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Safety, Security and Human Factors Business Division (DAP/SSH)

Understanding Safety Culture in Air Traffic Management

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EXECUTIVE SUMMARY

The term safety culture has been in use over the past few years in Air Traffic Management (ATM), but it is not always clear what is meant by this term, or how exactly it relates to the ATM industry. This report seeks to explain the concept of safety culture, first as it was developed in other industries since the mid '80s until now, and second in terms of how it specifically relates to ATM. It also seeks to explain the relationship between safety culture and Safety Management Systems (SMS), and show why safety culture is important even if a good SMS is in place.

The objectives of this report are to:
- Develop an understanding of safety culture in ATM, by identifying the safety culture elements through building on other industries' understanding of safety culture and tailoring this understanding to ATM's nature and needs
- Determine how safety culture develops and changes
- Determine the role and significance of safety culture in ATM
- Relate this understanding to current Safety Management System approaches as are being adopted by European ANSPs
- Develop a basis for safety culture measurement and guidance.

A semi-structured interview tool was developed, structured under the main SMS elements (including safety reporting, safety assessment, working practices and safety issues, safety resources etc.) and further safety culture prompt questions were developed to understand the mechanics of safety culture, that is, why it

is working and how it can fail.
The survey was undertaken with 52 staff (controllers, managers, supervisors, technicians) in four European ANSPs in 2005. The analysis process highlighted five similar themes, under which there were 18 key elements.

Using the responses, 'stories' provided evidence of the symbols, behaviours, assumptions and values (espoused and actual), and these were related to how safety culture might be undermining or supporting safety management. This enabled the identification of measures to improve safety culture where it was being 'disabled'. Examples of safety culture 'enablers' could also be identified, constituting good practice.

The results are in four main sections:
(I) the first showing a set of safety culture elements that can be the basis for a safety culture measurement tool
(II) the second showing the principal links between the safety culture and safety management elements
(III) the third showing the refinement and simplification of the safety culture model
(IV) and the fourth developing evidence of safety culture enablers and disablers.

The following safety culture themes and elements (in brackets) were identified:

1. **Safety Management Commitment (Priority of safety; Responsibility for safety; Resources for safety)**
2. **Trust in Organisational Safety Competence (Trust in safety process;**

Regulatory effectiveness)
3. **Involvement in Safety (Communication about changes; Communicating problems (speaking up); Involvement of ATCOs in safety; Management involvement in safety; Working with contractors)**
4. **ATCO Safety Competence (ATCO Competence; Team effectiveness; Training for safety in ATC; Procedures and working practices)**
5. **A Just Reporting and Learning Culture (Error tolerance, blame and punishment; Rewards and incentives, and Performance appraisal; Reporting (and investigating) incidents; Learning from incidents)**

The surveys found evidence that safety culture is important in ATM - even in cases where an SMS is in place, things may not be working properly due to safety culture impacts (in particular what this study has called 'safety culture disablers'). The results suggest that whilst a good SMS is necessary, it may not be sufficient. Efforts must therefore be made to measure safety culture as well, and identify and rectify short-comings. The scientific literature and the survey and analysis embodied in this report have laid the groundwork for a safety culture measurement and management framework. In particular the surveys and collaboration with four ANSPs has helped immensely with the transition from scientific theory to practical aspects that controllers and their managers will be able to relate to and work with.

There now exists a preliminary set of safety culture elements adapted to ATM, and their links to ATM SMS elements have

been identified. This result should become the basis for a safety culture measurement tool, as well as providing the areas for development of guidance and best practical guidance on safety culture for air traffic control centres. The simplified dynamic model of safety culture, together with its enablers and disablers, offers a usable framework with which to explore safety culture deficiencies or vulnerabilities, and a means to identify how best to tackle them. This latter aspect therefore has the dual use of developing safety culture guidance and serving as a safety culture investigation or intervention tool.

A roadmap for developing a way to manage safety culture can be seen as follows:

1. **Raise awareness and interest in ANSPs in the concept and role of safety culture**

2. **Verify the results of this study, and where possible enlarge the 'database' by involving more ANSPs**

3. **Further analysis of the mediating role of the supervisor (and technical support) in developing the safety culture**

4. **Develop initial guidance based on the work in the survey, structured according to the**

safety culture elements, and enrich such guidance via ANSP participation

5. **Develop a safety culture measurement system that can assess an ANSP's safety culture, identify vulnerabilities and pinpoint areas for improvement**

6. **Develop a safety culture intervention tool that ANSPs can utilise themselves (with external support) to explore and improve their safety culture**

7. **Develop a Safety Culture Learning Forum that will enable industry-led advancement in this area.**

BACKGROUND

Air Traffic Management (ATM) is a very safe industry - both in terms of quantitative measures such as accident rates and also qualitative measures such as the perceptions of the travelling public. That said, however, it is not often clear to those within the industry, let alone the outside observer, as to why the safety performance of the industry has been so good for so many years.

The industry is currently expanding to cope with increased levels of traffic and this is coupled with fundamental changes to how ATM services are provided.

- **Will the ATM system be able to cope safely with these changes?**
- **If so, how will it cope?**
- **What fundamental factors will keep the industry safe?**

All the above questions remain unresolved, and so in this era of expansion and change, one of the biggest challenges that the European ATM industry currently faces is identifying and classifying the crucial ingredients of effective safety management and the measures the industry should adopt to maintain its exceptional safety performance.

The development and implementation of Safety Management Systems (SMS) are seen by many in the industry as being the 'safety holy grail' as they formalise the safety of the ATM system in terms of a tangible and documented system of management policy and procedures. Therefore a multitude of initiatives are currently underway in Air Navigation Service Providers (ANSPs) all around

Europe, which are focussed upon the objective of developing SMS applicable to Air Traffic Management Services.

The intense activity to develop these SMS is not merely a compliancy response to the introduction of EUROCONTROL Safety Regulation Requirements (ESARRs) (e.g. see EUROCONTROL, 2000) but it is also an attempt to ensure that ATM retains its hard fought status of being an extremely reliable and safe industry.

Although it has been recognised that the existence of an appropriate and comprehensive SMS is necessary for maintaining and improving the safety of ATM operations, it is not an end in itself. A Safety Management System will not assure safety if it is not used properly and thus all the staff involved in the provision of ATM services need to be properly aware of its existence, understand its basis, and be motivated to use the Safety Management Systems that are currently being developed.

Employee awareness, understanding and motivation and similarly 'soft' phenomena such as their attitudes, perceptions and beliefs are all wrapped-up within the concept of **'organisational culture'**. The influence of culture is something that is often taken for granted by those working in the organisation but it has an implicit and very strong influence on the safe behaviour of employees (Cox and Flin, 1998).

Safety Culture, a sub-dimension of organisational culture, is therefore a fairly recent attempt in ATM to advance the

area of understanding the different organisational and managerial influences on safety. Research to link safety management with cultural factors is still to be fully embraced by the ANSP community and current research efforts are still mainly focussed upon safety management.

Recently in ATM, the term safety culture has come into the fore, as well as related terms such as **Just Culture**, and **Learning Culture**. Whilst such terms have been in use for some time in other industries, they are relatively new to ATM. Whilst a Safety Management System can be explained very explicitly, and written down as a formal documented system and associated processes, safety culture is harder to expound. Yet other industries have found it necessary to invest both in SMS and safety culture.

> An SMS may be seen as the *'Competence'* to manage safety in an explicit way, whereas Safety Culture refers more to the *'Commitment'* at all levels of the organisation to safety.

Clearly both **Competence** and **Commitment** are required to maintain ATM at its current high safety levels. Moreover, as will be seen later, it is important that there is 'coherence' in terms of safety values and attitudes throughout the different vertical layers of the organisation. If certain values and/or assumptions about safety are 'mis-aligned', safety cannot be optimised.

Safety culture has been shown to be a key predictor of safety performance in a number of industries (including nuclear, chemical, off-shore and rail). It is essentially the attitudes of personnel about the company's approach to safety, their perceptions about the magnitude of the risks that they face and their beliefs in the necessity, practicality and effectiveness of measures to control risks. There are strong indications that the safety culture concept would work when applied to the ATM industry and so the concept merits further development for ANSPs.

In terms of the relationship between safety culture and the area of safety management systems described above, the following could be postulated:

"Safety culture is a sub-element of the overall organisational culture. It is an abstract concept which is underpinned by the amalgamation of individual and group perceptions, thought processes, feelings and behaviour which in turn gives rise to the particular way of doing things in the organisation. Safety culture factors in turn will characterise and influence the deployment and effectiveness of the safety management resources, policies, practices and procedures (Kennedy and Kirwan, 1998)."

In this way, safety culture is seen as an enabler for safety.

The above definition therefore emphasises that certain features or characteristics of culture (e.g. group attitudes, perceptions and beliefs) will affect the way in which the documented safety manage-

ment system is carried out (Kennedy and Kirwan, 1995). Some of these safety culture features can be distinguished (e.g. via interviews with the workforce, observation of workforce activity, presence of safety posters on the bulletin boards, safety awareness briefings in the rest areas, etc.) and thus can be subsequently related to the safety management activities defined in the safety management documents.

In theory, therefore, explicit indicators of ATM safety culture can be derived. It should then be possible to develop a safety assessment and improvement approach which will focus on safety management systems whilst also providing explicit links to the safety culture features and characteristics that influence the effectiveness of safety management activities. The strength of treating safety culture and safety management in tandem is that the approach can focus upon both assessing and improving safety culture. Through safety culture assessments being related to tangible safety management processes, ANSPs can more readily understand the safety culture concept and thus target improvements to both their safety culture and safety management systems.

The remainder of this report therefore seeks to explain the concept of safety culture, show where it has come from, and how it relates specifically to ATM. However, this is not merely a theoretical piece of work. The project that led to this report has involved four ANSPs to determine how safety culture can support safety, and how lack of it can degrade safety,

and examples of both of these aspects are presented in Section: **Developing a Safety Culture for ATM** as evidence of the importance of safety culture for ATM. Section: **Safety Culture Survey** then discusses ways forward for ATM to manage safety culture, to maintain ATM's excellent safety reputation.

PROJECT OBJECTIVES

- **Develop an understanding of safety culture in ATM**
- **Identify the safety culture elements by building on other industries' understanding of safety culture and tailoring this understanding to ATM's nature and needs**
- **Ensure this understanding is not merely theoretical, but is also grounded in ANSP practical experience**
- **Determine how safety culture develops and changes**
- **Determine the role and significance of safety culture in ATM**
- **Relate this understanding to current Safety Management System approaches as are being adopted by European ANSPs**
- **Develop a basis for safety culture measurement and guidance**

APPROACH

The work in this project was undertaken in three main phases:

1

Review of safety culture literature and experience from other industries and ATM.
A bibliography of references is given at the end of this report. It should be noted that the literature review was largely based on references from 2001 onwards, since references after this time will encapsulate work from earlier times. The key insights from the literature review are presented in Section: *A Review of Safety Culture for ATM*.

