integrated "big picture" of collective mindfulness is established.

4. *Commitment to resilience* - Resilience requires that operational people are mindful about errors that have already occurred and to correct them before they worsen and cause more serious harm. It can be supported by training to build people's skills and mindset in mentally simulating different events/situations, how they can unravel, and how they might be corrected. This requires leadership within the organization to reinforce commitment to resilience.
5. *Under-specification of structure/Deference to expertise*- Deferring to expertise rather than authority when making important decisions. Expertise is relational, is an assemblage of knowledge, experience, learning, and intuition which is seldom embodied in a single individual. Credibility, a necessary component of expertise, is the mutual recognition of skill levels and legitimacy.

In addition to the safety mindfulness principles, McDonald et al. (2015) include the following other safety mindfulness aspects (see also Figure 3):

- *Situation awareness* - Fundamentally, collective mindfulness is about being proactive, about having the best and most up-to-date information when carrying out the task. It is about having shared situation awareness in teams, including (1) a high level of SA in individual team members for aspects of the situation necessary for their job; and (2) a high level of shared SA between team members, providing an accurate common operating picture of those aspects of the situation common to the needs of each member. Necessary situation awareness aspects include (a) looking ahead to the future and anticipating events, (b) monitoring and diagnosing the present, (c) deciding and acting, and (d) learning from the past. Individual safety mindfulness can be seen as an individual's situation awareness of risks related to a work situation, such that the individual is aware of possible threats/risks and is actively thinking about them in a given situation.
- *Learning cycles* - To promote a collective mindfulness within the organization possible approaches of knowledge building can be undertaken – i.e. top-down, bottom-up and horizontal approaches. These approaches have the high-level objective to expand knowledge and situation-awareness within different layers of the organization, to improve the information flow between the units/departments, the system efficiency, and ultimately to leverage change for improved safety performance.
- *Temporal and specificity aspects* - Several temporal and specificity layers can be distinguished. At the operational level transmission of safety information can be very fast, ranging from real-time to within several days, e.g. telling colleagues immediately, during a break, at the end of a shift, or when they next come on shift. Such information has immediacy, is highly contextual, and is understood by those who receive it. At middle management level, information from operations is

weighed in terms of its importance and its specificity, and it may be transmitted back down to ensure that all relevant operators are aware. This process typically takes anything from several days to a month. At the upper management level, the information is analysed and judged in the context of an overall risk picture. The feedback to operations, mediated through the middle layer, is typically in the range of months to years.

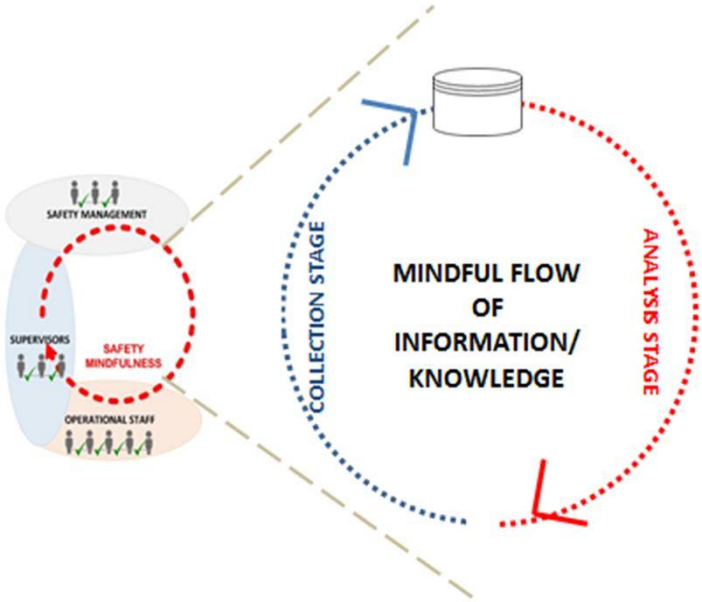


Figure 3: FSS Safety Mindfulness concept

2.4. Situation awareness modelling for safety mindfulness

As explained in Section 2.3, situation awareness, temporal and specificity aspects of associated information transfer in an organization, and learning cycles for adapting mental models are key aspects of safety mindfulness. In this section we provide some more background on situation awareness and mental models in an organizational context, and we introduce the concepts of risk situation awareness and risk mental models in support of studying safety mindfulness.

2.4.1. Situation awareness

The best known definition of situation awareness is by Endsley (1995): 'Situation awareness is the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future'. In this definition, situation awareness is a dynamic state of knowledge which discerns three levels: (1) perception of elements in the environment, (2) comprehension of the current situation, (3) projection of the future status. The process of achieving, acquiring and maintaining situation awareness is referred to as situation assessment (Endsley, 1995).

For teams of interacting humans, the situation awareness states of the humans involved depends on team processes such as communication and coordination, in addition to the cognitive processes as perception, comprehension and projection. Team situation awareness is defined by Endsley (1995) as 'the degree to which every team member possesses the situation awareness required for his or her responsibilities'. So it reflects the situation awareness as states of team members given particular requirements for situation awareness in the working context. Furthermore, shared situation awareness is defined as (Endsley & Jones, 2001) 'the degree to which team members have the same situation awareness on shared situation awareness requirements'. In other words, it reflects the overlap of situation awareness elements for which team members should have situation awareness. So, according to these definitions, team and shared situation awareness are complex structures, which are not simply state-based, as situation awareness is, but which can only be evaluated in the light of task-related requirements.

For joint cognitive systems, comprising humans and technical systems, the concept of distributed situation awareness has been proposed (Salmon et al., 2008; Stanton et al., 2006). In this context situation awareness is defined as 'activated knowledge for a specific task, at a specific time within a system', and can be held by humans and technical systems. In line with distributed cognition theory, distributed situation awareness is achieved through coordination between the agents of the joint cognitive system, and it is viewed as an emergent property of the joint cognitive system rather than as a property of the individual agents.

Chatzimichailidou (2015) defined risk situation awareness as the individual SA of a system agent which refers to the presence of threats and vulnerabilities that may lead to system accidents. Risk distributed situation awareness is considered as a special case of distributed situation awareness, indicating that each agent, on the one hand, may have a detailed picture of the threats and vulnerabilities of the part that the

agent controls, but on the other hand only retains a partial overview of the threats and vulnerabilities that are present in the entire system.

2.4.2. Mental models

Mental models are primary means in situation assessment processes, wherein they guide attention processes and classifying information in perception (level 1 SA), they are a means for integrating the elements towards an understanding of the current situation (level 2 SA), and they are a means to reason about future states (level 3 SA). Mental models were defined by Rouse and Morris (1986) as "mechanisms whereby humans generate description of system purpose and form, explanation of system functioning and observed system states, and prediction of future system states" and this definition is well in line with their role in situation assessment. Figure 4 provides a schematic overview of relations between situation awareness, mental model and overt behaviour (acting).

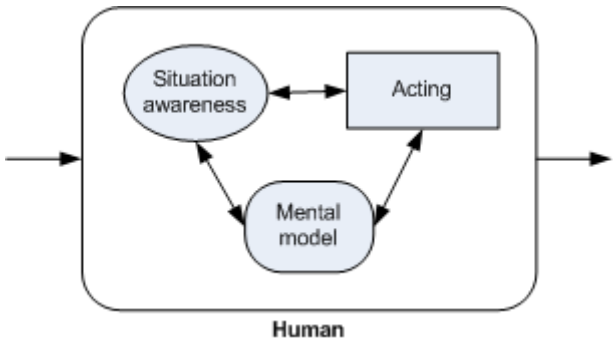


Figure 4: Schematic diagram of relations between situation awareness, mental model and overt behaviour (acting) of a human.

A review of Jones, Ross, Lynam, Perez, and Leitch (2011) provides an overview of the socio-psychological literature on mental models. Mental models are personal, internal representations of external reality that people use to interact with the world around them. They are simplified representations of reality and their aspects are influenced by personal goals and motives as well as by the cultural context. Mental models have been conceived to exist in working memory, as a dynamic computational structure for reasoning, or in long-term memory, as long-term knowledge structures enabling reasoning. Some researchers distinguish between mental models and schemata, where schemata refer to inflexible and generic knowledge structures, and mental models are used to flexibly combine schemata for specific and possibly new situations. Such kinds of schemata are also used by cognitive anthropologists to explain cultural understanding, where groups of people internalize shared experiences to come to cultural meaning, which individuals use to perceive and relate to the world around them (Quinn, 2005).

In the context of risk perception, it is considered that people use mental models or scripts to reason about hazards ("anything that could lead to harm") (Breakwell, 2007). Such mental models describe the components of a hazard, explain how a hazard may change over time, indicate who may be affected by the hazard, and explain how the hazard may be controlled. Clearly, the mental models held by people do not need to be scientifically grounded, they describe the possibly simplistic reasoning of individuals as a

basis for their risk perception and decisions made in dealing with hazards. Understanding such mental models is important for developing effective risk communication interventions, wherein it may be desirable to change the mental models about risk.

2.4.3. Risk situation awareness and risk mental models

As a key component of the situation awareness of individuals in an organization, a human operator should be aware of disturbances that impact the operation that the operator is working in, of the way that these disturbances may evolve, of the impact of these disturbances on the operations, and of the strategies that can be applied such that the effect of the disturbances is kept within acceptable bounds. Such disturbances can be any conditions, events or variations that may affect the operational performance, e.g. poor weather, high workload, failures of technical systems, or large traffic load. Part of such disturbances may have a negative effect on the safety of operations, and these disturbances are often named "hazards". In choosing strategies to deal with disturbances, human operators have to trade off the implications on different performance areas and on short-term and long-term goals. In such decision-making they have to deal with uncertainty, as the recognition of disturbances, the way that disturbances may evolve and have impact on the operations, and the effects of strategies are typically only known to a limited extent. The processes for recognizing and interpreting disturbances, and for choosing suitable strategies by individuals are based on their mental models.

For safety mindfulness the most relevant key performance area clearly is safety, but as people in the organization always have to deal with the full operational complexity, the mindfulness about safety can only be understood well in relation to the objectives for other key performance areas held by individuals and other organizational entities. Reasoning about safety is often done using the concept of risk, which combines the severity of potential consequences of a particular situation with the likelihood of attaining those consequences. Consequences considered in safety include incidents and accidents, which typically have (very) low likelihood values. The risk concept can also be used for reasoning about key performance areas other than safety, e.g. risk of financial loss, risk of continuity of operations, risk of environmental impact. Also in such areas, severity and likelihood levels can be defined, which are specific for the area considered.

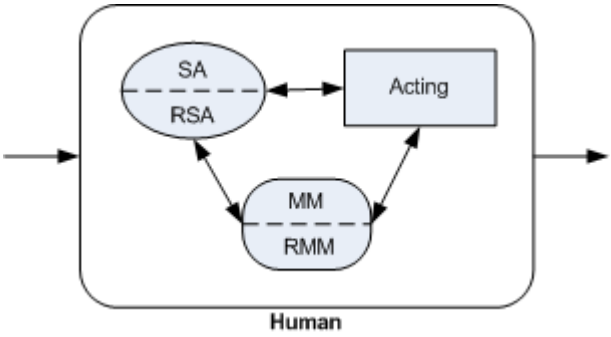
For arguing about situation awareness in the context of safety mindfulness, we will use the terms "risk situation awareness" and "risk mental model". Risk situation awareness is part of the situation awareness of an individual and it refers to the understanding of the risks in the current work situation, notably including safety risks, and to the decisions made by the individual for strategies for dealing with the perceived risks (see Figure 5). A risk mental model is a part of the mental model of an individual and it describes disturbances, ways to recognize disturbances, ways that disturbances can affect particular performance areas, strategies for effectively dealing with disturbances, and ways to decide on appropriate strategies. In classic information processing terminology, risk situation awareness refers to the working memory, describing risks that a person sees and understands now and in the near future, whereas a risk mental model refers to long term memory or knowledge base about risks. For example, a pilot might express his risk mental model by arguing that he would initiate a missed approach in case of

an unstable approach configuration, so as to assure operational safety. The actual performance of the pilot in an unstable approach condition might be different, because he does not fully recognize the risk as the actual situation evolves and he is already having a delay.

Risk situation awareness can be updated by interaction processes (e.g. observation, communication, handling) with other humans, technical systems and other entities in the working context, as well as by reasoning processes using risk mental models. Risk mental models can be adapted via the situation awareness of an individual by various learning processes, such as learning risks by own operational experiences, learning risks by communication with colleagues ("story telling"), or institutional learning about risks (basic and follow-up training, memos, pamphlets, etc.).

Figure 5: Diagram depicting risk situation awareness (RSA) as part of situation awareness (SA), and risk mental model (RMM) as part of mental model (MM).

