Does change challenge safety? Complexity in the civil aviation transport system

S. Høyland & K. Aase
University of Stavanger, Stavanger, Norway

ABSTRACT: The paper describes our attempt at mapping the complexity of the civil aviation system, in terms of how changes affect safety and interactions between actors within the system. Three cases were selected to represent three distinct levels of the transport system: the civil aviation authority case, the air traffic control/airport operation case and the maintenance case. Through the complexity perspective, we identified several positive system characteristics or mechanisms that contributed to maintain and improve safety during change processes, including a strong safety consciousness, collective coordination among individuals, and safety practices based on flexibility and knowledge sharing. These system characteristics were strengthened by changes with a positive perceived influence on safety, such as new technology improving flight safety. However, changes involving efficiency, merging and relocation were perceived to influence safety negatively by creating conflicts of priorities and reducing safety margins. The mixed effects of changes represented a common challenge across the three case organizations.

1 INTRODUCTION

To understand change it is necessary to understand the particular characteristics of the system to be studied. One trait of the civil aviation system is how the practices of various actors in the system, from operators to regulatory and political bodies, depend on current and emerging influences from national and international legislation, regulations and technology (in terms of methods, procedures and standards), and current and emerging market conditions (such as deregulation and changes in competition). Another trait of the civil aviation system is how the core task—transportation of people and goods from one destination to another—involves a high degree of cooperation and interaction between actors at every level, from the task of the aviation technician to ensure aircraft and flight reliability and the role of the air traffic controller to monitor and guide air traffic, to the responsibility of the regulator to ensure that the practices of the technician and controller are in accordance with current safety procedures and regulations.

In sum, the above traits of the civil aviation system illustrate a complex system comprised of a number of human, technological, organisational, and societal interactions, interfaces and dependencies. To understand the safety implications of changes occurring within such a complex system, the following two main objectives have guided our efforts:

1. To explore whether changes in different parts of the Norwegian aviation system affect the safety work within each organisation (internally)
2. To explore whether changes in the aviation system affect the relations between organisations that contributes to aviation safety (crosswise)

According to the objectives, we attempt to map the simultaneousness of changes and their possible implications for safety in the Norwegian civil aviation sector, ranging from a legislative level to ground level operators.

2 THEORIZING ON COMPLEXITY

2.1 What is complexity?

Complexity can be seen as a systemic property, permeating every level and actor of for example the civil aviation system, from the particular work tasks of the aviation technician to the changes implemented at a national and international political level. The following four categories of complexity reflect this view (Pettersen et al. 2008):

- **Technological complexity** arises from increased specialization, increased interactions, and reduced transparency that may contribute to hide critical system connections and dependencies, making the...
system more vulnerable (Wolf 2001, Perrow 1984). Applied at the aviation system, advanced computer systems may complicate observation and correction of error signals for the aviation technician.

- **Work situation complexity** is a product of cognitive aspects of the individual and the particular work situation or process (Rasmussen 1982, Goodstein et al. 1988, Woods 1988, Amalberti 1996, Hollnagel 1996). Transferred to the aviation system, complexity arises from how the work situation of the aviation technician is shaped by interactions between the particular process (maintenance of flight engine), user interfaces (visualization capability of tools), the individual itself (experience, competency, process knowledge), and the context of the individual (organizational structure, colleagues).

- **Organisational complexity** can be defined in a number of ways. One view is that organizations are open systems, where individuals, technology, and structures interact within and outside the organization, seeking ways of adapting to the environment (Weick 1977, Morgan 1986, Sandelands & Drazin 1989, Drazin & Sandelands 1992). Another view is that organizational complexity arises from attempts at achieving higher reliability between technology and individuals through redundancy of individuals and systems, and operational/collective sensitivity, thus increasing not only resilience to errors and accidents, but also the overall organizational complexity. Within the aviation system this can be seen through aircraft designs utilizing several computer systems that support the same functions (technical redundancy), and through pilots and technicians conferring with one another and thus maintaining the reliability of these systems (human redundancy and collective sensitivity).

- **Political/economical complexity** occurs when impulses and decisions at a macro level influence the premises and practices at meso (organization) and micro (operational) levels. Within the civil aviation system this can be observed through changes in national and international regulations and market conditions (deregulation), facilitated by national authorities and key international actors (like the European Aviation Safety Agency, EASA). Combined, the varying origin and changing nature of decisions and impulses challenge the ability of the particular organization to adapt, interpret and adjust, thus introducing political complexity. In addition, deregulation introduces competition and new actors, placing increased pressure on profit margins and operations, giving rise to economical complexity.