2

Survey of four ANSPs, using semi-structured interviews of personnel at multiple levels representing management, supervisory and 'workforce 'layers' in the organisation (the latter including controllers, maintenance staff and technicians), with the aim to:
(I) Understand the key factors that make up safety culture in ATM;
(II) Identify the safety culture factors that are working effectively and those that are not and relate these to safety culture 'enablers' and 'disablers';
(III) Document episodic indicators (stories / examples about safety culture) from the four ANSPs.
The results of the survey, which also show the examples and highlight the significance of safety culture in ATM and its role as safety 'enabler', are in Section: *Results of Safety Culture Survey*.

3

Develop an ATM safety culture 'framework' - essentially a 'roadmap' for developing the means to manage safety culture in ATM. This way forward is described in Section: *Summary and Conclusions: The Way Forward.*

A REVIEW OF SAFETY CULTURE FOR ATM

This section considers the origins of safety culture in other industries, its relationship with other concepts such as safety climate, just culture, and the safety management system approach, and its relevance to ATM.

WHAT IS SAFETY CULTURE?

ORGANISATIONAL CULTURE

To understand safety culture's origins, it is first necessary to consider organisational culture. Most of us spend a significant amount of time at work, and different companies and organisations can each be seen to have their own unique 'culture', which defines the way that company or organisation works or operates. To the people who have been in a company or organisation for some time, the way things work is simply accepted as 'how it is', whereas to outsiders or newcomers it may sometimes seem unusual. A key point, which will be returned to later, is that it can be difficult for people outside this culture to understand it or truly see how it works (and why it is done a particular way), and this can apply to safety behaviour as well as other 'products' from an organisation.

The concept of safety culture therefore has its origin in the social and behavioural psychology of the 1950's and 1960's that came to the fore in the organisational psychology, organisational behaviour, and management literature of the 1980's. The literature on organisational culture offers a number of definitions which encapsulate shared beliefs and values. For example, Uttal (1983) defines corporate (i.e. organisational) culture as *'a system of*

shared values (what is important) and beliefs (how things work) that interact with a company's people, organisational structures, and control systems to produce behavioural norms (the way we do things around here)' (p. 66). This definition appears to be so relevant to the current topic that Reason (1998) wrongly cited this as a definition of safety culture rather than organisational culture. Additionally, Schneider (1987) describes organisational culture as underlying assumptions about the world and about human nature, and Schein (1990) argues that these are *'basic assumptions which are invented, discovered or developed by a given group (and) ...taught to new members'* (p.110). The key point here is that these 'ways of doing things around here' are often taught or picked up during training, such as the On Job Training Instruction (OJTI) that most controllers experience prior to being validated as controllers. Training is therefore a critical key to the development of safe operating practices and safety culture.

SAFETY CULTURE

The term safety culture gained its first official use in an initial report into the **Chernobyl** nuclear power accident in the Ukraine (IAEA, 1986). The accident was a large shock for the industry as a whole, and was greeted by puzzlement as to how it could have happened. The IAEA(International Atomic Energy Agency) report introduced the concept to explain the organisational errors and operator violations that laid the conditions for disaster. Public Inquiry reports have since implicated poor safety culture within operating companies as a determinant of several high-profile accidents, such as the fire at King's Cross underground station (Fennell, 1998); the sinking of the Herald of Free Enterprise passenger ferry (Sheen, 1987), the passenger train crash at Clapham Junction (Hidden, 1989), and **Überlingen** (Ruitenberg, 2005). In the Überlingen accident there were several examples which potentially reflected poor safety culture such as lack of training and lack of manpower which resulted in a compromise of safety of operations. The relevance of safety cul-

ture to safe operation is not disputed (Cox & Flin, 1998).
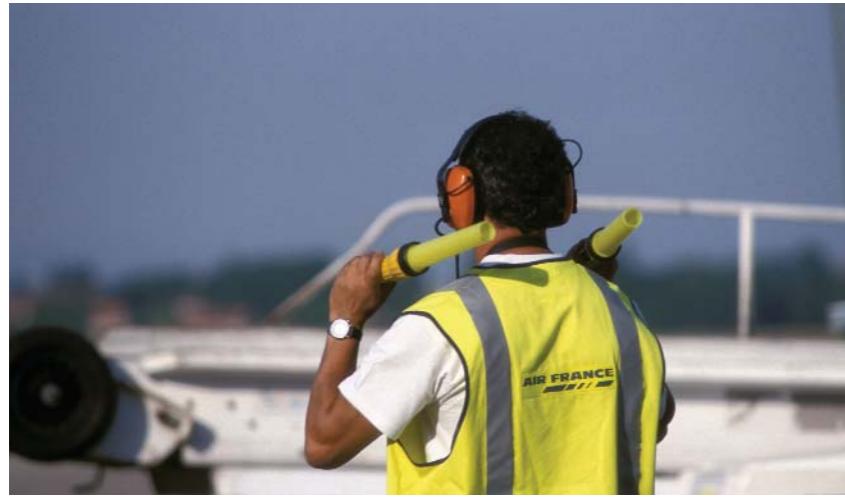
However, there has been only limited theoretical development of safety culture since the late 1990's (Wiegmann, Zhang, Thaden, Sharma, & Mitchell, 2002) despite Reason's (1998) argument that it is a concept 'whose time has come' (p. 293).

Safety culture therefore arose in the wake of Chernobyl, but has been applied in many industries including rail, space (the Challenger and Columbia accidents), chemical (the Bhopal disaster in 1984, retrospectively), and marine transport as noted above. It caught on particularly because it explained accidents that were not foreseeable, and moved attention from the person at the 'sharp end' of the accident (eg train driver, pilot, nuclear power plant operator - who was usually killed in any case) back to organisational decision-making and functioning that allowed pressures to build on safe operations, or allowed unsafe practices to flourish or at least continue. This shift in focus came from a realisation that unless the source of the problem was tackled, similar tragic accidents would occur.

Guldenmund (2000, p. 228) reviews 18 different definitions of safety culture, echoing Reason's (1997) assertion that defining culture has '...the definitional precision of a cloud' (p. 192). Two of the dominant definitions are as follows. With reference to the Chernobyl disaster, the International Atomic Energy Agency (IAEA) defined safety culture as *'...that assembly of characteristics and attitudes in organisations and individuals which established that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance'* (IAEA, 1991; p. 1). The UK Health and Safety Commission (HSC) endorse this position and provide a number of characteristics that are expected in positive safety cultures by defining the concept as *'... the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management. Organisations with a positive safety culture are characterised by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventative measures.'* (HSC, 1993: p. 23). These definitions of safety culture clearly resonate with the definitions of organisational culture stated earlier.

Building on the organisational culture literature, Reason (1997) identified five important components of safety culture as follows:

(I) **informed culture**
(II) **reporting culture**
(III) **just culture**
(IV) **flexible culture**
(V) **learning culture**

An *informed culture* is a safety system that collates data from accidents and near misses and combines them with information from proactive measures such as safety audits and climate surveys. In turn, this safety system requires the active and honest participation from the workforce to report near misses, complete attitude surveys and become involved in how safety is managed in their organisation. This is called a *reporting culture*, characterised by an organisational climate in which workers feel free to contribute to the informed culture. However, workers will not feel free to contribute unless a *just culture*, characterised by an atmosphere of trust, is in evidence. This must be distinguished from a no-blame culture, as a just culture does not turn a blind eye to criminal or negligent acts. In some instances, rewards may be offered for reporting near misses in much the same way as they are for safe behaviour although there are potential problems with this such as over-reporting.

A *flexibile culture* is one that successfully manages safety during change due to external demands, such as, for example, increasing technological complexity of an operating system, or increasing general or peak capacity in the ATM network, or major organisational changes (e.g. privatisation). Collecting this information is futile unless it is used to enhance the safety performance of the organisation.

A *learning culture* is needed to draw appropriate conclusions from the information collected along with the will to implement changes to procedures and equipment as deemed necessary.

These components are similar to those cited by Weick (1987) whose criteria for high reliability in an organisation is a culture that encourages interpretation, improvisation, unique action, and a *climate of trust and openness between management and workers.* Together,
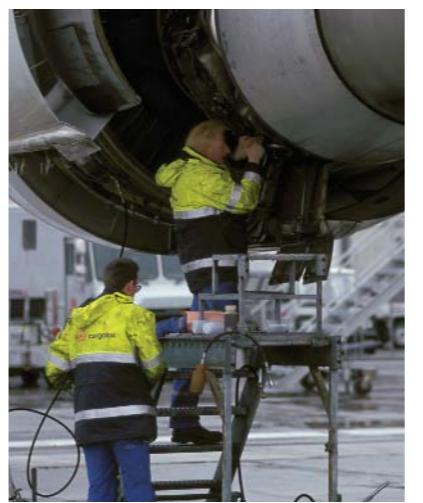
these components of safety culture will result in a set of social norms, which are unspoken rules of behaviour that will result in sanctions if not followed (Ostram, Wilhelmsen, & Kaplan, 1993). Behaviours that support safety and avoid sanctions could be reporting near misses and errors.

Although there has been much written on the topic, there has been little advance in its theoretical basis since the late '90s (Wiegmann et al., 2002). There is still a lack of instruments to measure it and a degree of ambiguity over definitions and thus subsequent measurement. Nevertheless, a review of the literature published in 2002 established several commonalities among safety culture definitions (Wiegmann et al., 2002).

Safety culture:

- operates at the group level or higher
- is related to management and supervisory systems
- emphasises a contribution from everyone at every level of the workforce
- has a relationship with members' behaviour at work
- is reflected in the relation between reward systems and safety performance
- is reflected in an organisation's willingness to develop and learn from errors, incidents and accidents
- is relatively enduring, stable and resistant to change[2]

Based on these extracted common themes a global definition of safety culture was proposed:

"Safety culture is the enduring value and priority placed on worker and public safety by everyone in every group at every level of an organisation. It refers to the extent to which individuals and groups will commit to personal responsibility for safety; act to preserve, enhance and communicate safety concerns; strive to actively learn, adapt and modify (both individual and organisational) behavior based on lessons learned from mistakes; and be rewarded in a manner consistent with these values" (Wiegmann et al., 2002).

This definition suggests that there is a *sliding scale of safety culture* from bad to excellent. This corresponds with current experience in the European ATM industry where, for example, initial safety culture measures have utilised a scale of maturity of safety culture between different ANSPs.