Temporal and specificity aspects and learning cycles can be represented by considering risk situation awareness and risk mental models of individuals in the overall organizational context. Figure 6 shows the schematic archetypical organization with operations, middle management and upper management, which



emphasises the (risk) situation awareness and (risk) mental models of each human in the organization. Learning cycles in the organization are based on the transfer of information between organizational entities and they can lead to adaptation of the mental models of humans in the organization. In a distributed situation awareness perspective, such information transfer can change the contents of knowledge systems ("their mental models"), which are used as part of safety management. Temporal and specificity aspects depend on the role of the agent in the organization and on the dynamics of the information transfer.

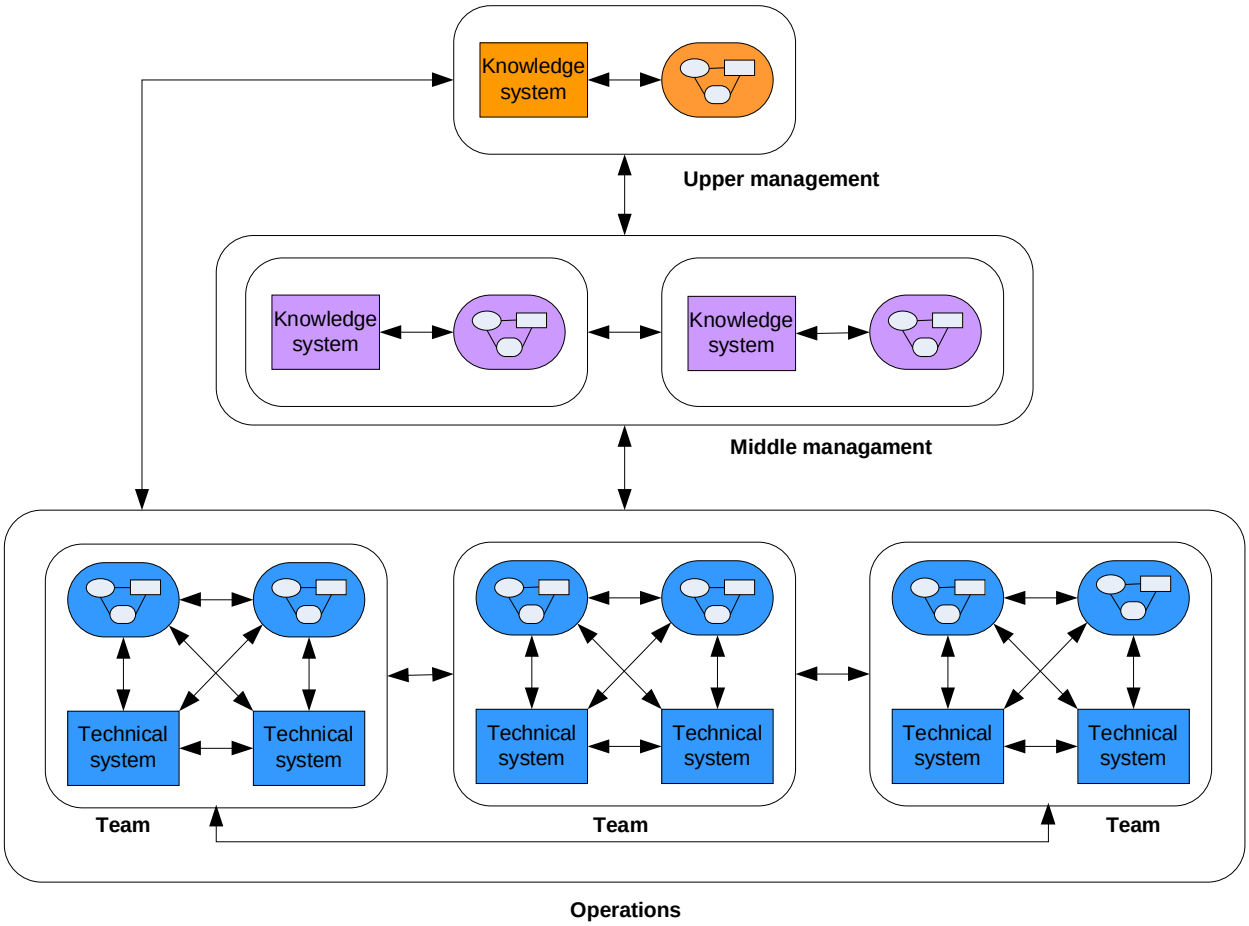


Figure 6: Situation awareness, mental models and knowledge system components in an archetypical organizational structure.

2.5. Discussion

Although Weick's ideas on Mindfulness are popular, they have proven difficult to implement, and so far there is no accepted measure of organizational mindfulness (Ray et. al., 2011). This is possibly because they have remained 'ideas' and principles rather than concrete proposals on how to support or even engineer better mindfulness into organisations. The FSS Safety Mindfulness concept will be applied in two distinctive cases to collect requirements aimed at concretising the concept with the specification of a model able to support and 'leverage' safety mindfulness as a living process in organisations.

3 METHODOLOGY: BUILDING A MULTIPLE CASE STUDY APPROACH

3.1. Introduction

This section presents the 'Case Study' method to draw on a framework able to describe and specify the properties of the FSS Safety Mindfulness concept, and consequently model it. Further, it provides the background methodological approach to data collection, recording and analysis to ensuring validity and reliability of the findings. To do so, it introduces the computer-based tool used to support the above – i.e. NVivo (© QSR International).

3.2. The case study method

3.2.1. Overview

The case study method has been proven to bring more compelling evidence, and the overall study is regarded as more robust (Herriot & Firestone, 1983). The method supports the in-depth understanding and description of complex social phenomena in contemporary real-life context (Yin, 2012, 2014). Based on the type of research question(s) posed (i.e. supporting either explanatory, exploratory, or descriptive case studies), the case study method can involve *single* or *multiple* cases. Single case studies (N=1) and multiple case studies (N>1) can be *holistic* (if the cases are studied and compared in their totality), or to have *embedded* subcases within an overall holistic case (if various units of analysis within identifiable cases are studied). The result is a two-by-two matrix. See Figure 7 below.

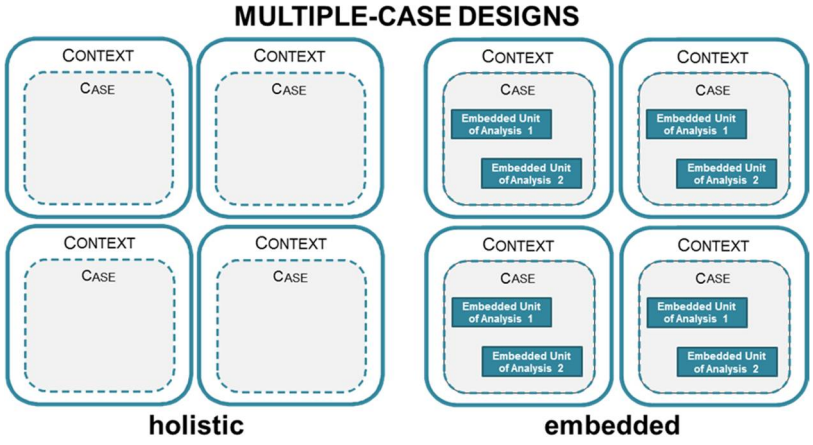


Figure 7: Two-by-two matrix of the multiple-case designs

The case study research design can include qualitative, quantitative, or both research strategies.

One of the strength in using a multiple case study design is that it can examine complementary facets of the main research questions, and eventually test the conditions under which similar findings are achieved, and can be *replicated*. In relation to 'replication', in multiple case studies the cases can be selected to predict similar results (direct replications) or to predict contrasting results but for anticipatable reasons (theoretical replications) (Yin, 2012).

Theoretical propositions guide the collection and analysis of data. The systematic collection/analysis of data in natural setting using multiple sources of evidence in multiple case studies can support the analytic (not statistical) generalization of case study findings to other situations/conditions. Thus, the analytic generalisation implies to generalize to 'theoretical propositions', not to 'population' as in statistical research.

3.2.2. Application in P5.2

In P5.2 a multiple case design approach has been followed. This will support replication and analytic generalisation of findings from the selected case studies. Further, it will support the definition and operationalisation of a FSS Safety Mindfulness model, able to leverage change in organisations and improve 'collective mindfulness' towards a safer environment.

The 'theoretical propositions' guiding the research refer to the principles and underlying characteristics of the Safety Mindfulness concept advanced in Year 1 (see D.5.2 – FSS Safety Mindfulness (McDonald et al., 2015) and Section 2.3 FSS Safety Mindfulness concept in this document). This includes:

Table 1: P5.2 Multiple-case study theoretical propositions/research questions

#	THEORETICAL PROPOSITIONS	DIMENSION ADDRESSED
1	- The more the recommendations/best practices from the actual working conditions and work-as-done in everyday operations are in place, the more is the likelihood of supporting the organisational collective mindfulness - Learning from situations/events which led to a failure or a success supports the creation of a safer mindful place - By 'grasping' every variation in the environment, different interpretations can be given in relation to the specific situation/event presented and enable the developing of a nuanced understanding of the context. This supports a "clear and detailed comprehension of emerging threats and on factors that interfere with such comprehension". - Organisations are complex. By recognising the complexity of organisations, the interdependent workings of the complex system itself needs to be understood - Interdisciplinary and inter-departmental activity enables the operational people to understand the changes and the complexity of a novel (unexpected) situation/event. This supports an integrated "big picture" of collective mindfulness - Training of operational people builds on people's skills and mindset in mentally simulating different events/situations, how they can unravel, and how they might be corrected - Leadership within the organization reinforces commitment to resilience. A collaborative leadership style enables and facilitates a collective mindfulness – to overcome individual .v. group boundaries. - Expertise rather than authority when making important decisions is built on experience, learning and intuition. Credibility, a necessary component of expertise, is the mutual recognition of skill levels and legitimacy.	**The five mindfulness principles and underlying dimensions (Weick & Sutcliffe, 2007)**

2	- SSA is in place when operational people are able to look to the future, and anticipate events – novel demands, new conditions, possible threats. - SSA is in place when expectations about future events are communicated and collectively shared - SSA is in place when operational people are able to understand and monitor what is currently happening in the context - SSA is in place when operational people are able to update safety assumptions and perspective, and forewarning possible changes - SSA is in place when organisations enhance/empower operational people to be better at identifying and communicating risks - SSA is in place when organisations enhance/empower operational people to be able to detect subtle changes in contexts and respond as appropriate - SSA is in place when appropriate communication/information tailored to the particular circumstances is spread between the different organizational layers to create informed collective mindfulness. - SSA is in place when "knowledge" sharing between different actors in the organization is promoted to support the collective understanding of the system, and the creation of a collective mind/cognitive frame of the operational people/team - SSA is sustained by specific tools used for data collection/analysis (qualitative .v. quantitative). The tools: are able to understand the complexity of the context; are built on the current practices/processes of the organization; are systematically updated; are used by both the middle/top managers and operational people to inform and being informed on the possible system variances. - SSA is in place when there is real-time interaction with different groups in the organization to develop a shared understanding of the situation at hand - SSA is in place when operational people are able to activate prepared actions or adjusting current mode of system functioning towards a safer outcome. - SSA involves dimensions of self-awareness and others' awareness. SSA is in place when operational people have the collective mindset necessary to detect and comprehend emerging threats before they bring about bad consequences - SSA is in place when operational people are able to learn the "right lesson" from the "right experience", to strengthen/reinforce what has worked well and what needs to be changed/adjusted - SSA is reinforced by the use of narratives and storytelling as means for understanding possible organizational patterns and therefore address safety - SSA is reinforced by the collective relying on both qualitative and quantitative sources which can provide as comprehensive systemic picture of risk as possible	**Promoting Shared Situation Awareness (SSA) (Endsley, 1995; Salmon et al., 2008; Stanton et al., 2006)**
3	- At operational level, the transmission of safety information has immediacy, is highly contextual and is understood by those who receive it. The process takes from real-time information to within days - At middle management level, the transmission of safety information	**Temporal and specificity aspects**

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	from operations is weighed in terms of its importance and its specificity, and it may be transmitted back down to ensure that all relevant operators are aware. This process typically takes anything from several days to a month. - At top management level, the information is analysed and judged in the context of an overall risk picture. The feedback to operations, mediated through the middle layer, is typically in the range of months to years.	
4	- Knowledge building to promote collective mindfulness can involve top-down, bottom-up and horizontal approaches. - Top-down, bottom-up and horizontal approaches support information flow between the units/departments, the system efficiency, and ultimately to leverage change for improved safety performance.	**Learning cycles**

In FSS, P5.2 the cases in the multiple case study design belong to ATS organisation representatives. The first case study involved an ATC organisation; while the second an airline company. Both responded to the same overriding theoretical propositions and were guided by similar research questions (i.e. the research questions took into account the peculiar context of the case study, and the problem area the intervention had the specific objective to address).