In addition, several case specific theories provide insights into particular complexity aspects that can improve our understanding of the aviation system:

a. Snook (2000) sees the accidental shoot down of two Black Hawk helicopters over Northern Iraq in 1994 (case) as a combination of interactions between individual and organizational factors. Specifically, due to perceptions of global procedures as static and impractical local adaptations of rules and procedures had occurred both at an individual level (pilots of the Black Hawk helicopters and F-15’s) and at an organizational level (practices within the control central). According to Snook (2000), over time this created a situation where local practices gradually detached itself from written procedures. Finally, the complex interactions between locally adapted practices of several actors both at an individual and organizational level contributed to the accident.

b. Similar to Snook (2000), Vaughan (1996; 2005) sees the Challenger accident as a culmination of individual, organizational, political and economical factors that over time had shaped the practices of the NASA organization in a particular way. Specifically, NASA had developed a tendency to normalize technical irregularities and deviations (individual and organizational aspects). The organization was also affected by an institutional culture (structural secrecy) and a production oriented culture that prioritized continued launching above thorough risk analyses (individual and organizational aspects). In addition, the organization struggled for continued support and resources from Congress, and a need for publicity (political and economical aspects). According to Vaughan (1996; 2005), the accident was a result of complex interactions between all these aspects.

c. Comparable to the complexity picture provided by Snook (2000) and Vaughan (1996; 2005), Woods (2005) identifies five patterns within NASA that are characteristic of the complexity involved in the Colombia accident: (1) a focus on production pressure, eroding defences and creating a drift towards failure, (2) a focus on previous success rather than failure anticipation, (3) a loss of the big picture due to fragmented and uncertain basis for decision making, (4) a disregard for new evidence in current risk assessments, and (5) a focus on the chain-of-command rather than coordination and overlap between organizational units. According to Woods (2005), the complex interactions between these organizational aspects affected individual decisions and actions within NASA in an adverse way, ultimately leading to the accident.
2.2 Constructing a descriptive framework

The complexity discussion above suggests that both processes specific to the individual organization itself (e.g. work practices, safety principles) and factors outside the control of the organization (e.g. national and international regulations), affect and determine the impacts of changes on safety and the interactions within and between actors. Since we are interested in understanding the complexity of the system as a whole this implies studying micro, meso and macro levels (Rasmussen 1997). Hence, we have chosen to operationalise socio-technical complexity using categories that reflect both individual and systemic properties: context, history, changes, change perception, safety perception, and safety practice. Context includes internal aspects (e.g. work environment, technical tools) and external aspects (e.g. competition, influence from authorities, international trends), while history covers habits and patterns of the particular organization and the system as a whole. Changes can be of both internal (e.g. priorities of material and personnel) and external (e.g. national and international influences) character, while safety perception represents the expressed view on safety and safety practice and observable safety activities as they are practiced. Finally, change perception covers the expressed view on changes and change aspects.

3 METHODOLOGY

The paper is based on empirical data gathered in three case studies within Norwegian civil aviation:

- The civil aviation authority case consists of 26 interviews with inspectors, advisors and managers. The object of this study was to describe perceptions of safety, safety practices and changes.
- The air traffic control/airport operation case contains a study of five airports with 126 informants (interviews), aimed at diagnosing the safety culture as a means for improvement. The case also includes qualitative free text data concerning changes and safety aspects from a questionnaire survey, with 231 respondents (managers, planners, engineers, air traffic controllers).
- The maintenance case was carried out as an exploratory study of a line maintenance department, with participant observation, 15 interviews and a number of informal discussions. The goal was to gain insight into how safety is created and maintained through work practices at an individual/group level. The case also includes free text data from the described questionnaire survey, with 283 respondents within maintenance (managers, planners, engineers, aviation technicians).

The descriptive framework for analyzing empirical data was achieved by systematic reviewing, structuring (through categorization), and describing the informants’ and respondents’ perceptions of change and safety aspects in each of the three cases, utilizing quotations and descriptions as close to the data material as possible. In all cases, research quality was ensured using trustworthiness criteria (Guba & Lincoln, 1981).

4 RESULTS

After empirical categorization according to our descriptive framework, the categories safety perception, safety practice and change perception are used both within and between the three cases. Below we present results according to these categories, within each case first (research objective 1) followed by a cross case comparison (research objective 2).

4.1 Results within cases

4.1.1 The Civil Aviation Authority (CAA) case

Safety perception: Informants demonstrate a strong awareness of how formal control mechanisms can support safety, emphasizing the role of market control (with operators), use of regulations to create predictability and the desire to standardize the relationship between operators and the authority. However, many informants describe safety as a general concept, in terms of being beneficial to society, achieving a $10^{-7}$ risk level etc. A lack of precision in the safety definitions was supported by informants’ impressions that CAA lacked a clearly articulated and communicated safety philosophy, and a collective coordination, discussion and communication of regulatory practice.

Safety practice: The results suggest that a strong individual safety consciousness exists within the CAA, evident from statements like “we all have an individual safety policy”, “we handle safety in a responsible way” and “you are never fully qualified when it comes to safety”. On the positive side, these quotations are examples of professional pride, responsibility and willingness to learn and evolve (professionalism traits). However, an approach to safety based on the values and norms of the individual also runs the risk of facilitating variations in safety practice, as these quotations demonstrate: “the inspection practice is fragmented”, “there exists a high individual consciousness, but no collective coordination” and “the organization lacks an overall inspection practice that is standardized rather than dependent of individuals”.