[2] This resistance to change is a function of any 'culture', but ideally an organisation is 'flexible' as described earlier and therefore can be adaptive in its safety approach when necessary.

The literature highlights two particular attributes of safety culture, namely **workforce involvement** and **management commitment**. These are described below.

WORKFORCE INVOLVEMENT

The International Nuclear Safety Advisory Group (INSAG) state that two outcomes indicative of high safety culture are a just reporting culture where the workforce feel comfortable reporting incidents and near misses, and a culture where individuals are willing to challenge unsafe acts and conditions (INSAG, 2002).

It is likely that the only way to achieve this level of cultural maturity is to have a workforce involved in health and safety. Workforce involvement is essentially about workers' control over their own safety.

Workforce involvement in safety takes several formal and informal forms including participating in risk assessments, safety audits and accident investigation, and discussing health and safety in meetings and 'toolbox talks'.

Provision of activities that increase involvement and the willingness of the workforce to become involved in safety initiatives can be influenced by supervisors and managers (Yule, 2005). For example, Simard & Marchand (1995) found that participative supervision and decentralised

use of power by middle managers to be the best predictor of workers' propensity to become involved in safety initiatives.

The outcomes of an involved workforce appear to be employees who are more willing to take on personal responsibility for safety (Cheyne et al., 2003), engage in and are more aware of safety issues, and are more willing to rectify them.

MANAGEMENT COMMITMENT (SAFETY LEADERSHIP)

Management commitment to safety has been established as the main influence on workforce safety climate perceptions (Clarke, 2005, Flin et al., 2000). Published research on leadership per se currently favours the transformational approach which proposes that leaders build on relationships with followers in order to achieve higher levels of performance than expected. The meaning of transformational leadership here is aiming to increase a team's awareness of the safety aspects of the task and their importance, and getting them to focus on organisational goals rather than individual ones. The aim is also to be 'visionary' and set motivating and intellectually stimulating goals, and to be 'inspirational'. Generally, transformational leadership is correlated

with 'charismatic' leadership, but this need not be the case.

Effective leaders are therefore vigilant and monitor performance and stay in good communication with their subordinates. They are able to identify mistakes, deviations from performance, and conditions that may endanger safety before they manifest as accidents. They also provide positive verbal feedback for good performance (i.e. for capturing errors, reporting near-misses, speaking up). Transformational leaders pay strong attention to communication and also articulate an appealing vision of the future. By doing so, they encourage employees to set aside personal gain in favour of longer-term success for the organisation. A growing literature shows that transformational leadership is significantly related to workers' rule compliance and safety motivation (e.g. Barling et al., 2002; O'Dea, 2000), and has been shown to significantly reduce industrial injury rates (Zohar, 2002a; 2002b).

SAFETY CULTURE AND SAFETY CLIMATE

The terms safety culture and safety climate have been used interchangeably in the literature (Cox & Flin, 1998). Denison (1996) states that the methods used by researchers can aid distinction between studies that have measured culture from those that have measured climate. He states that measuring culture requires qualitative methods whereas climate can be measured by quantitative methods and goes on to argue that quantitative measures such as questionnaire surveys cannot fully represent the underlying safety culture. These **safety climate surveys offer a snapshot of the prevailing state of safety** and are useful in determining employee perceptions about safety in their organisation at a particular moment in time. In concurrence, Schneider (1990) argues that climate can only give a flavour and indication of the underlying culture, and cannot capture the 'full richness' of the organisational culture. Cox and Cox (1996) also demonstrate this point by **likening culture to personality, and climate to mood.** Some responses may be indicative of the individual's stable underlying beliefs, values and personality but overall, the survey will reflect how the individual feels at that point in time. The comparison between culture and personality seems attractive because personality is relatively stable over time whereas climate and mood can be susceptible to short-term fluctuations (Pervin, 2003).

For this reason the focus in this report is on safety culture, not safety climate. However, when it comes to developing a

robust measure of safety culture, as will be discussed at the end of the report, it is necessary to take heed of the experiences from the domain of safety climate. Nevertheless, before leaving safety climate, there are several important insights for this report.

Much safety climate research has focused on perceptions of **management commitment to safety** (this mirrors safety culture's own focus on safety leadership, mentioned above). This is seen as an over-riding or primary factor. Perceptions of management commitment to safety are moderated by supervisor actions which would imply that safety climate should be relatively similar within work groups therefore indicating that safety climate should be operationalised at the group level (Zohar, 2000). A 'group' for ATM could represent a particular shift team of controllers. More recently Zohar & Luria (2005) have argued that safety climate also exists at the organisational level whereby workers across an organisation should have relatively homogenous (effectively the same) perceptions of top management's commitment to safety if the organisation has good safety climate. This would suggest that different controller shift teams at the same Air Traffic Control Centre for example would have the same perceptions about commitment to safety from top management.

Other researchers have also found that the level of an organisation's safety culture influences an individual's risk judgments (Adie et al., 2005), and that safety culture perceptions are different at different levels of an organisation and person-

nel categories (Ek & Arvidsson, 2002; Ek, Arvidsson, Akselsson, Johansson, & Josefsson, 2003). Also, there is some evidence that training significantly predicts safety culture (Arboleda, Morrow, Crum, & Shelley, 2003).

The **key insight** here is that for investigation and measurement of safety culture the group becomes the reference point, and 'group' can mean a group of controllers, technicians, or can refer to the supervisory layer or middle management, or top management. This suggests that **to understand safety culture in an organisation it will be necessary to sample from groups or personnel at different 'levels' in the organisation.**

The further implications from Zohar's work concern how values and attitudes about safety are learned by people in an organisation. Employees are informed about the possible consequences of safe or unsafe behaviours by paying attention to overt statements and actions by man-

agers and co-workers regarding safety as well as implicit messages from management about the relative status of safety compared to other organisational goals such as productivity, efficiency, schedule, service, and quality. It is these perceptions that are deemed to drive safe or unsafe behaviour.

A final and important insight from the safety climate literature concerns the investigation and measurement of safety culture. Many, if not most, safety climate measures have used questionnaires. However, within other disciplines of psychology, such as the personality literature, there have been attempts made to move away from self-report questionnaires, which can be heavily influenced by impression management (trying to make a good impression of oneself) and social desirability (wanting to be liked/accepted by one's peers/others). These two influences could play a role in industry when trying to measure safety culture as often individuals are aware of the correct answer and adjust their position accordingly or portray an image of the person they would like to be as opposed to what they actually are. Furthermore, how accurately can an individual appraise themselves? Can they make an informed judgement of their behaviour? For this reason **reliance on questionnaires alone is not recommended for safety culture investigation or measurement.**

As has been presented earlier, safety climate can be regarded as the indicator of the organisation's safety culture as perceived by employees at a point in time (Cox and Flin 1998). However, in reality the terms are not so clear cut, with many writers using the terms safety culture and safety climate interchangeably. To avoid further confusion between the two concepts, only safety culture will be referred to for the remainder of the Report.

SAFETY CULTURE AND SAFETY MANAGEMENT

'Safety Management' has also emerged as a concept and safety discipline in its own right in recent years. In general, research has often failed to distinguish between Safety Management and Safety Climate/Culture. Kennedy and Kirwan (1998) suggest that Safety Management should be regarded as **"a documented and formalised system of controlling against risk or harm."** Arguably Safety Management has always existed in ATM, because it cannot have been so safe for so long by pure chance or will alone. However, Safety Management in the past may have been a more implicit process or set of procedures. More recently though, and in line with ATM itself becoming more complex and interactive, Safety Management now refers to more explicit approaches and processes to achieve safe operation and output.

ANSP organisations are therefore now required to have a Safety Management System (SMS) implemented in the organisation compliant with ESARRs (ESARR 3). The requirements are designed to act as the basis for safety management focus and control as well as enabling outside audits of the SMS implementation.

Safety Management, however, is 'normative' in approach - it refers to how things should work, but as we all know, procedures are not always followed, for good or poor reasons. Therefore, however good the safety management system of an organisation is, the way it exists on paper does not necessarily reflect the way it is carried out in practice. It is the safety culture of the organisation which will "influence the deployment and effectiveness of the safety management resources, policies, practices and procedures" (Kennedy and Kirwan, 1998). Put simply,

> Safety Management reflects the **competence** of the organisation to manage safety, and Safety Culture reflects the actual **commitment** throughout the organisation.

One without the other does not bode well for the safety of an ANSP. The SMS, in practice, consists of a number of elements which can be represented by a number of SMS indicators, which again could be used as a breakdown of important safety issues related to organisational implementation of an SMS at an ANSP.

Typical SMS elements include:
- Policy
- Planning
- Safety Organisation
- Regulation and Standards
- Safety Assessment; Safety Surveys
- Training & Competence
- Infrastructure and External Services
- Safety Documents
- Operations and Work Controls
- Safety Occurrence Reports
- Reward / Incentive Systems.

It is therefore desirable, when looking at measuring or improving safety culture, to understand the relationship between such elements of the formal safety management approach and the equivalent safety culture 'elements', which might for example relate to trust, openness, communications, etc. It is unlikely that a one-to-one correspondence would be found between SMS and safety culture elements, but a mapping between the two is desirable, to show how certain safety culture elements or factors can support or enable certain SMS elements or functions, and also of course how they can also 'disable' a well-intentioned SMS. The SMS elements are therefore discussed later in more detail in Section: **Developing a Safety Culture Survey for ATM** in connection with the safety culture survey as carried out in this project, to show what degree of concordance exists between these two related approaches.

UNDERSTANDING HOW SAFETY CULTURE WORKS USING MODELS

When trying to understand something, it is often useful to develop a model that explains how something works, and what its main elements or features appear to be. Such a model (in this case safety culture in ATM) then clarifies what exactly is being studied (so there is no confusion between e.g. safety culture and other related concepts such as Safety Climate or Safety Management Systems), and can facilitate the development of measures, intervention approaches and guidance material. This section therefore explores a potential model of safety culture in ATM. First, however, it is necessary to discuss

the relationship between Safety Management Systems and Safety Culture, since the former are already in use in ATM, and any model of safety culture and its resultant 'elements' should ideally be 'concordant' with elements used by SMS approaches.