In both case studies a systematic research process was followed. This involved the adoption of the Qualitative Content Analysis methodology to establish quality of field research in the multiple case study research (see Section 3.3 for details). Overall, a qualitative research strategy was used in all case studies.

3.3. Qualitative Content Analysis

3.3.1. Overview

Qualitative Content Analysis (QCA) is a research approach '*for making reliable and valid inferences from qualitative material to the context of its use'* (Krippendorff, 2013; Schreier, 2012). The approach follows a systematic procedure that traces down all the research steps undertaken from the research design planning, data collection, recording/analysis, into the data reporting. In the multiple-case study the research steps are drawn on the pre-defined theoretical propositions/research questions, a protocol for data collection is designed, and the empiric material is interpreted through the use of categories from a coding frame. The *protocol* for data collection contains the references to the sources of evidence, the procedures and general rules that should be followed during the data collection in each of the case studies identified. The *coding frame* is a conceptual and hierarchical structure comprising categories and subcategories labelled to reflect the content/material that has to be described. The design of the coding frame can follow a (1) *concept-driven strategy* (or *deductive strategy*, based on predefined theoretical statements), a (2) *data-driven strategy* (or *inductive strategy*, where the coding frame structure emerges from the empirical data), or a (3) *mixed strategy* (where both strategies are used).

A systematic research process definition and traceability ensures validity and reliability. Figure 8 proposes the process that has been developed to support the above. The process design is the result of former research undertaken by the authors (Cahill & Callari, 2015; Callari, 2012), and systematic literature

analysis (Bengtsson, 2016; Krippendorff, 2013; Schreier, 2012). In particular, four tests, and 'case studies tactics' (Yin, 2009, p. 40) are used to judge the quality of the research process used. This includes:

- Reliability. It is concerned with the consistency, stability and repeatability of the informant's accounts as well as the investigators' ability to collect and record information accurately. This refers also to the extent to which a designed instrument yields data that is free from error; or the operations of a study (e.g. data collection procedure) can be repeated with the same results. Specifically, the steps of the process to corroborate the findings and the conclusions should be performed in a systematic and transparent way – i.e. sound protocols for data collection, and a reliable coding frame for data recording and analysis.
- Construct validity. This involves the identification of operational measures for the concepts under investigation. This can include the (1) use of multiple sources of evidence to support convergent lines of inquiry (Yin, 2014, p. 120), (2) to establish a chain of evidence, (3) to have the report reviewed by key-informants (e.g. expert form the same sector or context). Further, it involves the definition of metrics/KPI to measure what is studied.
- Internal validity. It refers to the conduct of the study such that inferences from the data are accurate (i.e., valid). That is, the extent to which research findings are a true reflection or representation of reality rather than being the effects of extraneous variables.
- External validity. Defining the domain to which the findings can be generalised. The generalisation implies the testing of a theory in a different setting/context. Hence, this involves analytic generalisation (the attempt to generalise a particular set of results to a broader theory) rather than statistical generalisation.

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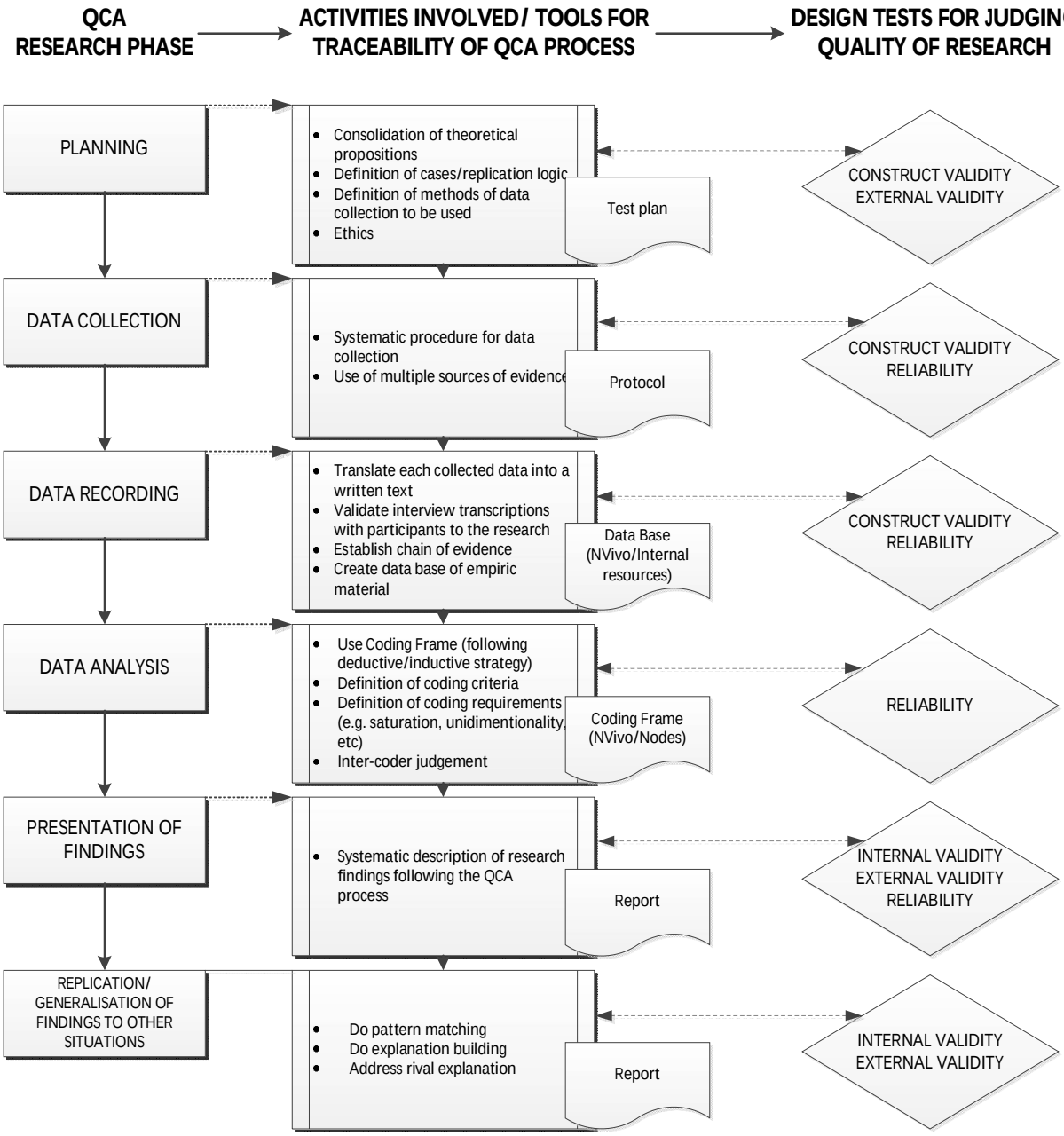

Figure 8: Criteria used for judging the quality of research

3.3.2. Application in P5.2

In P5.2 the Qualitative Content Analysis (QCA) approach was used to systematically describe the process of data collection, recording/coding and analysis of the selected case studies. A test plan including the main aspects of the research process was shared between the P5.2 partners prior to the actual field research (i.e. PLANNING phase). This included the main theoretical statements/research high-level objectives, the methods used for the data collection, the approach for data recording and analysis.

The identified/designed theoretical propositions referred to the Safety Mindfulness approach advanced in Year 1 (see also Subsection 3.2.2 and Table 1: P5.2 Multiple-case study theoretical propositions/research questions). The allied high level research questions designed to address the Safety Mindfulness concept in the selected organisations are the following:

- How can we support the implementation of an "organizational/collective" Safety Mindfulness system?
- How can we support the sharing and retrieving of useful information and data to successfully mitigate/avoid incidents and accidents within ATS organizations?

At a more detailed level, the Safety Mindfulness concept needs to respond to the following research questions:

- How is "collective mindfulness" informed?
- How is the "relevant" information derived and shared?
- How are the bottom-up, top-down and horizontal processes of data managing updated and shared?
- How do the people "feed the system for managing the information shared within the organisation" with the relevant/valid information of the knowledge that they have accumulated in the daily routines? And likewise how are they "fed by the system"?
- How can organisational procedures/processes and practices support all of this mindful organising?
- What are the conditions within the organisations which will enable a sustainable collective mindfulness process/activity?

A protocol for data collection was designed, and the definition of different sources of evidence agreed (i.e. DATA COLLECTION phase). The protocol was co-authored by the TCD investigators, and shared within the WP2 partners. See Table 2 below for an overview of the P5.2 protocol.

Table 2: Case Study Protocol

#	SOURCE OF EVIDENCE	GOAL
1	**Semi-structured interview**	The interview schedule should contain topics of investigation which will enable: - To understand how operators construct and maintain joint and coordinated actions through a common understand of the situation at hand. - To understand how to collect the 'intangible' expertise of the individual, and make it ' collective' – i.e. pass this knowledge onto the colleague, experts from different shifts - To understand how to share this knowledge to form a 'core base' to enable the operators anticipate and manage critical events

	Techniques/methods undertaken/considered in the interview schedule, to support the elicitation of tacit knowledge[1] (Joia & Lemos, 2010; Nonaka & Takeuchi, 1997; Nonaka & von Krogh, 2009). • Instructions to One's Double[2] (Callari, 2012; Oddone, 1984; Oddone & Re, 2002; Oddone, Re, & Briante, 2008) • Critical Incident Technique[3] (Butterfield, Borgen, Amundson, & Maglio, 2005; Flanagan, 1954) Overall, use of descriptive methods to understand the in-depth system variances of intrinsic work constraints, and where to leverage change, to improve the system ability to promote collective mindfulness (Pierre Falzon, 2006, 2008; P. Falzon, 2004; Leplat, 2001a, 2008, 2001b; Leplat & Hoc, 1983; Montmollin (de), 1996, 1997, 1999; Vicente, 1999)
2 Observations	The observation schedule should contain topics of investigation which will enable: - To understand how operators construct and maintain the social and cultural fabric of the system through the cooperative and coordinative 'talks' - To understand how this information is shared, and becomes a 'collective mind'

[1] According to Nonaka and Takeuchi (1997), knowledge is generated from the flow of information, anchored in the beliefs and commitments of its possessor. Knowledge may be divided into two distinct types, depending on how much it can be structured and codified: (1) explicit knowledge, which is expressed in formal language, words, symbols and numbers and can be conventionally and easily stored; (2) tacit knowledge, which is difficult to express in formal language, comes from experience, perceptions and individual values and depends on the context in which it is generated (Joia & Lemos, 2010; Nonaka & von Krogh, 2009). It is therefore important to search for ways to transfer users' tacit knowledge as a source of sustainable competitive advantage.
Tacit knowledge is a direct result of experience, reflection and dialogue and results in the form of know-how and best practices which are embedded in the experts and work system competence. This core competence is further expanded and developed from the working environments in which it is applied. This generates a wider 'contextually co-related' professional competence that is less formalised and adaptable to cultural and social rules, habits and situations specific to the environment in which the activity is performed. Descriptive methods to work analysis allow us to understand and extract in a digital form the current know-how and expanded competence of what people (i.e. cockpit crew and other operational roles) really do (and would like to do) in performing their task activities, are able to anticipate and prevent difficult or dangerous situations.

[2] The '**Instruction to One's Double**' method developed in the frame of the Ethnographic Approach and the 'Knowledge Elicitation' field. It is based on a verbal interaction (in the form of semi-structured interview) which guides the interviewee towards the description of what he does, how and in which context, pulling out what is usually considered "obvious" and therefore left at a tacit level. People are often unaware of the knowledge they possess or are incapable of expressing something that for them is natural and obvious, however qualified and experienced they are. 'Instructions to the Double' represents a setting for knowledge transmission, in which the richness of the researcher's 'saying' (in the theoretical and methodological backgrounds) and the richness of the operator's 'doing' (the experience, the flexibility) are integrated in a new character, the "Double". The pretence of a Double to whom the expert is asked to provide instructions of his/her daily routine <*Give me the instructions I need to replace you in your everyday work, so as nobody will realize that it is not you*> and the use of common language becomes a vital tool for sharing knowledge between the expert and the researcher.

[3] The CIT is a set of procedures for collecting direct observation of human behaviours in such a way as to facilitate their potential usefulness in solving practical problems and developing broad psychological principles. Initially the technique was grounded in describing the effective and ineffective work behaviours in executing a task; over time, the CIT was used to gain understanding about critical events or features within a (working) environment which might have a potentially important effect on the system objectives from the perspective of the individual, taking into account cognitive, affective and behavioural elements. The rationale of the technique is that critical incidents are easily recalled when they refer to rare, specific events, or recently happened, the occurring critical working situations, reproducing the operator(s) involved, the demands and needs posed and the answers provided; if evident, what challenges were faced.