CORE ELEMENTS TO BE CONSIDERED IN A MODEL

When considering 'soft' concepts such as culture, understanding must work from visible behaviour shown by groups of individuals right through to basic assumptions held by these groups as portrayed in Figure 1 (based upon Schein, 1992). This understanding is particularly relevant when attempting to develop means by which safety culture can be identified and measured.
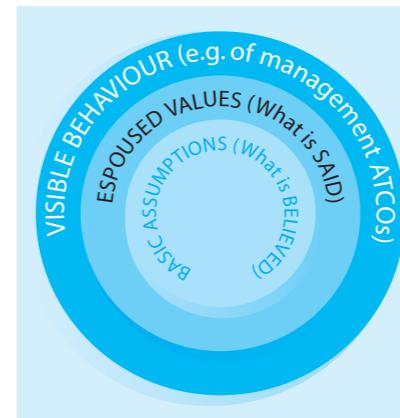
Figure 1. Layers of Culture (adapted from Schein, 1992)

Safety Managers are mainly interested in safety behaviour: what people will do in certain situations that may come to pass. Safety culture theory, however, tells us that the behaviour of individuals is influenced by the values of their superiors (particularly management) and peers, and the basic assumptions they have about how safety works in their organisation. Values may be those 'espoused' by management (the 'talk'), or actual acts (e.g. praising someone for raising a safety issue) which can also be seen as 'symbols' because they are visible (the 'walk'). Hence the phrase 'walking the talk' (meaning management don't just talk about safety, they do visible things about it).

There are several aspects of Schein's (1992) model that are worthy of note:
- Culture is about shared assumptions and can only be understood in a group setting
- Outsiders notice characteristic 'symbols' and can question underlying reasons, but only insiders can understand the full context. But since 'insiders' don't tend to notice these as symbols, because they may have become routine, both perspectives are needed to decipher culture.

When trying to investigate safety culture in an organisation, there are therefore several ways forward based on this model:
- Elicit symbols which are characteristic for the issue in the culture
- Search for espoused values by asking "Why do you do it like that?"
- Dig for basic assumptions by asking if values explain all symbols. Are there conflicts or anomalies?
- Sort cultural assumptions into those supporting and constraining the desired performance or objective. Is there group consensus on that?
- If basic assumptions must change to achieve the desired result, expect great investment in time and effort.

In summary, as far as developing and changing safety culture, *values are not seen to be the most crucial component to focus upon. Instead, assumptions will be the main driver and also the toughest factor to influence. The way in which assumptions are influenced will be via symbols and other visible factor such as behaviour.*

The above model of culture is a descriptive model, and it gives us the major core elements, but it is 'static'. What is needed is a more 'dynamic' model that will help to see how safety culture can be improved, leading to improved safety behaviour.

Therefore, as well as the components, knowledge of the 'dynamics' of the safety culture is crucial in order to monitor, measure, control and improve the safety culture. A tailored "Dynamic Safety Culture Model" was developed based on Mary Joe Hatch's (1993) dynamic culture model as presented in Figure 2. The specific aim of a dynamic culture model is to present an example of the dynamics of culture allowing for an understanding of the potential for change.
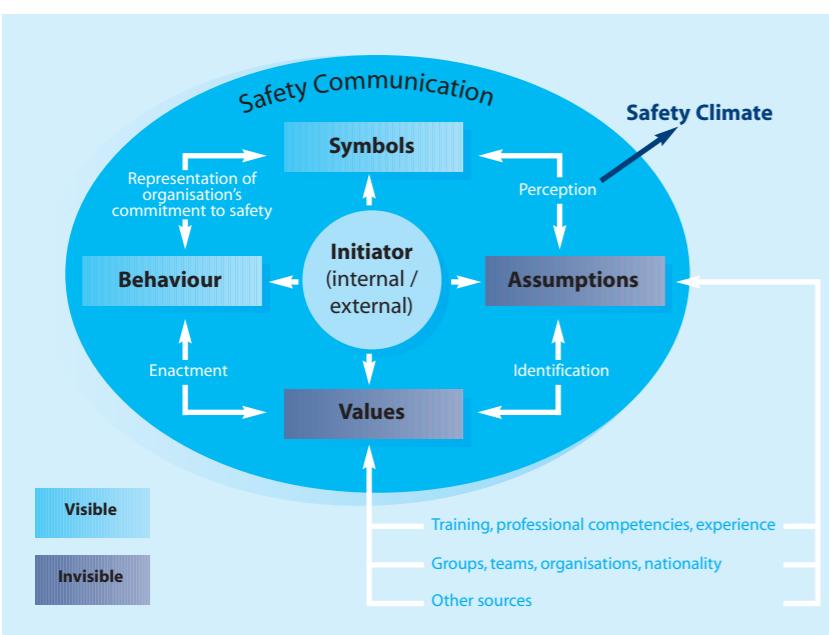
Safety communication is introduced as an underlying prerequisite for all dynamic culture changes. The ability to communicate assumptions and values is an important enabler for achieving shared perceptions, assumptions and values. Sources for safety culture are integrated into the model to demonstrate that there will be basic prevalent assumptions and values independent from the organisational assumptions and values. Safety climate is encompassed in this model representing the process of behaviour reflecting commitment to safety, but perceived by the employees based on their cultural background.

ORIGINATORS OF SAFETY CULTURE

An important assumption in the model is that safety culture has one or more originators. The safety culture originators will often be education, training, professional background, national identity, group identity etc. An important task is to analyse the clash between the original safety culture and the safety culture created by the organisation (if any).

Furthermore, an attempted safety culture change will have an initiator focusing most often on the behaviour, the symbolic elements or the original culture originators. However, dynamics in safety culture can also be initiated by shifts in assumptions and values among members of groups.

VISIBLE AND INVISIBLE LAYERS

The model works with a visible and an invisible layer: behaviour and symbols represent the visible layer and assumptions and values represent the invisible layer.. Thus in order to assess a specific safety culture, it is important to observe the behaviour and symbols while trying to learn about the assumptions and values. The process of assessing the underlying values and assumptions represents an interpretation phase. The result is therefore subjective and highly dependent on the values and assumptions of the person doing the interpretation.

Figure 2. Dynamic Safety Culture Model adapted from Hatch, 1993

EXAMPLE OF THE MODEL: THE NAVIAIR REPORTING SYSTEM

"In 2001, a new law was passed by the Danish Parliament, mandating the establishment of a compulsory, strictly non-punitive, and strictly confidential system for the reporting of aviation incidents. A particular and perhaps unusual feature of this reporting system is that not only are employees (typically Air Traffic Controllers and pilots) ensured strict immunity against penalties and disclosure but also, in fact, any breach against the non-disclosure guarantee is made a punishable offence."
(NAVIAIR - Peter Majgård Nørbjerg, 2002).

The implementation of the reporting system in NAVIAIR that embraced the new legal framework is well documented and provided a good example for the purpose of testing the model presented above.

Figure 3 depicts the example in the context of the dynamic safety culture model:

RESULTS

The safety culture is improved by strengthening a just, reporting, informed, flexible and learning culture. The reporting system becomes a formal focal point for shared assumptions and values enacted into consistent behaviour. The enactment provides basis for better incident analyses, trend assessments and potential for improvement which ultimately improves safety.
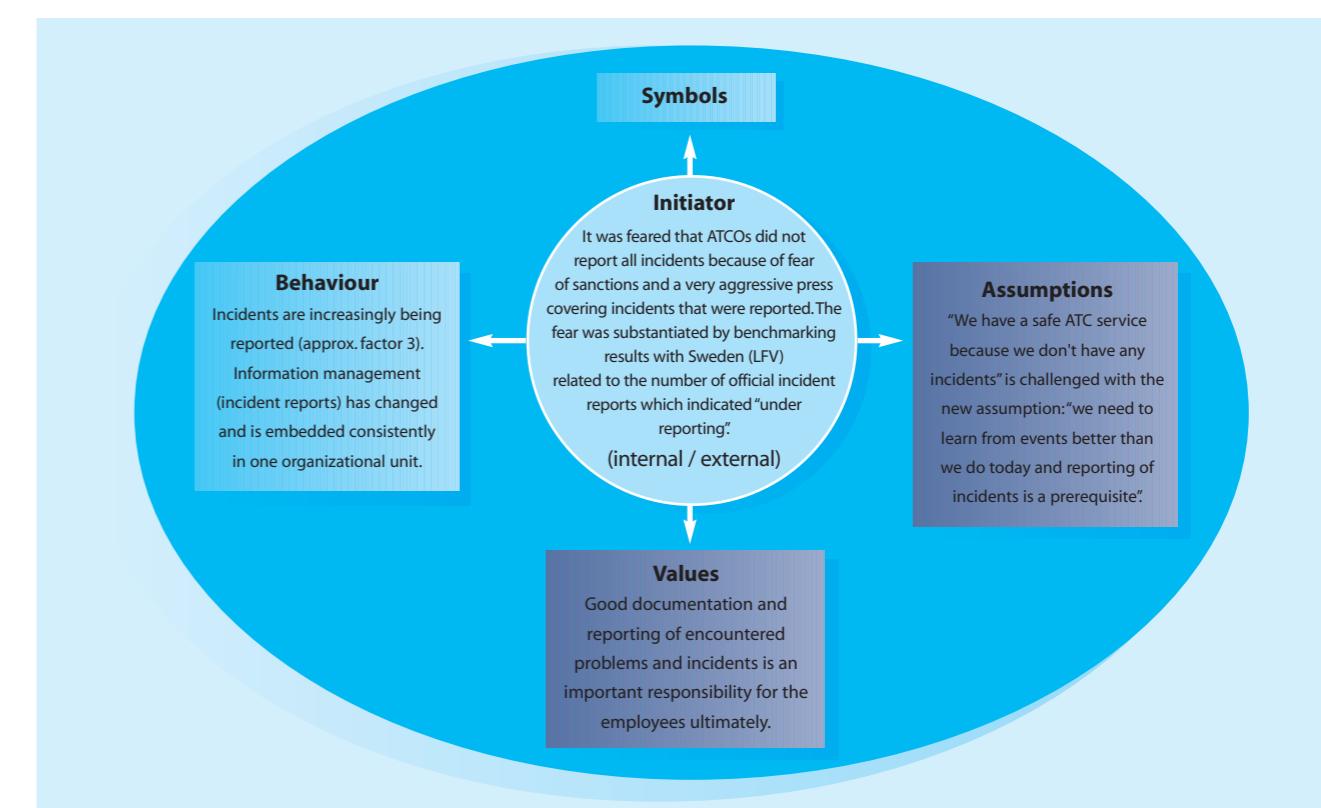

Figure 3. NAVIAIR Reporting System (in the context of the Dynamic Model for Safety Culture)

DEVELOPING A SAFETY CULTURE SURVEY FOR ATM

The previous chapters have considered safety culture from a research perspective. This section now attempts to link theory to practice and experience in four European ANSPs. The model (based on Hatch, 1993) was used to define questions that could be asked at different levels in four different ANSPs to ascertain how safety culture worked in individual ACCs. As will be seen, this led to insights on safety culture and its importance, and laid the foundation for a safety culture measurement system, safety culture guidance, and improvement approach. It also led to a simplification of the cultural models discussed above.

SURVEY SCOPE

It was decided to survey four ANSPs that were geographically disparate, which would also tend to give them different cultural traits according to geographical diversity on the European map. Figure 3 shows that there are many facets to culture, from the level of the operational element (the Team), to the regional and national level influences and nuances that will affect culture.

Within this study, people inside an ACC organisation were interviewed so, at most, this covered the first three inner rings in Figure 4. Regional and national differences were therefore not under investigation in this phase of the investigation of safety culture. However the fact that four disparate ANSPs were investigated means that the results as a whole will tend to be more generic than if focusing on a single ANSP or culturally homogeneous part of Europe (e.g. focusing

only on Scandinavia, or North-West Europe, or the Latin countries, etc.). Nevertheless regional and national cultural aspects can be important (Guldenmund, 2000) and so it is planned in a later phase to expand the number of participating countries.
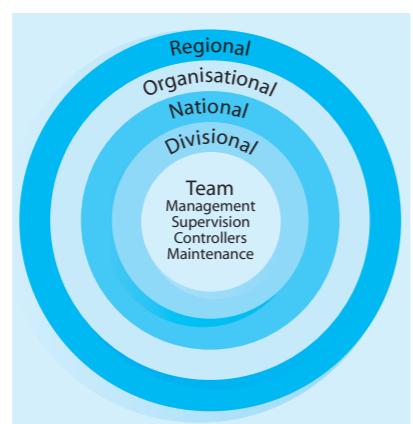
Figure 4. Organisational Layers Considered in Survey Content

DEVELOPMENT OF THE SAFETY CULTURE SURVEY TOOL

LITERATURE INPUTS TO SURVEY DESIGN

Key references for the development of the survey approach appropriate to ATM included EUROCONTROL (Gordon et al, 2004), and Swedish studies on safety climate (Ek et al, 2002, 2003). Outside of aviation and ATM there are various studies that were consulted including those performed in the oil and gas industry (see Mearns et al, 2003 and 2004) and also a number of landmark nuclear power studies (see Lee, 1993; ACSNI, 1993; IAEA, 1994).

EXPERT INPUTS TO SURVEY DESIGN

If the development of safety culture surveys in ATM and other industries is used as a reference point, it can be seen that the generation of the survey items can often take many months in itself. When starting to develop a survey from scratch, the methodology that is usually adopted in the running of 'focus groups'. Focus groups are an approach where the workshop participants hold different organisational functions or job roles. This interaction of different roles allows a wide perspective to be adopted in the identification of the items for the survey.

However, there was not the availability of time and resources in the project to support such an approach. Therefore, in order to supplement the information derived from the literature review, the project team combined their experience in safety culture surveys with their experience of ATM operations, in order to arrive at the initial set of items for the survey. The mechanism to achieve this was a brainstorming session between the specialists in the project team in order to generate the safety culture survey items.

IDENTIFYING SAFETY MANAGEMENT SURVEY ITEMS

A crucial part of the design of the survey was to determine the means by which safety culture and safety management factors could be related to one another. If this was not done, it would be likely to lead to confusion between the two approaches, and it would also be had to show where safety culture could undermine or support Safety Management Systems. The way in which this can be

achieved 'theoretically' was described in Section: *A Review of Safety Culture* for ATM through the development of the Safety Culture Model. However, this relationship needed to be established at a 'practical' level in terms of how the items on the survey were related to SMS aspects. In effect there were three inputs to this process: i) ESARR 3 elements - the 'official' SMS elements; ii) DNV 'River Diagram' Approach - a multi-industrial set of SMS elements; iii) EEC Safety Climate Survey (Gordon et al, 2004) - a set of safety climate elements strongly aligned to safety management.

From these three sets, the following final twelve main SMS elements were derived to structure the questionnaire. Examples of the survey questions structured according to these SMS elements are found in Annex A.

- Policy
- Planning
- Safety Organisation
- Regulation and Standards
- Safety Assessment
- Safety Surveys
- Training and Competence
- Infrastructure and External Services
- Safety Documents
- Operations and Work Controls
- Safety Occurrence Reports
- Reward / Incentive Systems

DETERMINING SAFETY CULTURE QUESTIONS AND PROMPTS

Safety culture theory suggests that to understand the mechanics of safety culture, that is, why it is working and how it can fail, it is necessary to see how organi-

sations project their safety image (through what they say and do *behaviours and symbols*, and how that image is perceived via *assumptions and values*). However, when talking to controllers and managers at ACCs, such psychological terms may not be clearly understood, and indeed there can be confusion between these terms even amongst psychologists. Therefore questions must be asked about concrete issues as may appear as SMS elements, such as safety reporting, safety assessment, working practices and safety issues, safety resources etc. The answers to questions on these aspects can then be interpreted by safety culture analysts to identify underlying assumptions, values, etc., and to show where safety is working and where it is not, and how it is failing. It is this latter point that is key. It is often very easy to see a poor safety culture, but quite another matter to discern how to put it right. This is because the problems are often at the 'invisible' or cultural layer (e.g. differing assumptions between controllers and management). This section therefore explains what was done in the survey, what was found, and how it can help us to understand and 'fix' safety culture problems. As will also be seen at the end of the section, the basic psychological aspects of safety culture in any case can be reduced to a more understandable, communicable and therefore ultimately a more usable approach.

In the surveys described in the next section, a link needed to be made between an SMS area and indicator based survey, and the Dynamic Safety Culture Model. When asking questions based on the SMS indicators in ANSPs, the answers

described examples of how the organisation worked with and committed to safety (as perceived by the respondent). The survey questions featured a series of follow-up questions formulated in 'SMS language'. An example of the question approach for part of an SMS area is as follows.

Many questions were asked, based around SMS areas as identified earlier. Note that it is up to the respondents to provide the context in the answer. The analysts were searching for examples (stories) or evidence of safety culture in action, whether functional or dysfunctional. Follow-up questions and later analysis would then focus on interpreting the answers in terms of the symbols or symbolic behavior, and the analysis of the respondents' interpretation of such symbols/behaviour to show their assumptions and values (detailed examples are given later).

These were developed to help elicit the safety culture information. Essentially the questions and prompts attempt to achieve elicitation of the following items:

- Verify safety culture dimensions relevant to the ANSP
- Identify factors working effectively or not
- Relate safety culture factors to Safety Management Systems
- Document episodic indicators from ANSPs (i.e. stories about safety culture)
- Identify ways to improve safety culture.

SAFETY CULTURE SURVEY

ADMINISTERING THE SURVEY

The survey items acted as prompts in order to explore safety culture issues in the semi-structured interview format. This was usually two interviewers to one respondent, allowing one interviewer to ask the questions, the other to take notes and seek clarification. This format also helped with analysis later. Some group interviews also occurred, e.g. a small group of supervisors or controllers interviewed together. The interviews at each ANSP were spread over two to three days. People were selected from operational levels (i.e. controllers, technical support and maintenance), supervision and line management, and upper management levels (e.g. director level). Table 1 shows the number and type of personnel interviewed at the four ANSPs.

Level	ANSP1	ANSP2	ANSP3	ANSP4	TOTAL
Management	3	1	1	2	7
Supervisor	0	2	1	5	8
Operational	8	7	10	7	32
Technical/support	1	1	2	2	6
Total	12	11	14	16	53
Individual Interviews	5	7	5	0	17
Group Interviews	2	2	2	6	12

Table 1. Interviewee type at each ANSP

Finally, in order for interviewees to feel comfortable and free to respond openly in their interviews, there needed to be an emphatic and clear approach defined to address confidentiality of participant's responses and any associated data issues. Interviewees were assured that their responses would be treated in confidence, where both individuals and organisations have been made anonymous in the report write-up.

ANALYSING, INTERPRETING AND SUMMARISING THE DATA

The transcripts (undertaken online) from the interviews were initially documented in a word document in free-format. The analysis process was as follows:

Documenting and Sorting - the analyst identified and highlighted phrases in the interview scripts that helped to explain how the safety culture worked in the ANSP. For each ANSP, the analyst combined the highlighted phases and categorised them according to similar themes.

The results from the four ANSPs were combined, and the resulting groups of phrases were then labeled into 20 elements (and x sub-elements) under 5 main themes.

Interpretation - using the responses and the inherent 'stories' or evidence to determine symbols, behaviours, assumptions and values (espoused and actual), and relate these to how safety culture might be undermining or supporting safety management.

Re-structuring of Data - using the model, the information was re-constructed to show how safety culture was working, and how it was failing. This also enabled the identification of measures to improve safety culture where it was being ***'disabled'***. Examples of safety culture ***'enablers'*** could also be identified, constituting good practice.

Re-evaluation of the Model - The analysis was useful in identifying the enablers and disablers and re-constructing the issues, leading to suggestions for safety culture improvement. However, the allocation of responses into symbols and behaviours, and into assumptions and values, was not so clear-cut. In terms of a method it has two problems: I) classification was not robust enough; and II) the terms used (e.g. symbol, value, assumption etc) were not felt to be clear and concrete enough. The method was more a psychologist's tool, rather than a tool that could be used by people inside an ANSP. Therefore the model has been simplified as described in Section: ***Refinement of the Safety Culture Model: Safety Culture Enablers and Disablers***.

RESULTS OF SAFETY CULTURE SURVEY

The results are in four main sections:
- the first showing a set of safety culture elements that can be the basis for a safety culture measurement tool
- the second showing the principal links between the safety culture and safety management elements
- the third showing the refinement and simplification of the safety culture model
- and the fourth developing evidence of safety culture enablers and disablers.

'Disablers' are those factors that prevent development of a positive safety culture, while ***'Enablers'*** facilitate the process.

SAFETY CULTURE ELEMENTS

The various interview results were pooled to generate a large list of issues. Several of the analysts were involved in clustering these in to a set of comprehensive safety culture elements. These are defined in Tables 2.1-2.5, and are exemplified by extracted statements from the interviews.