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3	**Workshops/Focus group**	The schedule should contain topics of investigation which will enable: - To understand how flow of information is enabled within same layers/between layers / how this is facilitated / when this is hindered - To understand how different tools can be merged/integrated to provide an overall picture of the safety issues tackled in the organisation - To understand what features/ format a possible tool should have/ how to use it, etc.
4	**Tools analysis**	To analyse current tools in use
5	**Documents**	Documents produced

A Data Base to record (i.e. DATA RECORDING phase) all empirical material was created using NVivo, a Computer-Assisted Qualitative Data Analysis Software (CAQDAS). NVivo (© QSR International) enables the recording and processing of large volumes of data in a reliable/traceable manner (Bazeley, 2007). Each case study included a 'project' in NVivo. All empiric material (e.g. observation data) was translated into written text and recorded in the allied NVivo project. An overview of the NVivo features and use is provided in the Appendix (see Appendix A - NVivo: features and use)

Further, the coding frame to code the qualitative material and analyse it was built (i.e. DATA ANALYSIS phase). This followed a concept-driven strategy, as it relied on the FSS Safety Mindfulness approach principles/components) and key-literature (e.g. Lekka, 2011). See Table 3: FSS Safety Mindfulness Coding Frame – deductive strategy. The proposed coding frame was created also in NVivo (i.e. Tree Nodes, and Free Nodes for new emerging concepts).

Table 3: FSS Safety Mindfulness Coding Frame – deductive strategy

Category	Sub-category	Description
SAFETY CULTURE	**Organisational Culture**	- Values and behaviours promoted in the organisation - Just culture. Encouragement to report without fear of blame
	Individual/collective mindset	- Focus on the individual – how safety is developed, and challenges are addressed,
	Accountability	- The extent to which the different stakeholders are responsible/accountable for their actions within the organisation
CONTAINMENT OF UNEXPECTED EVENTS	**Deference to expertise**	- Deference downward to lower ranking members of the organization - The way in which decisions are supported - The way in which feedback from different decisions are shared
	Oscillation between hierarchical and flat/ decentralised structures	How safety-problem solving/decision-making is advanced within the different organisational layers
PROBLEM ANTICIPATION	**Preoccupation with failure/success**	- Pay attention to weak signals that may be symptoms of larger problems within the system; pay attention to factors/aspects that supported success stories. Report failures/success stories - Support recommendations of all events, which may feed a share information collective mindfulness system - Regularly and robustly discussing potential threats to reliability. Assess own failures - Pose questions- ex. Reasons cognitive questions re failure which might occur at the human-system interface. Speaking up and share information - Anticipate and specify significant mistakes that they don't want to make.
	Reluctance to simplify	- Ability to grasp variation in the environment and see specific changes that need to be made - Ability to recombine existing knowledge/ skills/ abilities into novel combination, to register and handle complexity
	Sensitivity to operations	- Constant interaction deepens people's understanding of the interdependent workings of the complex system itself. This support people cope more effectively with unexpected surprises.

		- Interdisciplinary and interdepartmental activity
LEARNING ORIENTATION	**Technical training**	- Formal opportunities to learn from past actions/technical aspects of the work. Formal organisational learning paths
	Organisational communications (top-down)	- Formal communications provided from the organisation to the operational people, with an aim to inform/learn - Procedures reviewed in line with knowledge base
	Informal settings	- Informal workshops/moments where to share experience, information, knowledge
MINDFUL LEADERSHIP	**Engagement with front-line staff**	- Actions to promote engagement with front-line staff
	Investment of resources	- Resources invested by the organisation to promote safety initiatives
INSTRUMENTS/TOOLS TO SUPPORT MINDFUL KNOWLEDGE/ INFORMATION	**To feed-in**	- Tools and procedures to enable the recording and analysis of safety-related issues
	To feed-back	- Tools and procedures to enable the extraction of safety-related issues/ best practices

The categorisation of the empiric material into the predefined coding frame followed the following requirements:

- **Unidimensionality**. Each category in the coding frame reflects only one aspect of the concept.
- **Mutual exclusiveness**. Each unit of coding/thematic topic is assigned to one category only.
- **Exhaustiveness**. Each unit of coding is assigned to at least one category in the coding frame.
- **Saturation**. Saturation is met when one of the coding units of each of the categories in the coding frame has been assigned. (Grbich, 2013, p. 82).

In each of the case studies undertaken, the coding frame considered and included new categories and sub-categories emerging from the empiric material.

The data analysis supported the assessment of level of convergence in relation to the key concepts explored. To assess the validity and reliability of the findings, two TCD coders were involved in the categorization process of the empiric material and analysis of the data. Through NVivo the 'inter-rater reliability' or the degree of agreement between the two TCD coders was run. This allowed to calculate for each case study the (1) percentage agreement (i.e. the percentage of the source's content where the two users agree on whether the content may be coded at the node) and (2) Kappa coefficient.

3.4. Discussion

Qualitative research plays an important role in investigating the safety mindfulness concept, as it allows to understand the in-depth phenomena in complex dynamic organisations. Qualitative research involves an interpretive and naturalistic approach: This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them (Corbin & Strauss, 2008; Marshall & Rossman, 2010).

The case study researches the in-depth study of instances of a phenomenon in its natural context and from the perspective of the participants involved in the phenomenon (Gerring, 2007; Simons, 2009; Yin, 2009, 2012). Hence, the case study approach supports the investigation of the safety mindfulness concept as a social process in its organizational environment, thus the capturing of the emergent and immanent properties of contexts, and the room for improvement towards a safer organisational goal. A multiple case study design was used to produce detailed descriptions of the mindfulness phenomenon using theoretical statements/research questions to guide the collection and analysis of data in each case study. The use of multiple cases strengthens the results by replicating the patterns thereby increasing the robustness of the findings (Yin, 2012). The replication logic used was theoretical replication – i.e. where the cases are designed to cover different theoretical conditions. Since multiple case studies rely on analytic rather than statistical generalizations, each case served to collect requirements to specify/operationalise a Safety Mindfulness model. Critically, to support the above, a Qualitative Content Analysis method is used (Bengtsson, 2016; Krippendorff, 2013; Schreier, 2012). This supports the design and application of a systematic process from the research design (i.e. Planning Phase) into the replication of results (i.e. relying on replication logic to provide external validation to the findings). The use of multiple sources of evidence supported data triangulation and consistency of results. Data recording and analysis was supported by NVivo (© QSR International) (Bazeley, 2007).

The two case studies conducted on the field will enable comparisons as well as they give the possibility to draw patterns across the cases and obtain more reliability in the overall results, and specification/operationalisation of the Safety Mindfulness model.

4 SAFETY MINDFULNESS MODEL

4.1. Introduction

This section presents the Safety Mindfulness model, and the underlying mechanisms.

4.2. Background

'*It is argued that it is not enough to focus on senior managers, middle managers, or front- line employees in isolation. Organizational mindfulness must be created by top administrators, synchronized across levels by middle managers […], and translated into action on the front line*.' (Vogus & Sutcliffe, 2012)

All organisations, whatever their domain of operations or management philosophy, expect or require their members to act in particular ways. However the circumstances in which they act cannot be absolutely predetermined - so all systems carry some level of risk of failure due to some combination of the environment of the operation, the people, the social organisation and the technologies deployed. Classic feedback and correction mechanisms are triggered when things go wrong, but these are also imperfect – both because they cannot always or easily identify those factors that can prevent future circumstances that can lead to failure (particularly when incidents of actual or potential failure are very rare) and because, even if they are identified, the implementation of improvement is also subject to failure.

In order to overcome these short-comings of self-correction, organisations need to identify how to progressively improve the operation and its organizational supports so that the capability to act in a safe, effective and appropriate manner is continually reinforced and the overall effectiveness of the operation is improved. A key way of doing this involves capturing and sharing everyday experience, both positive and negative, and improving the flow of information that is relevant to the context of operational decisions and actions; this adds value through more effective decision and action in the operational context. This can also stimulate a more effective flow of decisions and actions in improvement projects; value is gained by identifying areas for improvement and by more reliably closing the loop to effective implementation.

This is a collaborative concept of organizational mindfulness – creating a purposeful flow of information that actively supports people's capability to act to fulfil their particular role and authority (at whatever level). This is the principle of 'Distributed Authority' – authority to act is distributed throughout an organization and this needs to be actively supported to ensure a safe and effective organization.

However it is not enough just to act with best intentions, those actions need to have the consequence of an improved functioning of the operation. Good governance requires that this is done in an accountable way – that actions done to ensure safety are transparently in conformity with best practice and in turn contribute to best practice - actions and their consequences need to be made transparent. Those with specific responsibilities for safety should be fully in the loop so that this becomes an integral part of the organisation's capability for safety.

Distributed Authority and Accountability are two sides of the same coin comprising a self-regulatory system of governance capable of constantly improving its standards of performance. The value that is delivered may concern safety, operational effectiveness, efficiency or sustainability of the service delivered to the customer. In summary, good governance actively supports the *Authority* of all to act to fulfil their responsibilities that is *distributed* throughout the system, in order to achieve *Value* in improved and more reliable system performance, at the same time reinforcing *Accountability* for such actions in the control of risk.

4.3. Safety Mindfulness model

In this approach Good Governance concerns creating the optimal conditions for decision and action, both directly within operations and in projects to improve the operation. This is both the source of enhanced **value** and of **accountability**. This is a collective activity that mobilises the resources of the organization to sustain and improve its operations. At an organizational level mindfulness is not just the aggregate of the mental orientation of all its members. It requires showing how the organization as a whole can mobilise its resources to identify, understand and respond effectively and adaptively to potential threats embedded in its operations and operational environment, influencing both how people approach their operational responsibilities and how the organization can reflect on, improve and change its systems. This model is illustrated in Figure 13 below.

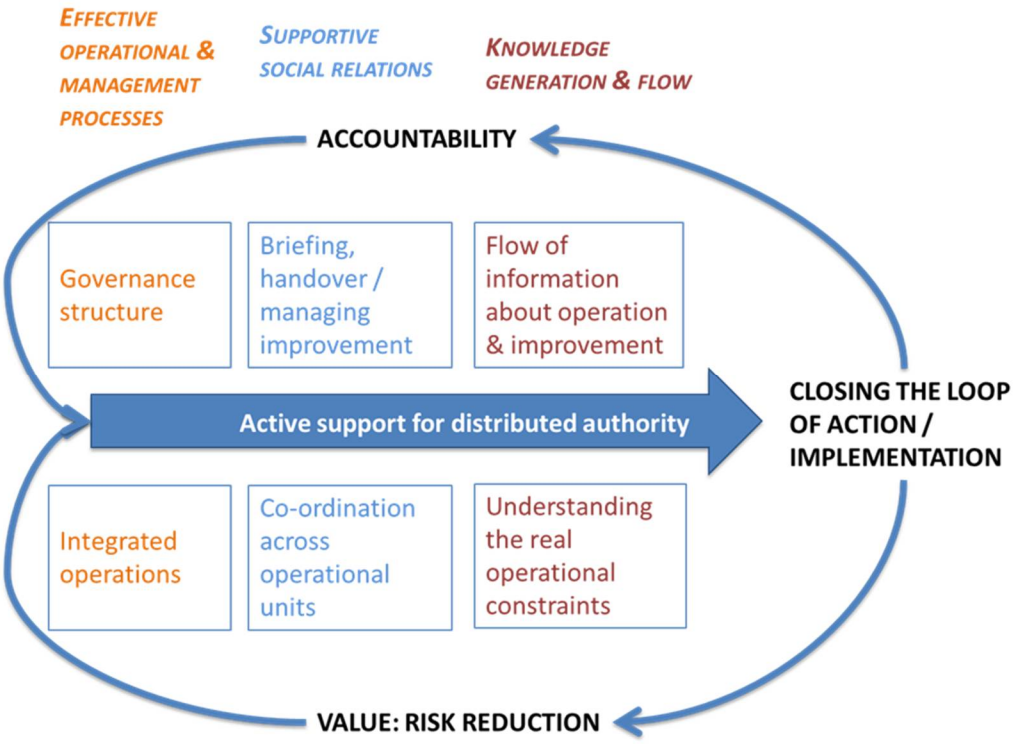

Figure 9: Safety Mindfulness model

In summary, self-regulation depends on the different aspects of the socio-technical system working together to create the conditions that support effective implementation in operations and improvement. The flow of information and the sharing and transformation of knowledge that is fully grounded in real operational constraints represent the core activity. This requires nurturing by supportive social relations: both good co-ordination and leadership across relevant operational units, as well as amongst management groups and teams dedicated to improvement. Clear and effective operational and management processes provide an institutional governance structure enabling accountability for all this activity and its outcome across all the operational linkages between interdependent service processes.