Tables 2.1-2.5 - Safety Culture Elements, Sub Elements and Examples of Phrases from Interviews

1. SAFETY MANAGEMENT COMMITMENT

	DISABLER EXAMPLES	ENABLER EXAMPLES
Priority of safety	• Sometimes the goal is to handle heavy traffic • People are pulled between safety and delivering a service • There is no separate safety department	• The previous manager's focus was on no delays. The focus now is to maintain safety levels • The Manager writes a monthly intranet letter and finishes with "better safe than sorry"
Responsibility for safety	• It is the responsibility of staff to read the new procedures in their own time • There is no official safety department. This leads to unclear responsibilities for safety implementation • Safety responsibility has not been delegated	• People feel they are responsible • The SMS has brought the focus on personal responsibility • Responsibility is a proactive participation by staff, it cannot be dictated by management • Personal goal of zero losses of separation is realistic
Resources for safety	• The financial situation does not allow for the role of a safety manager • There are insufficient resources to carry out safety cases, despite a formal SMS being in place	• The required budget for doing the job is always available

2. TRUST IN ORGANISATIONAL SAFETY COMPETENCE

	DISABLER EXAMPLES	ENABLER EXAMPLES
Trust in safety process	- We're producing safety cases but we're not doing local house-keeping - The SMS is developed but not yet implemented - The SMS structure is not supporting us - There are not enough simulations to test the new procedures - I did not trust the simulator people. They told us it would be easy, but it did not make sense. They did not listen to us	- The right people (experienced and current controllers) are involved in safety assessments - Periodical system check in maintenance are carried out where a preventative culture is encouraged among maintenance staff - A report highlighting system problems is given to the manufacturer. These are loaded onto the simulator to check they have been rectified
Regulatory effectiveness	- Separation of regulator and ANSP would allow more formal auditing - There is a lack of communication between the ANSP and the regulator	

3. INVOLVEMENT IN SAFETY

	DISABLER EXAMPLES	ENABLER EXAMPLES
Communication about changes	- New procedures are issued by staff notice - Office notices are not an effective way to communicate, as there is only one accessible computer with the information and no verification that controllers understand - People sometimes forget to do the computer-based briefing before shift	- A safety briefing from the station manager to the team outlines new staff notices, new activities, restrictions etc - For big changes, controllers are given training in simulations - Maintenance engineers communicate with controllers before touching a system
Communicating problems (speaking up)	- We have no-one to complain to. The 'open door' policy does not exist - Some people can be difficult to talk to about their mistakes - Controllers are less willing to speak up (about improvements to systems) as they are not listened to	- I feel able to discuss with colleagues if they do something wrong - There are clear reporting lines when there is a failure - We discuss working methods during "team meetings" to collect ideas for improvement - Debriefing and report from the team meetings are given to management
Involvement of ATCOs in safety	- Controllers' involvement in safety assessments is for show - Designers do not listen to controllers opinions - I do not feel responsible or involved in new changes	- Controllers' proposals are taken into consideration - There is controller input into the design of the system, which ensures user requirements are addressed
Management involvement in safety	- Controller briefing by management is there to cover management's backs - controllers are just told to read the notices - Briefing by station manager is not very complete	Management ask about incident trends, and they communicate the message that we need to improve safety
Working with contractors	- The external services/supplier did not want to help. Their focus was on selling - The relationship with the ATM system manufacturer improved when operations worked directly with them	Informal relationships with contractors helps the work

4. ATCO SAFETY COMPETENCE

	DISABLER EXAMPLES	ENABLER EXAMPLES
ATCO competence	• Competency is only called into question when there is an incident • Controllers still make errors, even good controllers might not know everything they should	• We have annual theoretical and practical tests yearly • You have to pass stringent tests to become a controller
Team effectiveness	• You have to learn a new way of working when you change teams (which can be difficult if the team is not relaxed) • Some controllers are easier to work with than others (with regard to working style)	• We ask for help when it's busy • We don't leave a position vacant if someone might need a break • Supervisor puts those people together who work well
Training for safety in ATC	• There is a lack of fallback training and emergency training • Computer-based training was not enough to train controllers in using the new system • Need to improve training using results from incident reports	• Training strongly enforces safety
Procedures & working practices	• Having to feed the system all the time means that we can lose the picture • Controllers sometimes have to go around the edge of procedures to do their job • ATC performance in approach and departures is close to minima	• There is no need to break most rules • Supervisors are looking for overload situations and are helping out • Controllers stay in position during handover until incoming controller is satisfied

5. A JUST REPORTING AND LEARNING CULTURE

	DISABLER EXAMPLES	ENABLER EXAMPLES
Error tolerance, blame & punishment	• People make mistakes, but here you're not supposed to • Some people don't report because they believe they might get blamed • There is a lack of consistency across the organisation with regard to discipline and re-training	• Management believe that it is human to make errors • We have a no-blame culture where staff are encouraged to report all incidents • We learn from incidents - controllers do not feel punished
Rewards & incentives & Performance appraisal	• We never get praise for doing the job without incidents • People resent the financial bonus as it is based on a self-performance appraisal • Our performance appraisals are not relevant to our job	• Controllers reward each other for difficult performances • Maintenance is appreciated for no loss of control • Engineering has safety goals as personal performance goals
Reporting (and investigating) incidents	• It is not in our character to report incidents • We're not supposed to report minor incidents, things that cannot be noticed • We don't have formal incident reporting forms (only the ICAO minimum requirements) • We need to have proactive safety analysis (to point out what could go wrong)	• Controllers are encouraged to report in order to see trends and make changes • We have trust in the confidentiality of the incident reporting process • Supervisors receive training in discussing incidents with controllers • Traffic replay is used (supervisor prepares themselves by replaying it alone first)
Learning from incidents	• Follow-up can be very slow • There is a lack of organisational learning from feedback on system problems reported - feedback is only given to the shift or individual • There is no feedback from incident analysis; neither on information dissemination nor actions taken • Safety issues are generally discussed, but no forms are completed • Training and feedback on incidents would make our job less stressful	• Supervisors take on the remedial actions • They have case examples of incidents to show other controllers (with the controllers permission) • We complete the reporting form ourselves and tell our colleagues what happened and what should be done • Quick feedback on incidents is provided to controllers

These elements therefore capture the safety-related safety culture aspects from the interviews at the four ANSPs, and could act as the basis for a safety culture measurement tool for European ATM. As discussed earlier though, it is useful to understand links between such elements and SMS elements. Otherwise there is a risk of confusion between the two areas, which would inevitably lead to disagreement over what matters (e.g. the significance of safety culture problems) and how best to tackle it (strengthening of SMS or safety culture improvement measures).

RELATING SAFETY CULTURE AND SAFETY MANAGEMENT ELEMENTS

Although in the development of the survey method a 12-element SMS model was utilised, in this section a 16-element SMS system (an adapted 'River Diagram' approach, mentioned earlier) is used because this more elucidated set of SMS elements enables a more precise matching between safety culture and SMS. A matrix showing the principal links between safety culture elements and SMS elements is shown in Table 3.

Safety Culture Elements (identified during ANSP survey)	1. Policy	2. Planning	3. Organisational Structure	4. Safety Regulation & External Standards	5. Safety Assessment & Risk Mitigation	6. Operations Control	7. Competency	8. Infrstructure & External Services	9. Safety Documentation	10. Safety Occurrences	11. Health Management	12. Emergency Preparedness	13. Security	14. Safety Monitoring	15. Safety Survey & Review	16. Communications & Culture
1. Safety Management Commitment																
Priority of safety	✓															✓
Responsibility for safety		✓														
Resources for safety				✓		✓										
2. Trust in Organisational Safety Competence																
Trust in safety process					✓				✓							
Regulatory effectiveness			✓												✓	
3. Involvement in Safety																
Communication about changes						✓	✓	✓								✓
Communicating problems (speaking up)																✓
Involvement of ATCOs in safety				✓												
Management involvement in safety															✓	✓
Working with contractors						✓		✓								
4. ATCO Safety Competence																
ATCO competence							✓									
Team effectiveness																✓
Training for safety in ATC							✓							✓		
Procedures & working practices						✓				✓						
5. A Just Reporting & Learning Culture																
Error tolerance, blame & punishment																✓
Rewards & incentives & performance appraisal																✓
Reporting (and investigating) incidents										✓						
Learning from incidents						✓				✓				✓		

Table 3. Matrix of Safety Culture elements that can affect SMS Elements

REFINEMENT OF THE SAFETY CULTURE MODEL

As described in Section: *Safety Culture Survey Analysing, Interpreting and Summarising the Data*, classifying the data using the terms in the Hatch (1993) model, such as symbols, behaviours, assumptions and values, was not robust enough and it was thought the method was more a psychologist's tool, rather than a tool that could be used by people inside an ANSP. Therefore a simplified safety culture model has been developed. The essential elements have been identified as the following:

- **What is BELIEVED**
- **What is SAID**
- **What is DONE**
- **The OUTCOME**

These simpler categories are less confusing and easier to communicate to stakeholders. Nevertheless, they do encapsulate the key ingredients of a dynamic model of safety culture: *what is believed* includes assumptions and values; *what is said* includes symbols and behaviour; *what is done* is behaviour; and *the outcome* includes behaviours, values and assumptions. The resulting 'model' is shown in Figure 5.
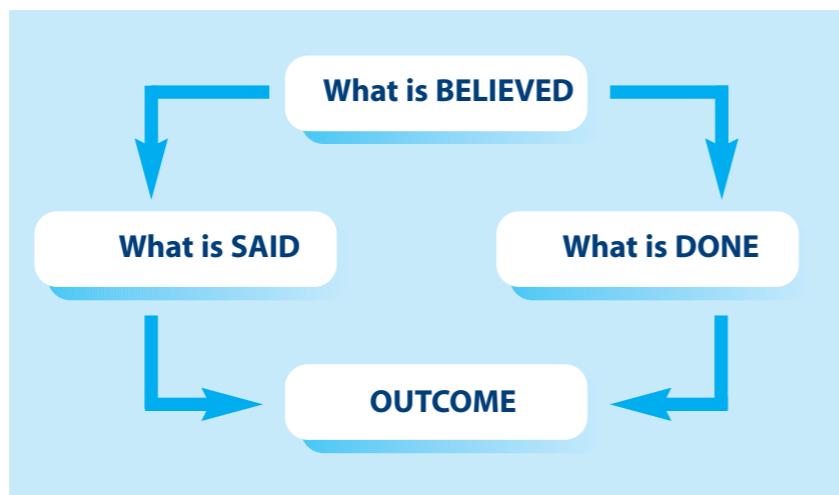

Figure 5. Simplified Safety Culture Model

This model can therefore still search for stories and evidence of safety culture, but it is easier to focus on *what is said*, typically by management (the espoused values), and then determine whether the perception (or reality) is that the management 'walk the talk' or not. With respect to *what is done* and *what is believed*, this is often where the digression begins, for example between one group and another. This may be represented by one group (e.g. management) believing one thing and another group (e.g. ATCOs) believing another. *The outcome* shows whether it matters or not.

Consider an example:
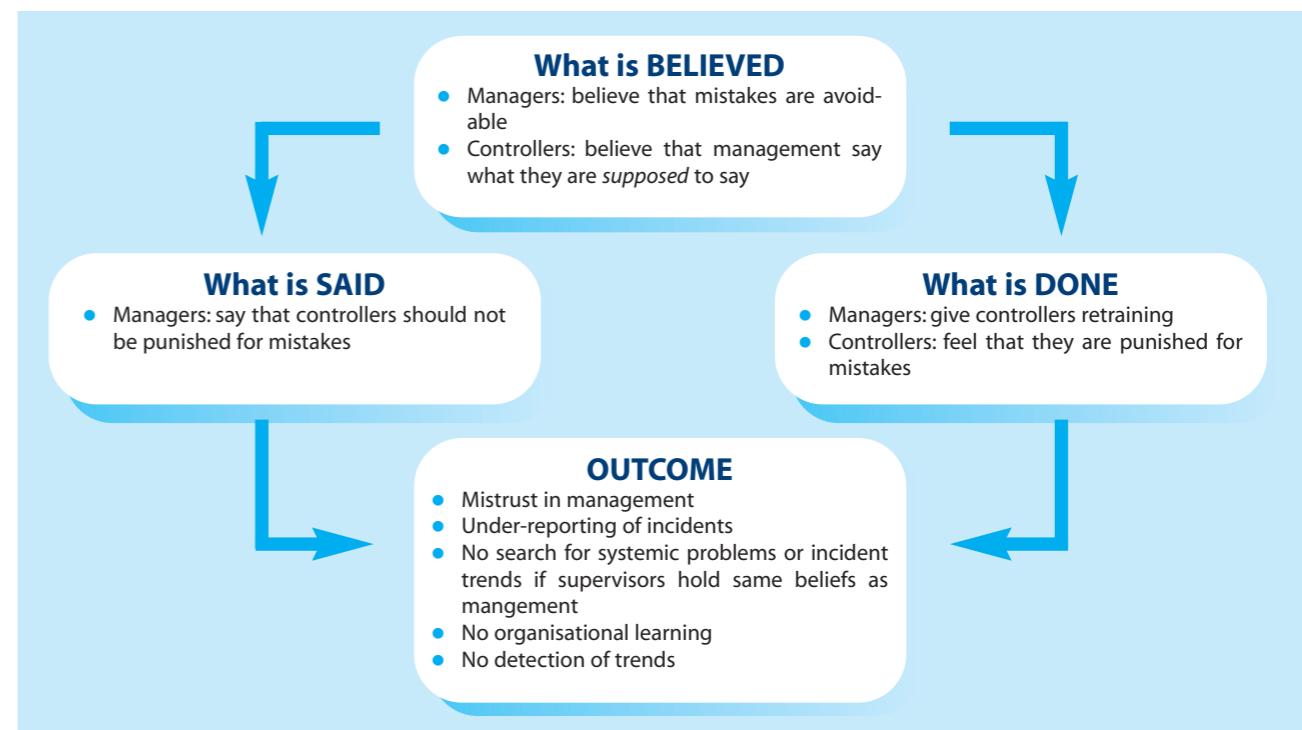
Figure 6. Example of the Simplified Safety Culture Model

RELATING SAFETY CULTURE TO SAFETY MANAGEMENT ASPECTS

In this example we see that several SMS aspects are affected. Incident reporting is likely to be affected, and so is the chance for organisational learning. The management in contrast will see low incident reporting as positive, because they believe performance can be error free. Safety assessment is also likely to be separated organisationally from incident analysis, and even if it is not, it will be able to deduce little, because most likely there will not be detailed incident investigation nor searching for root and systemic causes (because the controller 'just got it wrong, so re-train him'). Policy, note, is not overtly affected, because the policy may

well state what the top management say - but of course then it is a misrepresentation of the safety reality in the organisation.

Yet the impact on trust, on belief that safety is taken seriously and belief in the SMS, will be greatly undermined. This impact is harder to gauge but it is clearly an undesirable impact and is non-benign in terms of safety culture.

This example shows an example of one safety culture disabler, using the refined model (in the previous model the key aspect is a difference between management and controller assumptions: the former believe error-free performance is possible, the latter do not). The utility comes however from pin-pointing where the root of the problem lies, in this case at

the belief level and the action level. Management need to be persuaded that even very good controllers may have incidents, particularly when they are trying to finely balance safety and management goals of efficiency and productivity, in sometimes complex air traffic situations. They need to understand that having no incidents and in-depth analysis means that you do not know what may be around the corner.

Having shown an example of the approach, the following section gives more re-constructed examples of the enablers and disablers that were found, and the types of safety culture issues that arose during the safety surveys.

SAFETY CULTURE ENABLERS AND DISABLERS

The idea of these examples is to show how safety culture actually works, or can fail, within an ANSP. The examples focus mainly on two groups, management and workforce, the latter usually referring to the ATCO level. Arguably there is at least a third intermediate level for supervisors (when discussing an ACC), but their mediating role in safety culture is not yet clear,

nor was it clarified by the surveys[3]. In general, if the management and controllers share the same beliefs about safety and behave accordingly, this pattern usually reflects positive safety culture although it could also reflect negative safety culture if the issue being considered is something such as shared amongst both management and operations. Where management and controllers do not share the same beliefs about safety or their behaviours are in opposition, this pattern

reflects negative safety culture and its associated dis-enablers.

The following examples are used to illustrate the above propositions in greater detail.

[3] The supervisory and middle management roles are those of 'intermediary', and are therefore likely to act as amplifier or ameliorator, i.e. either accentuating safety culture effects, or else diminishing or compensating for them to reduce their impact. This role can thus be positive or negative, but is not yet fully understood.

Examples of Safety Culture Enablers

1. SAFETY OCCURRENCE REPORTS: DEVELOPING A CULTURE OF TRUST

Management and controllers believe in incident reporting and trust each other in order to learn from incidents.

	MANAGEMENT	OPERATIONAL STAFF
What was BELIEVED	• Both controllers and management believe they should submit reports of all occurrences. • Both controllers and management believe human errors exist and reports are an important basis for learning and improving safety.	
What was DONE	• Management do not punish those who report, instead that are supported and the report is addressed. • The ATCO reports the incident to the supervisor and they discuss the incident.	
OUTCOME	• Controllers and management trust each other and a just culture where occurrences are reported exists.	

2. SAFETY GOALS AS PERSONAL PERFORMANCE GOALS

Engineers are given individual performance goals that relate to the system level performance goals with the aim of increasing the safety of the ATM service.

	MANAGEMENT	OPERATIONAL STAFF
What was BELIEVED	• The organisation views safety as being as important as any other goals for the ATM service. To achieve high capacity is not sufficient alone; adequate levels of safety also need to be achieved.	
What was DONE	• Safety is seen to be treated by management as an important determinant of performance among staff. • Through the formal evaluation and appraisal system, the organisation recognises that safety goals are at least as important as capacity goals (e.g. engineers are required to check radar information regularly in order to estimate position errors).	
OUTCOME	• Through appropriate management tools, engineers appreciate that safety is at least an equally important part of their job as any of the other functions they are required to perform.	

3. LESSON DISSEMINATION OF SAFETY OCCURRENCE REPORTS

There is an initiative from operations to share information about incidents with each other, without encouragement from management. In this situation, to improve the organisational learning, management would need to take a more active role in lesson dissemination.

	MANAGEMENT	OPERATIONAL STAFF
What was BELIEVED	• Not known	• The senior instructors' activities are accepted by the controllers as a professional approach to safety. • Based on best and worst practice it is possible to develop new and better procedures. • To share best and worst practice among ATCOs.
What was DONE	• Not known.	• A senior instructor from the training department develops presentations of occurred incidents, discusses them with the ATCOs and provides suggestions for new procedures. The initiative is informal, personal and not formally supported by the organisation.
OUTCOME		• Shared beliefs strengthening the subculture identity and improving safety. However, the process is not formally integrated or supported by the organisation.

4. SAFETY POLICY: DEVELOPING A MEANINGFUL STATEMENT

Chief of the centre regularly demonstrates his commitment to safety.

	MANAGEMENT	OPERATIONAL STAFF
What was BELIEVED	• To prioritise safety as the key parameter. • If an ANSP does not ensure safety as a primary goal, it will face serious problems.	
What was DONE	• The chief of centre consistently ends newsletters and communiqué with the sentence "Better safe than sorry". In addition, his daily enactment supports the statement.	• Controllers remember the motto and take it seriously.
OUTCOME	• The common culture and cooperate identity is strengthened around the common goal/value. ATCO feels supported by management when they prioritise safety over other goals.	

Examples of Safety Culture Disablers

1. SAFETY OCCURRENCE REPORTS - NO BLAME AND PUNISHMENT

Management and controllers have different views on human error, leading to a lack of trust between them, and reduced reporting.

	MANAGEMENT	OPERATIONAL STAFF
What was BELIEVED	• Human errors can be avoided by strong enforcement. "You should not make mistakes."	• We cope with the situation as best we can but are only human: "human errors exist."
What was SAID	• We have a no-blame culture.	
What was DONE	• If the ATCO is culpable they could be suspended, retrained, or another appropriate measure.	• The ATCO will be blamed and punished if mistakes are noticed.
OUTCOME	• Separation in shared understanding leading to lack of trust between two parties and reduced incident reporting and learning.	

2. OPERATIONS & WORK CONTROLS: INFORMALLY MODIFYING PROCEDURES

Introduction of an environmental law led to management and controllers having difference perspectives on following the environmentally-related procedures.

	MANAGEMENT	OPERATIONAL STAFF
What was BELIEVED	• Management accept environmental legislation.	• "The environmentally related procedures are jeopardising safety levels" "Legislation" is perceived as jeopardising safety levels by employees. • To produce a safe service is more important than producing an environmentally friendly service (shared by management and employees).
What was SAID	• "Procedures are safety assessed and therefore safe".	
What was DONE	• Unknown.	• The ATCO adjusts the procedures to ensure safety.
OUTCOME	• ATCO behaviour (infringements of the procedures) is not expected by management.	• The applied procedures are "unmanaged" and not assessed for the situation, although has been formally accepted.

3. TRAINING AND COMPETENCE: LACK OF PREPARATION FOR UNUSUAL INCIDENTS

ATCO experiences a non-routine or emergency situation, but are not prepared for dealing with such events.