One way of describing this self-regulatory governance model is in terms of a process, a mechanism and an outcome. Taking these in reverse order, the outcome concerns the value produced – the creation of mindful and improved operations. The mechanism concerns the way in which information is produced, circulated, transformed and put to work. The process is the sequence of activities and stages through which an initial state (e.g. identification of a problem) is transformed into the final state (the implementation of a successful solution).

We have defined *Value* in terms of improved and more reliable system performance. There are actually three levels at which we can describe this value: Each successful improvement initiative delivers its own potential value; the reproducibility of successful change initiatives creates a sustainable value that derives from the embedding of the process and its information flows in the social organization; this in turn creates a knowledge base that creates the capacity to speed up the learning – reflecting on what has worked in the past together with more profound knowledge of how the system functions can enable more powerful solutions implemented more effectively. This is a kind of 'double-loop learning' (Argyris & Schön, 1996). The aim is to enable an exponential virtuous cycle of value creation.

Closing the loop of action or implementation in this way is what demonstrates value from an improved operation – greater reliability, functioning more effectively. This value may be expressed in terms of safety, but equally it is applicable to dimensions of quality, cost of service, environmental impact etc. In fact this approach lends itself to an integrated strategic risk management framework in which all significant risks to an operation are analysed and prioritized; potential conflicts and synergies can be addressed; responsibility for agreed programmes of action can be allocated, with clear accountability for the outcome being realized in due time.

4.4. Leverage change, to create mindful organisations

The basic currency that is being managed is information about variance in the operational system, identified by people with operational expertise. The starting point is generating much more information about that variance, understanding why it is there and how it helps or hinders the operation. Two principles govern the management and transformation of that information – *relevance* (a mechanism for managing large amounts of information) and *leverage* (the means of transforming that information into knowledge about how to change the system).

In a complex information-rich environment, it is necessary to find a way of sorting and distributing a mass of information without overwhelming people with information overload. The principle of *relevance* applied here involves the location of each action sequence or initiative clearly within the appropriate operational context, which either gave rise to it or is germane to the processing and resolution of the problem. Of course this relies upon the availability and integration of data streams from planning to operations that define that operational context appropriately. This then governs the feedback of information to where it is most appropriate

4.4.1. Understanding the real operational constraints

Leverage concerns the capacity to progressively transform knowledge about a system from identifying a problem to proposing a solution, to planning how to implement that solution, to reviewing and verifying how that implementation has worked. Each stage of that transformation can bring in new parameters and considerations. Only in very simple problems do problem, solution and implementation match up as a single transformation of the problem space. For most socio-technical problems each stage invokes new dimensions to be brought to bear.

For most socio-technical issues, the necessary transformation involves making tacit knowledge explicit in order to understand the process from different points of view and to maintain mindfulness about core principles of how the system operates. Making this knowledge explicit is an essential basis for knowing how to change a system that is often largely taken for granted. Being able to represent this in a socio-technical model, however simple, may be important in showing how the as-is can turn into the to-be, and to understand what it would take to implement that. This is the key issue in leverage.

These principles – relevance and leverage – seek to resolve the paradox of recognizing complexity without sacrificing efficacy. Seeking to understand the complexity of operations maximises the flow of information. It is impossible to model all this variance, but it is possible to contextualize it in the operational activity that produced it, thus making it tractable. However, seeking to change the system requires us to fix an aspect of it in an as-is model in order to transform it into a to-be model, in order to implement it and verify that implementation. Such models are a representation of the desired/expected reality and we use those as base to evaluate the variance. In turn that implementation will generate variance – problems and issues that were not anticipated or understood. That variance needs to be used to review and adjust the improvement process. Thus relevance and leverage are iterated from the level of the operation to the improvement process itself

4.4.2. The logic of management action

Creating the right conditions (essentially the right knowledge) makes it possible to create a compelling obligation to act on that knowledge; this is the basis of an effective handover of responsibility from one agent (stakeholder role) to another. Adopting this principle, an information-rich management process creates a quasi-contractual sequence that drives the process seamlessly from problem to solution. This process is outlined in Table 1 below. The criterion for each stage identifies what needs to be achieved for the handover to result in an effective obligation to act on that knowledge in the next stage. Making this

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sequence transparent is the core principle of accountability. Accountability creates that obligation – hence it is described as a 'quasi-contractual sequence'.

This new knowledge may not, in itself, be sufficient to enable the transformation that sets up the next transfer to the subsequent stage. A variety of supports (methods, tools, workshops, training, etc.) may be necessary to transform the initial knowledge state at that stage to ensure that the next handover in turn creates a compelling obligation on the next agent. This is the principle of Distributed Authority by which maximum support is given to all who have responsibility, at whatever level, to act in an informed and effective manner, whether carrying out normal operational duties or implementing some improvement or change. Of course there is not always agreement – there are different interests and different points of view. However this framework provides a context for addressing and resolving these disagreements because it is predicated on mutual obligation and accountability for action. Where there are irreconcilable differences this will bring the process to a halt, but otherwise the process is designed to ensure it leads to action, which requires the parties to the process to act together to resolve conflict.

4.4.3. Managing improvement

The issues of leadership and co-ordination are critical here. For many faced with managing an improvement project, this is a major challenge. They need support of training, facilitation and coaching. Improvement also requires time and effort – a dedicated team to a project or several projects is necessary to mobilise this effort. This team needs to be resourced and supported. Thus the principle of Distributed Authority requires thinking through and providing the social supports necessary to carry out the programme.

It also involves understanding when and where are the best opportunities for influence of colleagues, superiors and others to enhance a mindful approach to operations and effective improvement – briefings, handovers, de-briefings, etc.

4.4.4. Governance structure

The information flow needs to be institutionalised in a management process. This can be embedded in existing periodic management meetings, but the agendas and conduct of these meetings need to actively progress each project from stage to stage. Thus accountability is embedded in the routinisation of management practice at every level. This may need to work in different ways for problems that can be locally solved, to those that can be solved at the level of a particular plant, to those that need escalation to the overall organization or group. Again there is an iteration of the basic structure of the process and information flow from local to intermediate to global. Accountability then can be escalated from the level of delivering the operation through the reporting relationships in the organization and from the accountable manager to the regulating authority.

4.5. The logic of integrating system risk

In aviation, as in many other operations that carry significant risk, those risks are not specific to any one organization. As processes are shared, as multiple services are delivered across a core process (e.g. a flight

operation) so the risks are shared risks according to the interdependencies across those processes and services. Here the real demands of co-ordination in a multi-agency operational system come to the fore. It is a question of identifying or uncovering dependencies between operational units that are not directly accountable to each other and understanding how these can be more effectively managed.

Collaboration along shared processes creates the basis for managing shared risks in an integrated way across an extended enterprise. The logic of this is to identify a strong rationale for sharing information and collaborating in risk management. If this rationale is accepted it is extendable progressively to the whole system of systems

Thus the action sequence based on *Reciprocal obligation* enables *Vertical escalation* of accountability from the operational sharp end to the regulatory authority and *Horizontal escalation* across all the interdependencies of an extended enterprise to ensure the effective control of all risks which potential compromise the reliable production of value by the system as a whole.

4.6. Achieving Impact

One major issue is the transparency of the whole system. It is only when the process delivers an outcome that the value is realized. It is only then that the rationale and functionality of each stage becomes apparent. Therefore the process needs to be treated as a whole and be shown to work with examples that are not too challenging but deliver real value. It is only when people see an outcome of reports that the value of reporting is appreciated. This can be the provision of relevant information in a timely way to support their decisions and actions. It is only when people see the challenges of implementation of improvement actions that they fully appreciate the need for a high quality of investigation or analysis of the core problem that is being addressed. It is only when people see the verified outcome of implemented improvement actions translated into sustained performance improvements that they see the value of investing in thorough and effective improvement programmes.

Each stage from report to investigation to recommendations to implementation to evaluation is more difficult than the last. Yet to those seeking to implement such a process it is always the next stage that seems to hold the key. If people do not report problems, then having an effective reporting system seems to be the critical step. Likewise when there are a large number of reports, the quality of investigation and analysis is the panacea. When there are recommendations, handover to implementation is the crucial step; this is where many systems start to break down – the handover transfers responsibility, but accountability for implementation is weak. There is little or no targeted feedback of information. Thus there is now increasing emphasis on implementation, but this is not often accompanied by sufficient focus on how to verify the quality of the implementation and the effectiveness of the outcome.

Thus from the point of view of each stage, it is hard to see the whole process as an integrated whole. This is particularly because there is no one owner of the whole process: it involves a progressive handover from one stakeholder to the next and back again in a series of progressive virtuous spirals each adding potential to the value realization of the whole process. No-one easily sees the whole process from their own point of view. Therefore it is important to create visibility of the logic of the whole and shared

ownership of the overall process. This is the vision of mindful organizing leading to collective organizational mindfulness.

Table 4: Stages of a mindful organising organisation

	Stage	Criterion for each stage	General principle
1	Carry out operational plan	Record availability of resources & activity	Define relevance
2	Identify problem	Serious outcome (from one or many reports)	Establish potential value
3	Identify solution	Effective Mechanism to improve outcome	Identify leverage
4	Circulate stories	Relevant stories	Relevance; distributed authority
5	Plan implementation	Credible practical mechanism in action plan	Establish relevant context for improvement. Establish accountability
6	Implement solution	Capability to achieve outcome	Distributed authority; enable leverage
7	Review / check	Interim implementation / adjustment of plan	Re-affirm leverage; review value?
8	Verify	Full implementation of plan and immediate outcome	Affirm accountability
9	Monitor overall impact	Sustained improved outcome	Realise value

4.7. Discussion

The Safety Mindfulness model is grounded on the Safety Mindfulness (including the five principles and the other concepts – see also Table 1) concept and the requirements collected in the multiple case studies developed in Year 2. The model takes the point of view of an organizational information flow, which will support all different layers within the target organization to have *the right information at the right time*.

This model will be evaluated in Year 3.

5 SAFETY MINDFULNESS METRICS

5.1. Introduction

A metric is a system or standard of measurement. A safety mindfulness metric thus specifies a way to measure safety mindfulness. Since safety mindfulness is a complex concept/model, which entails a multitude of aspects, there can be a range of associated metrics. This section provides a range of potential safety mindfulness metrics, which build upon the theoretical background presented in Section 2, and link implicitly into the designed model in Section 7.

Section 5.2 presents a number of metrics that are associated to the safety mindfulness principles in the work of Weick and Sutcliffe (2001, 2007). Section 0 further extends the metrics related to the safety mindfulness principles by assessing the maturity of pre-conditions in an organization to achieve safety mindfulness. Section 5.4 presents safety mindfulness metrics that are associated to risk situation awareness and risk mental models. Section 5.5 provides a discussion of the various metrics.

5.2. Metrics for the safety mindfulness principles

5.2.1. Questionnaires of Weick and Sutcliffe (2007)

The safety mindfulness principles used in this research (see Section 2.3) are based upon work of Weick and Sutcliffe (2001, 2007). As metrics, Weick and Sutcliffe developed a Collective Mindfulness scale, which uses a questionnaire that is intended as a way for managers to assess the mindfulness in their organizations. Most questions in this questionnaire are on a three-point Likert scale and a summed score for each of the principles is associated with a low, moderate or strong mindfulness level. As an example, Table 5 shows the set of questions that a manager can use to assess the reluctance to simplify interpretations. It also shows the additive scoring system and thresholds that delineate low, moderate and strong mindfulness.

Audit 5.5: Assessing Your Firm's Reluctance to Simplify

How well do following statements describe your work unit, department, or organization? For each item, circle the number that best reflects your conclusion: 1 = not at all, 2 = to some extent, 3 = a great deal.

1. People around here take nothing for granted.	1	2	3
2. Questioning is encouraged.	1	2	3
3. We strive to challenge the status quo.	1	2	3
4. People feel free to bring up problems and tough issues.	1	2	3
5. People generally deepen their analyses to better grasp the nature of the problems that arise.	1	2	3
6. People are encouraged to express different views of the world.	1	2	3
7. People listen carefully, and it is rare that someone's view goes unheard.	1	2	3
8. People are not attacked when they report information that could interrupt operations.	1	2	3
9. When something unexpected happens, people spend more time analyzing than advocating for their view.	1	2	3
10. Skeptics are highly valued.	1	2	3
11. People trust each other.	1	2	3
12. People show considerable respect for one another.	1	2	3

Scoring: Add the numbers. If you score higher than 24, the potential to *avoid simplification* is strong. If you score between 15 and 24, the potential to avoid simplification is moderate. Scores lower than 15 suggest that you should be actively considering how you can immediately improve your capabilities to prevent simplification in order to improve your firm's capacity for mindfulness.

Table 5: Excerpt of (Weick & Sutcliffe, 2007) for assessing reluctance to simplify interpretations.