	MANAGEMENT	OPERATIONAL STAFF
What was BELIEVED	• We don't have the resources to carry out additional training.	• The ATCO maybe left on their own to deal with non-normal operations, because the organization does not want to prepare them properly for dealing with these types of events. Management do not want to take responsibility for things that occur outside of the normal situations.
What was SAID	• Not known.	
What was DONE	• There is no training for situations that fall outside of normal operations. There is resistance to update training programs and modules to deal with such types of events.	• Request from ATCOs for training to deal with emergencies.
OUTCOME	• ATCOs specialise themselves in a sector which they know well, feel comfortable controlling and where they feel they can deal completely with any situation likely to occur. They will therefore not feel motivated to operate a more challenging sector or airspace that is known to be more problematic.	

4. SAFETY ORGANISATION: OPEN DOOR POLICY

Management and controllers have different views on discussing issues with the Operations Manager.

	MANAGEMENT	OPERATIONAL STAFF
What was BELIEVED	• I have an open door policy but not the means to support it.	• The door is not really "open". Management do not have the time to respond to their request.
What was SAID	• We have an open door policy!	
What was DONE	• There are more important things to do that are of higher priority.	• No physical barriers - but the "open door" is not experienced as effective means for communication by employees.
OUTCOME		• Employees see the open door policy as a token gesture and don't use it.

SUMMARY AND CONCLUSIONS

SAFETY CULTURE IN ATM

Safety culture has been in existence as a fixed concept since shortly after the Chernobyl nuclear power plant accident approximately twenty years ago. It is recognised in other industries as the culture underlying safety - how safety works in an organisation. It is distinct from SMS which is the formal system for managing safety, and is different from safety climate, which is a snapshot of safety attitudes, whereas safety culture is more enduring and stable. Poor safety culture can undermine or even negate SMS efforts.

The surveys found evidence that safety culture is important in ATM - even in cases where an SMS is in place things may not be working properly due to safety culture

impacts (in particular what this study has called safety culture disablers). The results suggest that whilst a good SMS is necessary, it may not be sufficient. Efforts must therefore be made to measure safety culture as well, and identify and rectify short-comings. The scientific literature and the survey and analysis embodied in this report have laid the groundwork for a safety culture measurement and management framework. In particular, the surveys and collaboration with four ANSPs has helped immensely with the transition from scientific theory to practical aspects that controllers and their managers will be able to relate to and work with.

There now exists a preliminary set of safety culture elements adapted to ATM, and their links to ATM SMS elements have

been identified. This result should become the basis for a safety culture measurement tool, as well as providing the areas for development of guidance and best practical guidance on safety culture for air traffic control centres. The simplified dynamic model of safety culture, together with its enablers and disablers, offers a usable framework with which to explore safety culture deficiencies or vulnerabilities, and a means to identify how best to tackle them. This latter aspect therefore has the dual use of developing safety culture guidance and serving as a safety culture investigation or intervention tool.

THE WAY FORWARD

A roadmap for developing a way to manage safety culture can be seen as follows:

1. **Raise awareness and interest in ANSPs in the concept and role of safety culture**

2. **Verify the results of this study, and where possible enlarge the 'database' by involving more ANSPs**

3. **Further analysis of the mediating role of the supervisor (and technical support) in developing the safety culture**

4. **Develop initial guidance based on the work in the survey, structured according to the safety culture elements, and enrich such guidance via ANSP participation**

5. **Develop a safety culture measurement system that can assess an ANSP's safety culture, identify vulnerabilities and pinpoint areas for improvement**

6. **Develop a safety culture intervention tool that ANSPs can utilise themselves (with external support) to explore and improve their safety culture**

7. **Develop a Safety Culture Learning Forum that will enable industry-led advancement in this area.**

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ANNEX A - SEMI STRUCTURED INTERVIEW GUIDANCE SHEET

	1	2	3	4	5	6	7	8	9	10	11	12
	POLICY	PLANNING	SAFETY ORGANISATION	REGULATION & STANDARDS	SAFETY ASSESSMENT	SAFETY SURVEYS	TRAINING & COMPETENCE	INFRASTRUCTURE & EXTERNAL SERVICES	SAFETY DOCUMENTS	OPERATIONS & WORK CONTROLS	SAFETY OCCURRENCE REPORTS	REWARD / INCENTIVE SYSTEMS
Safety Management System Indicator(s)	Policy statement	Safety plans (e.g. Strategic and Project Plans)	Organigrams, Safety Terms of Reference (Accountability / Responsibility), Safety Meeting Structure / Definition	ESARRs, ICAO, National Regulations	Safety case, risk assessment and miti-gation procedures, etc.	Planned and regularly performed safety sur-veys	Licensing and training requirements	Procurement practices, supplier management practices	Relevant SMS and relat-ed output documenta-tion	Administrative Controls (e.g. change manage-ment processes, system interrupt)	MOR, SSE, Voluntary Reports	Company incentive and bonus systems
Safety Culture Prompt Question	PQ1: Do you have a Safety Policy state-ment?	PQ2: Do you perform safety surveys?	PQ3: How is your safety organisation defined?	PQ4: Do you have to comply with Regulations and Standards?	PQ5: How are safety assessments conduct-ed?	PQ6: Are Safety Surveys performed in your Centre?	PQ7: Are competencies obtained and main-tained to an appropriate level?	PQ8: Do you have to work with external par-ties or suppliers?	PQ9: With what types of safety documentation do you work?	PQ10: What procedures and controls do you use in order to ensure safety?	PQ11: How is occurrence reporting and investiga-tion performed?	PQ12: Are you reward-ed/punished based on your performance?
Safety Culture Follow-Up Question(s)	FQ1.1: How is it defined/developed (participation, processes)? FQ1.2: Are you aware of the content? FQ1.3: How is it com-municated? FQ1.4: How does it affect your daily work life/behaviour? FQ1.5: Is it underpin-ning your own under-standing of safety? FQ1.6: Is it underpin-ning your under-standing of organisa-tions commitment to safety?	FQ2.1: Do you have an official accessible safety survey plan? FQ2.2: How is it defined/developed (participation, processes)? FQ2.3: Can you recall examples of develop-ments initiated by a (planned/ad-hoc) safety survey? FQ2.4: Should the safety survey be han-dled differently?	FQ3.1: Is there direct link to management? (from ATCO to CEO?) FQ3.2: How is respon-sibility and liability for safety defined? FQ3.3: Can you pro-vide examples on good/poor safety management? FQ3.4: Does manage-ment learn from past events? FQ3.5: Does manage-ment adopt lessons learnt into the organi-sation? FQ3.6: How are stan-dards and regulations communicated?	FQ4.1: Are you aware of the regulations and external standards applicable for your job? FQ4.2: How were you made aware of these requirements?	FQ5.1: What triggers safety assessments? FQ5.2: Are the right people involved?	FQ 6.1: What is your involvement in regu-lar safety surveys? FQ 6.2: Can you pro-vide examples on changes evolving from such a survey?	FQ7.1: Could training improve? FQ7.2: Do you feel that awareness of safety stems from education or organisation or both?	PQ8.1: How are safety levels agreed and ensured for external sup-pliers and contractors? PQ8.2: Have you had any problems with suppliers and contractors regard-ing safety and how are these issues addressed?	FQ9.1: Is the safety docu-mentation available and easily understood? FQ9.2: For what type of systems and issues is safety documentation produced? FQ9.3: How is it ensured that safety records are stiil relevant or kept up to date?	FQ10.1: Are there occa-sions where procedures are not followed in order to get your job done?/ Do procedures always describe the safest way of working? FQ10.2: Is there anyone in the centre you really don't want to work with? Do you have shared risk perceptions (values)? Also with management? FQ10.3: Have you experi-enced a situation where you afterwards think you should have called an overload?	FQ11.1: Who is involved? FQ11.2: Is reporting anonymous, confidential or public? FQ11.3: What is your experience with the reporting system? (Trust) FQ11.4: Can you recall examples of develop-ments initiated by an occurrence reporting and following investiga-tion? (How is the general performance of the reporting and investiga-tion?) FQ11.5: Can you recall examples of occurrences which did not result in appropriate develop-ments? FQ11.6: Do you receive feedback after investiga-tions have ended? How is it carried out? (Tough messages to communi-cate)	FQ12.1: What actions cause rewards/ punish-ment? FQ12.2: How do your col-leagues and managers react when you submit an occurrence report? (And if you don't?) / When you take a safety initiative?
Relationships to Model	How the organisation works with safety (perceived by the respondent), hence it can tell us things about: (applied throughout the questionnaire). Which parts of it are symbols for the employees/managers? How do employees/managers perceive these symbols? Are the underlying assumptions in compliance with the employees/managers assumptions? Are the expressed values adopted as employee values? How is it enacted? Is the enactment underpinning the statement it self? How do employees enact assumptions and values? Is it possible to trace origin of assumptions and values? (Main purpose: To assess strength of sub-culture and distance to overall culture and SMS and trace origin of assumptions and values)											
Further Guidance	Regulations and Standards may be applicable at both a high level and a detailed working level. Therefore probe at both of these lev-els.	These are essentially the enactment of daily safety values. Note it can be short-sighted to focus too much attention to "most safety critical risks" because of the risk of overlooking other important aspects?	Examine the paths for safety communication and how is safety information commu-nicated and dissemi-nated. Explore how individual safety responsibility is implemented? When there is a safety issue who can they talk to. What does your safety committee do? Ask for examples of safety leadership in the organisation.	Regulations and Standards may be applicable at both a high level and a detailed working level. Therefore probe at both of these lev-els.	SMS guideline depicts assessments when operational and or technical changes are introduced. Methodologies are "fixed". Are these guidelines symbols which the employees appreciate as values? Try to assess the rela-tive risks in the job. Investigate with man-agers the main risks in their organisation and what they are doing about it. How often do they consider the possible risks in the operation and what actions do they take as a result?	Respondents may not be able to cite exam-ples - if so, investigate whether there are any areas that safety sur-veys should address.	Explore whether the organisation invests suf-ficient resources into training. Strong symbol, motivation, safety culture enhancer (professional from education it self) …	This is likely to be more applicable for managers and engineers. However, ATCOs may express real-tionships with other ANSPs for instance.	Safety documents may be applicable at both a high level and a detailed working level. Therefore probe at both of these levels.	Focus on deviations between symbols and employee enactment. Are they still acting on their own assumptions and values (e.g. repre-senting a separate safety sub-culture)?	Examples/Stories (good and bad). Enactment of values related to safety reporting: What hap-pens? Is it enough? (Shared values about pri-orities?)	Enactment into behav-iour (management and leadership) and turning it into symbols. Motivational factors are strong symbols are more than salary. (career opportunities and per-sonal development, appreciation, involve-ment in safety work/defining solu-tions…). Explore whether risk-taking is rewarded. With management, it may be interesting to explore if they failed in any area of business (e.g. capacity, safety, PR, budg-ets), which would have the worst repurcussions?