Such questionnaires were developed for all principles and examples of questionnaire items are (Weick & Sutcliffe, 2007):

1. *Preoccupation with failure* - "When treat near misses as information about the health of our system and try to learn from them", "If you make a mistake it is not held against you", and "People are rewarded if they spot potential trouble spots".
2. *Reluctance to simplify interpretations* - "People around here take nothing for granted", "Questioning is encouraged", "When something unexpected happens, people spend more time analysing than advocating their view", and "Skeptics are highly valued".
3. *Sensitivity to operations* - "Supervisors readily pitch in whenever necessary", "People are familiar with operations beyond their own job", and "We have access to a variety of resources whenever unexpected surprises crop up".

4. *Commitment to resilience* - "This organization is actively concerned with developing people's skills and knowledge", "People have a number of informal contacts that they sometimes use to solve problems", and "Most people have the skills to act on the unexpected problems that arise".
5. *Deference to expertise* - "People in this organization value expertise and experience over hierarchical rank", "It is generally easy to obtain expert assistance when something comes up that we don't know how to handle", and "If something out of the ordinary happens, people know who has the expertise to respond".

5.2.2. Metrics by safety mindfulness questionnaires

As a way towards metrics for safety mindfulness, a series of questions inspired by the sets of (2007) may be developed, which can be scored on a Likert scale. The questionnaire may be answered by various groups of employees in an organization. Rather than asking for a managerial perspective on the organization (as is done in the approach by Weick and Sutcliff), these questions may consider the individual mindfulness of employees in the organization. A perspective on the organizational mindfulness may be achieved by combining the answers of groups in the organization. Metrics related to the results of such questionnaires include means and variances in the scores for the groups studied.

This approach and the kinds of metrics bear similarity with a safety culture survey. Also for the types of questions there exists overlaps with typical question sets used in safety culture surveys, e.g. as applied in FSS-WP5.3. No systematic comparison of those question sets has been performed though.

5.2.3. Other metrics inspired by the questionnaires of Weick and Sutcliff (2007)

Other metrics for the safety mindfulness principles can be related to the issues raised in the mindfulness questionnaires of (Weick & Sutcliffe, 2007), e.g.:

- What is the frequency of reports of failures or unsafe conditions?
- What is the frequency of reports of success stories?
- How often are recommendations provided in follow-up to reports of failures of successes?
- How often is the way of working actually changed in follow-up to recommendations?
- How much time or effort is devoted towards analysis and understanding of anomalies?
- The level of training of employees with regard to variations in operations.
- The level of training of employees towards understanding operations beyond their own job.
- The level of discretion that employees have to resolve (unexpected) problems.
- The level skills of employees to deal with variations in operations.
- The level of discretion that employees have to resolve (unexpected) problems.

5.3. Assessment of safety mindfulness pre-conditions and maturity

A complementary approach to continuous assessment of safety mindfulness is to assess the maturity, i.e. the potential safety mindfulness, of the concerned organisation regarding processes, activities, technical components and structures. These that can be seen as pre-conditions for achieving safety mindfulness as they enable, and limit, the ability to achieve a mindful approach to safety. Such an assessment can be based on interviews and document analysis of existing safety procedures, tools, processes, organization and training approaches. The purpose of this complementary assessment is to establish to which maturity level the organization works related to a set of dimensions that describe the pre-conditions for safety mindfulness.

As stated above, safety mindfulness is an active process involving sense-making (attention), reflection and learning, on both individual and organizational levels. Therefore, the pre-conditions for safety mindfulness can be related to organisational processes and structures to encourage interaction between individuals, learning processes incorporated in the work system, as well as technical support for attentional processes and data collection about deviations/accidents. Such efforts can be related to a simplistic view of event management like 'before-during-after'.

The aim of such a maturity metric of safety mindfulness pre-conditions is thus to provide a means to calibrate the activities of an organization in relation to increasing safety mindfulness stages along several dimensions. Similar approaches of maturity of safety-related processes are not uncommon, as examples the CANSO SMS Effectiveness and Maturity levels (CANSO, 2015) and the HSE Culture Ladder (Hudson, 2007) may be mentioned here.

Below we suggest a maturity assessment scheme that has four main components: Mindfulness dimensions, categories, maturity levels, and relative descriptions of maturity levels per dimension and category:

- The maturity scheme takes the five dimensions of mindfulness modified from Weick & Sutcliffe (2007) as the main dimensions. These are Preoccupation with the diversity of everyday operations (originally in Weick & Sutcliffe (2007): Preoccupation with failure), Reluctance to simplify interpretations, Sensitivity to operations, Commitment to resilience, Deference to expertise. Thus, these dimensions are currently theory-driven. They may be revised if the results of the project indicate other safety mindfulness dimensions to be a more appropriate characterization of the mindfulness concept
- The categories of assessment for each dimension are currently set to categories emerging from preliminary results of the multiple-case studies mentioned in earlier sections of this report, as well as suggestions from the literature (e.g. the Resilience Assessment Grid; Hollnagel, 2011). These are Process, Reporting, Training, and Technical Systems. These are preliminary suggestions and may be revised following case studies highlighting a different characterization of each dimension. These dimensions have been selected to be easily related to operational and safety processes that aviation organisations already have in place, but at the same time general enough

to be applicable to a wide range of Air Traffic System organizations and systems. They are intended to jointly cover organisational, technical, and human performance aspects.

- Maturity levels are currently not specified, only the extremes and where possible intermediate. The stages included here should be pragmatic and data-driven from case studies to provide distinctive stages that give actionable guidance of how to progress to the next stage.
- The contents of the actual stages where dimensions, categories and maturity levels meet are concrete contents of the stages of maturity of safety mindfulness. The contents are suggested to be based on literature (similar outcomes and criteria are presented by Weick & Sutcliffe, 2007) but also data-driven, i.e. emerging from the data extracted from a multiple-case study approach (for which preliminary results are presented in earlier chapters). Currently, examples of contents from both preliminary data and literature (Weick & Sutcliffe, 2007) are used.

Table 6: The proposed maturity scheme for assessing safety mindfulness.

Pre-occupation with the diversity of everyday operations	Low	...	High
Processes	Only obligatory ICAO/EU-driven accident/incident analysis		Everyday operations analysis, through observation and retrospective analyses, always trying to investigate how expectations differ from actual outcomes
Reporting culture	Aiming to find errors for correction		Just, blame-free, non-punitive, people are rewarded if they spot potential trouble, for the purpose of understanding the difference between expectations and outcomes, people feel free to talk about issues
Training	None specific for noticing and handling diversity of operations		Extensive frequent training using a diverse range of what-if scenarios, training focuses on procedures but also how to assess deviations in terms of preconditions for procedures to be successful
Technical systems	No technical support for everyday operations analysis		Technical systems support everyday operations analysis (e.g. decision support, replay, data analysis), focusing on understanding diversity rather than error

Reluctance to simplify interpretations	Low	...	High
Processes	Processes are static and not-adjustable, questioning discouraged, processes based on work-as-expected rather than recognizing complexity		Processes are in place to take in expert opinions and time is taken to investigate and understand the complexity of operations and take these into account in organizational decision making
Reporting culture	Punitive		Just – sceptics are highly valued, stories of detailed operational phenomena are actively distributed
Training	Training only on high-level processes		Training encourage critical thinking, reflection and generation of multiple scenarios when facing uncertainty
Technical systems	Only regulation-based basic technical analysis tools		Systems can present data from a variety of sources and present it in different ways, support detailed analysis of narratives

Sensitivity to operations	Low	...	High
Processes	No specific processes in place to observe how work is ongoing and if it would need to be organizationally adjusted, no resources allocated that can be allocated flexibly		Work is organized in a flexible manner with some degree of slack in terms of resources, operations can be adjusted to actual demands
Reporting culture	Punitive		Just, stories of operational issues are sought in

		detail and systematically analysed, engagement of staff to obtain "the bigger picture"
Training	Top-down regulation-based training only	Operators are trained to work in different positions/roles, trained in different ways of performing functions or resolving situations, operators are trained to understand other operators' perspectives and build common ground, learning from actual operational scenarios
Technical systems	No support for information sharing between levels or roles	Systems allow for "overhearing" of communication, viewing other's actions and displays, information exchange with other entities/organisations etc.

Commitment to resilience	Low	...	High
Processes	No processes in place that assess vulnerabilities, past, present or future, and no flexibility to react to fluctuations in terms of resource allocation or organizational adjustments		Processes in place that encourage out of the box thinking with respect to systemic vulnerabilities and threats, regular updates of risks picture and assessment of the gap between work-as-imagined and as described formally on the one hand and work-as-done and coping strategies on the other
Reporting culture	Punitive		Staff encouraged to discuss potential vulnerabilities and systemic effects such as potential for cascading events and how everyday work adapts to these
Training	No training other than on events from standard regulated requirements		Programs for knowledge exchange and general problem solving skills, different variations of what-if scenarios of disturbances included in training

Technical systems	None	Experiences and narratives of previous events are easily accessible through technical means

Deference to expertise	**Low** ...	**High**
Processes	Administratively oriented processes focusing on accountability only, rather than seeking expertise and diversity in perspectives	Competence oriented rather than administratively oriented processes, processes are in place for how to include necessary expertise when necessary in decision making and adjustments of processes
Reporting culture	Punitive	Just, valuing expert judgement and experience-based reasoning in treating reports, aggregation and learning from sets of reports and trends rather than individual incidents
Training	No attention to including diverse expertise across roles and organizations during training	Developing expertise is encouraged, experience is valued, realistic training cases inviting for discussion among experts
Technical systems	No technical support for including expertise	Systems allow expert users to perform complex analyses, establishing trends across stories and narratives as well as incidents

5.4. Safety mindfulness metrics for risk situation awareness and risk mental models

In Section 2.4 we defined risk situation awareness and risk mental models as a way to study safety mindfulness in an organizational context. Risk situation awareness is part of the situation awareness of an individual and it refers to the understanding of the risks in the current work situation, notably including safety risks, and to the decisions made by the individual for strategies for dealing with the perceived risks. A risk mental model is a part of the mental model of an individual and it describes disturbances, ways to recognize disturbances, ways that disturbances can affect particular performance areas, strategies for

effectively dealing with disturbances, and ways to decide on appropriate strategies. In an organization, (risk) situation awareness and (risk) mental models of the humans are interdependent, given its interactions and information flows (see Figure 6 on page 25).

Next, safety mindfulness metrics in relation with risk situation awareness and risk mental models are presented for the following subjects:

- Individual risk mental models)
- Diversity of risk mental models
- Adaptation of risk mental models (learning)
- Simulation of risk situation awareness

5.4.1. Individual risk mental models

Metrics for risk mental models of individuals try to grasp the understanding of humans in an organization about the safety risks of its operations. Table 7 defines a number of metrics for risk mental models of individuals in the organization, including operators, middle management and upper management. The basis of these metrics is the identification of the most important hazards and disturbances (M1 and M2) that operators have to deal with in their work. Both hazards and disturbances are conditions, events or variations that influence the performance of operations, but hazards refer to cases that have a negative effect on safety in particular. By asking for both categories, people are inclined to also consider important conditions that influence the way of working of operators beyond safety. Next, metric M3 asks to describe main strategies for the identified hazards and disturbances. As such, operators and managers are asked about their (understanding of the) strategies used to deal with the most important hazards and disturbances that operators are facing in their work. Metric M4 considers the judgements of individuals of the safety risks given the occurrence of a hazard or disturbance as identified for M1 and M2. The background of metric M5 is that there are other types of risks beyond safety risks (e.g. financial, environmental) and that it is the judgement of the overall conglomerate of risks that drives the behaviour of individuals in the organization. Therefore, metric M5 asks for the types of other risks that an individual finds relevant and a judgement of these risks for the identified hazards and disturbances.

Table 7: Metrics for risk mental models of individuals.

No.	Metric
M1	What are the most important hazards that operators have to deal with (e.g. the top-10)? A hazard is any condition, event or variation that has a negative effect on flight safety.
M2	What are the most important disturbances that operators have to deal with (e.g. the top-10)? A disturbance is any condition, event or variation that influences operational performance. There may be an overlap with the hazards identified in M1.
M3	What are the main strategies used by operators to deal with the disturbances and hazards? Provide main strategies for each hazard and disturbance indicated in M1 and M2.
M4	How do you judge the safety risk given the occurrence of a hazard or disturbance on a scale from low to high risk (e.g. a 10-point scale) for each hazard and disturbance indicated in M1 and M2?

M5	What are types of risk other than safety risk given the occurrence of a hazard or disturbance (e.g. financial risk, environmental risk, delay risk)? How do you judge these risks on a scale from low to high (e.g. a 10-point scale), given the occurrence of a hazard or disturbance as indicated in M1 and M2?

The method to acquire data for the metrics of Table 7 should be in line with the key point, being that they refer to the risk mental models of individuals. Questionnaires, 1-to-1 interviews, or a combination of questionnaires and interviews are methods that are able to collect the views of individuals in the organization. Since the metrics are primarily based on open questions regarding hazards, disturbances, strategies and associated risks, they cannot be answered easily and quickly, and it may be needed to use an interview-type of support to achieve appropriate answering. As this is a labour-intensive way for achieving the metrics data, it is expected that a restricted number of people can be addressed in the process. For this a selection should be made to achieve suitable numbers of people in the organizational layers.

5.4.2. Diversity of risk mental models

The metrics for individual risk mental models of Table 7 provide the basis to study the diversity of risk mental models held by groups of individuals in an organization and between different organizations. The following types of comparisons provide key examples for characterizing intra-and inter-organizational diversity:

- Diversity of metrics for operators in a team;
- Diversity of metrics for operators in different teams;
- Diversity of metrics for different types of operators in the same organization (e.g. controllers and technicians);
- Diversity of metrics for different types of operators in different organizations (e.g. controllers and pilots);
- Diversity of metrics for operators and middle management (in the same organization);
- Diversity of metrics for operators and upper management (in the same organization);
- Diversity of metrics for middle and upper management (in the same organization);
- Diversity of metrics for middle management in different organizations (e.g. ANSP and airline);
- Diversity of metrics for upper management in different organizations.

The diversity can be characterized with respect to each of the metrics of Table 7. For instance, what are the most important hazards and disturbances according to operators versus management, what are differences in views on the use of strategies for dealing with hazards and disturbances, and in what way do judgements on safety risks and other risks differ between groups? Comparison of the metrics can provide detailed insight in the organizational safety mindfulness, and provide detailed feedback to safety management. In particular, a high level of diversity in the metrics reveals that perceptions on hazards, disturbances, strategies and risks highly differ between groups in the organization. Although such differences do not need to be problematic, their reasons should be understood. As a way towards such

understanding workshops with the involved groups may be organized, wherein the backgrounds of the perceptions are discussed. Such a workshop can support a better understanding of the viewpoints and it may identify means to support more consistency in the risk mental models.

5.4.3. Adaptation of risk mental models (learning)

A key aspect of safety mindfulness is learning, i.e. the top-down, bottom-up and horizontal information flows in an organization. These interactions support adaptation of risk mental models. Table 7 provides metrics for such learning. In particular, the metrics refer to the frequency (M6) and effectiveness (M7) of learning about safety risks by various mediums, such as other operators, management, and information bulletins. These metrics can be straightforwardly characterized on scales, enabling easy comparison of learning via the various mediums. In addition, metric M8 considers an open question regarding the kinds of safety-related aspects that have been learned. This provides more detail on the content of the learning. These metrics M6 to M8 may be acquired by a questionnaire or as part of an interview.

Table 8: Metrics for adaptation of risk mental models

No.	Metric
M6	How often do you learn about safety risks and the way to effectively deal with them by *Medium X* (e.g. on a scale from daily, weekly, monthly, yearly, once per 5 years, less than once per 5 years)?
M7	How would you rate the effectiveness of safety risk learning by *Medium X* (e.g. on a scale from 1 (ineffective) to 10 (very effective))?
M8	What are the most important safety-related aspects that you learned by *Medium X* in the last year?
In above metrics *Medium X* is chosen from the following options: • own operational experience; • operator with a same function (e.g. controllers among each other); • operator not with a same function (e.g. controllers and technicians in an ANSP); • operator from another organization (e.g. controller learning from a pilot); • middle manager; • upper manager; • basic training; • safety information provided by the organization (e.g. bulletins)	

Organizations typically use some kind of knowledge system to keep track of safety-related occurrences in their safety management system. The effectiveness of the usage of such a knowledge system by the organization is part of its collective safety mindfulness. Metrics for safety knowledge systems are provided in

Table 9. These metrics refer to the reporting and feedback by a safety knowledge system. It is assumed that these kinds of metrics can be achieved via the administrator of the safety knowledge system in an organization.

Table 9: Metrics for usage of a safety knowledge system

M9	How often are safety-related occurrences reported towards a safety knowledge system?
M10	How are occurrence reports processed towards an update of some organizational risk model?
M11	How often and in what way are results from a safety knowledge system used to inform people in the organization about the development of risks?

5.4.4. Simulation of risk situation awareness

Risk situation awareness is a dynamic state of an individual that reflects the perceived risk and the selected strategy to deal with the perceived risk in a particular situation. It depends on the overall situation awareness and the risk mental model of the individual. As a way to understand risk situation awareness and the related risk mental model, humans in the organization can be depicted in a particular situation and they can be asked for their understanding of the risk and the decisions they would make.

- Particular situations can be presented by words, by pictures or movies, or by real-time experiments.
- Operators can be asked for their perception of the risk of the situation and about the strategy they would apply.
- The diversity of risk perception and strategies within a homogeneous group can be studied.
- Risk perceptions and strategies of operators from different groups and organizations (e.g. pilot, controllers) can be studied and compared.
- Risk perceptions and strategies as expected by middle management can be contrasted with those of operators.

There can be a variety of metrics related to such simulations towards understanding of risk situation awareness, which depend on the level of realism and detail in the simulations.

5.5. Discussion

In this section the following types of safety mindfulness metrics were introduced:

- Metrics by safety mindfulness questionnaires;
- Metrics for assessment of safety mindfulness pre-conditions and maturity;
- Metrics for risk situation awareness and risk mental models.

These metrics can be discussed using the following questions:

- Do the metrics cover the variety of aspects of the safety mindfulness concept as defined in (McDonald et al., 2015)?
- What effort is needed to determine the metrics in an application?

- What is the accuracy of the measurements?
- What is the clarity of the metric? (Is it well-defined and can it be easily understood?)
- What is potential overlap with the other P5 research streams?
- What can we learn from the metric for improving safety mindfulness?

This discussion sets a basis for choosing metrics for the FSS-WP5.2 use cases.

5.5.1. Metrics by safety mindfulness questionnaires

The metrics that can be achieved by safety mindfulness questionnaires, as described in Section 5.2.2, directly address the five safety mindfulness principles and indirectly they may also refer to some of the other safety mindfulness aspects (situation awareness, temporal/specificity, learning). If the questionnaire would be distributed over large parts of the organization, this would require a large effort. This effort might be reduced by distributing the questionnaire among a restricted part of the organization (e.g. management), but this may lead to a biased perspective. Results derived by safety mindfulness questionnaires can be clear and accurate, given that the questions are well stated and analysed. General limitations of perception-based research exist. The use of surveys requires a minimal level of reliability and validity analysis on the items. There is a potential overlap of such surveys with safety culture research in FSS-WP5.3. As such, the development of a safety mindfulness questionnaire should take well into consideration a safety culture questionnaire used at an organization, such that overlap is avoided and the questionnaires have their unique focal points. The metrics may reveal strong points and weak points in safety mindfulness. The strong points can be used as examples for other organizations. The weak point can be targeted for improvement. The metrics as such do not provide a direct way to achieve such improvement.

5.5.2. Metrics for assessment of safety mindfulness pre-conditions and maturity

The metrics that can be achieved by the maturity scheme, as described in Section 8.3, build upon the safety mindfulness principles. However, it is indicated that they do not directly measure these safety mindfulness principles, but rather that they measure the pre-conditions for achieving safety mindfulness. Considering the descriptions of organizational aspects leading to high safety mindfulness scores, it can be observed, though, that they tend to be based on the same types of information as used in organizational mindfulness questionnaires. As such they basically seem to cover the safety mindfulness principles. The stratification over organizational aspects, such as processes, reporting, training and technical systems, provides an extra layer that asks for some additional thinking about the implications for each of these aspects, e.g. in regard to learning. It is not indicated how the information for the assessment is achieved, but it is assumed that this can be done using a variety of sources and that the overall assessment is done by (a team of) analysts. The effort depends on the sources used for the assessment and may be low to medium. The current definition of the metrics is a first step, which needs to be improved, e.g., through populating the maturity levels with more operational examples from case studies, but it is expected that these kinds of metrics can have a good clarity. The accuracy of the measurements would depend on the types of sources used. There is a link with safety management research in WP5.5, but the safety

mindfulness principles-based approach is independent and can provide new insights. The metrics may reveal strong and weak points in safety mindfulness, and goals of fulfilling pre-conditions for high maturity (in terms of processes, reporting, technology, and training), but (currently) no direct means/methods of towards improvement of safety mindfulness.

5.5.3. Metrics for risk situation awareness and risk mental models

The metrics that are based on the concepts of risk situation awareness and risk mental models, as defined in Section 5.5.3, describe the safety mindfulness aspects with respect to situation awareness, temporal/specificity, and learning. The safety mindfulness principles are not directly addressed, but may be touched upon indirectly. The metrics for an important part consider risk perception and its adaptation in the overall organization. They can be gathered using questionnaires and/or workshops with different groups in the organization. The effort for such processes can be medium to high, depending on the amounts of people targeted. The questions asked are a mix of open questions (e.g. about hazards, disturbances and strategies) and closed questions (e.g. risk indications). Given such mix there is a need for post-processing wherein similar hazards/disturbances/strategies are grouped and associated with values for risk indicators. The metrics of such analysis thus provide insight in the risk perception in the organization. These kinds of results are not yet considered in other P5 research streams. The metrics may reveal strong and weak points in risk situation awareness and risk mental models, but no direct ways towards their improvement.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

This document presents the FSS Safety Mindfulness methodology, which has been designed to apply the mindfulness principles/dimensions included in the Safety Mindfulness concept advanced in Year 1, and collect requirements to draw a model able to support/leverage change in organization aspiring to be 'more mindful' – Mindful Self-Regulation. To do so:

- The Safety Mindfulness concept has been described in great detail, to provide a full understanding of the principles/dimensions that will support both the operational, supervisory and middle management layers to better understand the system they work in, and share safety knowledge-based information., and highlight the challenge: move from principles into concrete proposals on how to support or even engineer better mindfulness into organisations.
- *How can we make sure to generalize from theory/theoretical assumption and collect requirements able to specify a model?* A multiple case study method has been used to demonstrate it. The case study method supports in-depth study of instances of a phenomenon in its natural context and from the perspective of the participants involved in the phenomenon (Gerring, 2007; Simons, 2009; Yin, 2009, 2012). Hence, the case study will support the investigation of the safety mindfulness concept as a social process in its organizational environment.
- A multiple case study design was used to produce detailed descriptions of the mindfulness phenomenon using theoretical statements/research questions to guide the collection and analysis of data in each case study. The use of multiple cases strengthens the results by replicating the patterns thereby increasing the robustness of the findings (Yin, 2012).
- The replication logic used was theoretical replication – i.e. where the cases are designed to cover different theoretical conditions.
- Qualitative Content Analysis method was used (Bengtsson, 2016; Krippendorff, 2013; Schreier, 2012) to supports the design and application of a systematic process from the research design into the replication of results (i.e. relying on replication logic to provide external validation to the findings). The use of multiple sources of evidence supported data triangulation and consistency of results. Data recording and analysis was supported by NVivo (© QSR International) (Bazeley, 2007).
- Overall, a qualitative research design was used in both case studies.
- The case studies were applied in an ATC organization in The Netherlands (i.e. Maastricht Upper Area Control Centre) and an airline Italian company (i.e. Alitalia). The two case studies followed the same protocol for data collection, but tested two different implementation approaches. The MUAC case study showed an 'AS-IS' picture of the current mindfulness state-of-the-art; the Alitalia case study was developed to promote a 'TO-BE' intervention.
- Overall, In MUAC there is an opportunity to enhance timely feedback of risk related information back into the operation, creating opportunities to share information, stimulating active

awareness and learning. In Alitalia there is no clear process for managing problem solving and improvement in an accountable way.

- The case studies supported the collection of requirements to specify/operationalise the Safety Mindfulness model.
- Metrics have been advanced to evaluate the extent to which the model can actually leverage more mindful organisations.

6.2. Recommendations

In Year 3 the following plan is envisaged:

- A proposal to apply the Safety Mindfulness model will be advanced to both MUAC and Alitalia. This will advance the case study design to the next stage. In year 2 two contrasting case studies have been advanced – contrasting in terms of the operational focus (and type of process), the strengths and weaknesses of the safety management approach, and the focus on implementation. The MUAC case study set the framework for the AS-IS evaluation, which was then applied to the Alitalia case. In year three the Alitalia case is expected to make good progress in terms of implementation, testing the model as a template for implementing Mindful Self-Regulation. At the same time the prospects for implementation will be explored in detail in MUAC, again testing, in principle, the applicability of the model and learning from experience in Alitalia. This creates a powerful multiple case study approach in which the two case studies can be compared and contrasted in two phases. Analytic generalisation of the different contexts in which the model has been tested will reinforce the external validity of the model, defining more clearly the domain to which the findings can be generalised.
- This will also have benefits in the development of Mindfulness metrics. In particular, the implementation framework should enable the development and customisation of a focussed Capability Maturity Model (i.e. a more Mindfulness Capability Maturity Model, seen not only in terms of SMS). Two other case studies will be included in the evaluation process, in particular to test the metrics selected.

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Appendix A NVIVO: FEATURES AND USE

This section provides a short summary of how NVivo is used for the P5.2 (1) data recording (i.e. creation of a Data Base including all empiric material from field research in the '*Internals*' of NVivo Sources section), (2) data coding (i.e. creation of the '*Tree* Nodes' corresponding to the P5.2 'coding frame') and (3) analysis (i.e. association of coding units of the A-PiMod 'Cases' to the sub-categories of the coding frame).

Data records in NVivo are stored under the Section '*Sources'*. The raw material (e.g. transcribed interviews, working documents, etc) is held in the so-call 'Internals', which represent the on-going data gathering to support growing conclusions. Internals can be provided with attributes. On-line sources or supporting material useful for the identified cases, but not directly involved in the data analysis are referred to as 'Externals'.

Nodes in NVivo refer to coding frame categories and provide the storage areas in NVivo for references to coding text. A concept-driven approach to categorisation can be applied by *Tree Nodes; this* reflects the coding frame adopted in P5.2. Data-driven information which will emerge by the validation activities collection process can be stored in the NVivo *Free Nodes.*

The coding process is realised by associating strings of text from the Internals saved in the NVivo project to the related subcategories of the Safety Mindfulness coding frame /NVivo Tree Nodes. By so doing, each subcategory will record the selected coding units from the empiric material

Appendix B MUAC - INTERVIEW SCHEDULE

First: DEFINE OBJECTIVES To understand how to collect the 'intangible' expertise of the individual, and make it ' collective' – i.e. pass this knowledge onto the colleague, experts from different shifts" and "To understand how to share this knowledge to form a 'core base' to enable the operators anticipate and manage critical events".

As such – Think of on smaller events that might have transgressed towards more severe incidents if the controllers would not have behaved as they did in preventing the situation from getting worse. – E.g. a separation infringement incident that occurred at MUAC, but then to ask about other occasions which might have started with a similar mindset but which didn't end up in an incident because of the controllers' strategies.

Further - how information about such occasions is or may be distributed in the organization, and how controllers apply such information in their work..

Section #	Category/dimension	High level questions
1/semi-structured interview (SAFETY MINDFULNESS concept)	(1) preoccupation with failures/ success	Pay attention to weak signals of failure that may be symptoms of larger problems within the system – pay attention to factors/aspects that supported success stories - How critical events happened in the past have been recorded? How signals/small changes get detected and become critical for shared information? How these events supported the definition of practices and recommendations? How recommendations are shared/support the definition of a collective mindfulness data base? How critical events get selected/and considered relevant for data analysis/recommendation definition? How the organisation/system support the front/line people/supervisors with useful historical data?
	(2) reluctance to simplify interpretations	Ability to grasp variation in the environment and see specific changes that need to be made – what information is then shared? What variation is informed about? Ability to act on what it is seen – ability to recombine existing knowledge, skills and abilities into novel combination, to register and handle complexity –How can we support the different skills and knowledge in play?

	(3) sensitivity to operations	Monitor "expectable interactions" and respond promptly to the unexpected. It's about seeing what we are actually doing regardless of what we were supposed to do, based on intentions, designs, and plans. Support the performance of actions that accept the ambiguities of intentions – how the "relevant" information is considered and managed as "relevant"/valid? Heed to small adjustments to routines/normal operations – how operational people feed the system with information, and how the system likewise inform the operational people with useful 'critical/relevant' data?
	(4) commitment to building resilience	How the lessons learn have become part of the current process/practices? How this new flow of information has being reinforced? Before starting your work activity—what is the information you would like to have?
	(5) under-specification of structure/deference of expertise	Emphasis on an assembly of knowledge, experience, learning, and intuition. How decisions can be supported? How feedback from different decisions can be shared?
	HANDOVER	How the process of handover fits within the larger systems of communication and organisation? Policy designed to improve safety practice- teamwork / Leadership /Trust How does the handover take place? What instruments? How practices are shared/ Recorded?
2/CIT	[Specify a critical event in advance of the interview?]	Would you recall a specific event (not necessarily a near miss/incident) / a variation of normal routine which could turn out into an accident that was successfully managed? How this event was shared? Would you recall a specific event which turned out into an accident? What went wrong? What information could have been of relevance to tackle the event successfully? Thinking of that event, what company data would have been useful? What did you/your group learn? What did the company

		lean? How this affected the organisational process? Leveraged some specific changes?
3/ Instruction to the Double	[specify a critical scenario to elicit tacit knowledge to deal with critical events]	Imagine tomorrow I will be you, performing your task/activities – Instruct me in a way that nobody will notice the difference

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Appendix C MUAC - BRIEFING INFORMATION

Project Information

FUTURE SKY SAFETY is an EU-funded transport research programme in the field of European aviation safety, which brings together 32 European partners to develop new tools and new approaches to aeronautics safety, initially over a four-year period starting in January 2015.

Future Sky Safety Programme has the high-level objective to reduce the likelihood of organisational accidents in aviation via development and implementation of a Safe Performance System. Safety focus has traditionally been on technical failures and human error as they occur in operations. New and promising approaches consider the overall socio-technical system in the full operational and organizational context. The research Future Sky Safety is advancing addresses effects of organizational structures, processes and cultural phenomena on safety performance in aviation organizations.

The key areas comprising the resolution of the next aviation accidents are safety intelligence, safety culture, safety mindfulness and an agile response capability at organisational and inter-organisational levels. These elements are all available, but they need to be focused on the daily realities of aviation-related organisations, and then integrated into a cohesive system that will work for all parts of the aviation industry, whether ground or air, operational or support.

TCD lead a Work Package to design a novel approach/method to maintain safety mindfulness in operational situations. The idea is that if operational staff are aware of the possible threats can occur in their day-to-day activities, they can anticipate (most of) them. While operational staff are certainly aware of most of the risks, there are two sources of risk for which they may not have current information. The first is risk information that is taken from a wider pool of information than the operational layer (including supervisors) traditionally has access to. This may be risks identified by looking across several organisations or even across an industry. Such information is relevant but may take a long time to filter back down to operational staff in organisations. The second source of risk information concerns new risks that may have been noticed by one or two individuals during their daily work, but have not yet been passed up the chain and identified as risks that operational staff need to be concerned about. Such risks may be passed on from one individual to another, but this will be an ad hoc process rather than formal, and may not reach the person who really needs it in time. Both these types of risk information may eventually reach the right people, but this can take too much time, and an incident can occur before existing processes have identified, analysed and processed such information, and disseminated it to the collective workforce.

Safety Mindfulness aims to provide much faster and effective processes to give operational people these types of information, via top-down, bottom-up and horizontal information-sharing processes.

Objective of the field research

We are carrying out a field research at MUAC to validate the concept/approach that we are advancing, in order to investigate:

- How operational people and supervisors are able to anticipate and successfully manage possible threats in daily practice
- How operational people and supervisors can enhance the sharing of expertise and critical events in the daily practise?
- How useful information and data to successfully mitigate/avoid incidents/accidents can be (1) from the one side, stored/recorded, and (2) from the other, retrieved/extracted when needed

Participation in Session and Confidentiality

Participation in the validation session is voluntary and there will be no consequence if you choose not to participate or to end your participation. You are free to withdraw at any time.

Please note that both video and audio information might be recorded.

We will only collect information relevant to the research study.

The information you will provide will be solely used for the purpose of evaluating the Safety Mindfulness Approach. All information obtained from the session will be anonymised during the analysis and it will not be used for any purpose other than this research.

Any information that is recorded will remain strictly confidential.

This includes information you report about your professional experiences and behaviours, and/or information about ATCD companies you have worked for and/or currently work for (i.e. procedures and processes, how safety is managed, safety culture, training, problems controllers experience as a result of management decision making and so forth).

If during the course of the sessions, you refer to a safety critical incident which you were directly involved in, we will remind you of your professional responsibilities (i.e. file an Air Safety Report). We will also remind you of the need to make any confidential internal reports in relation to safety incidents and/or near misses, using airlines own confidential reporting system. We will also inform you about the legal limits on confidentiality – in case there is a real and imminent threat to safety.

We will store, handle, transfer and dispose of all records, both written and unwritten in a way that attends to the needs for privacy and security. All research data (profile forms, transcripts of interviews, video data of collaborative sessions/simulator validation exercises) will be de-identified after each research session. The processing of information will be done through computerized means, at the Centre for Innovative Human Systems (CIHS), Trinity College Dublin, and treated under the Freedom of Information Acts (2014).

Please note that this research has been carried out under the auspices of the Trinity College Dublin, School of Psychology, Research Ethics Committee, which operates within the Irish Legal Framework. If any issues or disputes arise, it will be resolved under the rules of the Irish regulation.

Procedure

The data collection will follow a protocol to ensure internal validity and reliability. This will include the use of different sources of evidence – i.e. interviews, observations, workshops, material analysis. Prior to each session you will be briefed about the specific goals and procedure which will be undertaken.

Roles

TCD is in charge of the field research data collection. MUAC/EUROCONTROL partners will support the management of the research (e.g. recruitment, logistics).

The Participant - Encourage participant not to 'over-perform', and to act naturally

Further details on the project can be found at https://www.futuresky-safety.eu/project-5/. Please ask the researcher if you have any further questions.

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Appendix D MUAC - CONSENT FORM (INTERVIEW SESSION)

Background information

The FSS Safety Mindfulness concept will be advanced to develop and demonstrate how to manage operational situations mindfully. The concept comprises different aspects which will support both the operational, supervisory and middle management layers to better understand the system they work in, and share safety knowledge-based information.

Goal of this session

This session is meant to collect information about your work activity and practice. In particular we would like to investigate

- How you anticipate and successfully manage possible threats in daily practice
- How you support the sharing of expertise and critical events in the daily practise
- How useful information and data to successfully mitigate/avoid incidents/accidents can be (1) from the one side, stored/recorded, and (2) from the other, retrieved/extracted when needed

Procedure

The interview will last about 1 hour. We will follow a script for this. Please note that the interview will be recorded.

Participation in Session and Confidentiality

Participation in this session is voluntary and there will be no consequence if you choose not to participate or to end your participation. You are free to withdraw at any time.

Please note that any information that is recorded will remain strictly confidential.

The information you will provide will be solely used for the purpose of the project.

All information obtained from the session will be anonymised during the analysis and it will not be used for any purpose other than this research. The processing of information will be done through computerized means, at the Centre for Innovative Human Systems (CIHS), Trinity College Dublin, and treated under the Freedom of Information Acts (2014).

Further details on the project can be found at https://www.futuresky-safety.eu/project-5/. Please ask the researcher if you have any further questions.

Informed Consent

1. I confirm that I have read and understood the above information and have had the opportunity to ask further questions.
2. I understand that my participation is voluntary and that I am free to withdraw at any time.
3. I agree to take part in this validation session

Future Sky Safety has received funding from the EU's Horizon 2020 Research and Innovation Programme, under Grant Agreement No. 640597.

4. This research has been carried out under the auspices of the Trinity College Dublin, School of Psychology, Research Ethics Committee, which operates within the Irish Legal Framework. I agree that if any issues or disputes arise, it will be resolved under the rules of the Irish regulation.

NAME OF PARTICIPANT (PRINT NAME) _____

WORK POSTAL ADDRESS _____

PHONE NUMBER _____

EMAIL ADDRESS _____

DATE _____

SIGNATURE _____

Contact Details

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Appendix E MUAC - PROFILE FORM

Dear Participant,

Please complete this profile form which captures certain personal information along with information concerning your professional expertise.

This information will be recorded using computerised means at the Centre for Innovative Human Systems (CIHS), Trinity College Dublin, and treated under the Freedom of Information Acts (1997 & 2003).

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PERSONAL INFORMATION

First Name	
Surname	
Gender	☐ Male ☐ Female
Age range	☐ ≤ 24 years old ☐ 25- 29 years old ☐ 30- 34 years old ☐ 35-39 years old ☐ 40- 44 years old ☐ 45-49 years old ☐ 50- 54 years old ☐ 55-59 years old ☐ ≥60 years old
Nationality	

PROFESSIONAL EXPERIENCE

Current role Job Title	☐ _____ ☐ _____
Years in the current role	☐ _____
~~~~~~~~~~~~~~~~~~~~

Overall years within the company	Total _____ From _____ to date

Previous role Job Title	□ _____ □ _____
Years in the previous role	□ _____
Indicate if this was in a **different company**	
Overall years within the company (only if different from current)	Total _____ From _____ To _____

Other relevant experience	*(Please, list below)* _____ _____ _____ _____

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