Change perception: Informants typically describe the recent focus on risk based inspections (focusing on identifying and addressing system weaknesses and risks), opposed to the previous practice of
detailed inspections. The transition to such inspection methodology has been problematic due to variations in concept definitions and interpretations, a lack of responsibility, and the creation of a risk-based approach in an organization based on individual practice and tacit knowledge. The change from a single-provider (monopolist) market to deregulation, resulting in increased competition and focus on the individual airline, marks another important change for the informants. This change has demanded increased vigilance and inspection openness/focus, and it has also created a certain lack of clarity between the desire of political authorities to lower the requirements for operators within the market and the focus of the CAA on thorough evaluation of existing and new operators. International rules and regulations are commonly discussed by many informants. The transition to EASA (European Aviation Safety Agency) is described as particularly problematic, since the existing national legislation has to coexist with the new EASA regulation for several years. This is seen as time consuming, further complicated by descriptions of how political authorities restrict the resources for updates on changes and translation of changes from English to Norwegian. According to one informant, the problem of being updated is symptomatic of the many and simultaneous international changes in general. A fourth important change is the relocation of CAA from Oslo (south of Norway) to Bodø (north of Norway). During the relocation process, loss of competency and knowledge transfer (tacit knowledge) occurred when much of the existing (experienced) personnel were unwilling to move to Bodø and had to be replaced by new personnel. Other informants describe the effects of this situation as lessened by the professionalism of the individuals in Oslo, and their determination to transfer existing competency.

4.1.2 The air traffic control/airport operation case

In this case, we discuss safety perception related to the questionnaire survey, and safety practice related to the study of five airports. In addition, a selection of change categories identified from the questionnaire survey is discussed.

Safety perception: To achieve safety within aviation, many respondents focus on all measures and efforts aimed at reducing or avoiding incidents and accidents. Other respondents define safety through the creation of barriers against adverse events, through reduced risk of incidents and accidents or through personnel, routines and systems that can reduce risk or affect the safety level. The focus on achieving aviation safety is also reflected through the view that all individuals, equipment, procedures, rules, etc involved in the transportation of passengers from point A to B, as a whole, contribute to aviation safety. The following quotations illustrate such views: “to achieve acceptable flight safety all parts of the organizations involved must have safety as a first priority” and “[aviation safety involves] physical and human aspects that are relevant to air traffic, and all factors that directly or indirectly affect task performance”.

Safety practice: Several results indicate variations in the practice of safety. Informants in three of five airports describe procedures as characterized by having high respect, status and normative value, as illustrated by one informant: “when the work entails routines we do not know, we consult the procedure”. In contrast, the two remaining airports emphasize everyday work routines as less rule by procedures, and where procedures are considered more of a guidance for instance to drive ways, speed limits and security/access. However, among all airports deviation from procedures occur due to security interfering with the performance of everyday work tasks, or due to the need of getting the job done, or due to a lack of training and/or procedural knowledge. The procedural deviations to a lesser degree occur among the former three airports. Variations in safety practice are also evident in how airports handle conflicting goals. Within three of the airports, conflicts between safety and other concerns are handled positively through (a) management’s way of prioritizing safety, (b) prioritizing safe job performance above efficiency, and (c) the utilization of necessary resources to support safe practices. Informants at the other two airports emphasize that there exists conflicts between safety and the need of getting the job done, and that they are not being properly resolved. Contributing factors include the need to resolve traffic load in tight areas to ensure production and turn around time, resulting in procedural deviations.

Change perception: 8 change categories are identified in the questionnaire survey. (1) Restructuring, (2) development in reporting systems, (3) development in technology, systems and equipment, (4) development in competency, (5) development in quality and management systems, (6) development in international regulation, (7) development in security, and (8) economy and efficiency. In this paper, category 1, 4, 6 and 8 are discussed to illustrate main results.

Among descriptions of restructuring, the privatization of the air traffic control/airport operation organization and a recent efficiency program are seen as negative change influences, in combination with a negative view on restructuring processes in general among respondents, in terms of insecurity, unrest, malcontent, stress etc. Negative associations also relate to the relocation of the CAA to Bodø, the merging of airlines and the reduction of air traffic control stations. A positive restructuring process emphasized by
many respondents is the creation of the CAA as an independent organization. Other positive associations to changes include competence development, such as introducing requirements to practical and theoretical competency updates and testing through courses, and implementing crew resource management (CRM) programs. Positive descriptions also include development in international regulations in the direction of “harmonization of rules and procedures” and “more uniform use of procedures and systems”. According to one respondent, the focus on standardization has resulted in “improved predictability of air traffic flow”. Of negative change influences the focus on economy and efficiency are particular strong among respondents, including views that a recent efficiency program (downsizing, cost-cutting) have shifted the priorities in direction of economy, creating a conflict between economy and safety in general and specific issues like lack of education and a double moral (speak safety but act opposite).

4.1.3 The maintenance case

In the maintenance case, we discuss safety perception related to the questionnaire survey, and safety practice related to the line maintenance study. In addition, a selection of change categories identified from both studies is discussed.

Safety perception: Many respondents see aviation safety as a product of the entire system, meaning everyone involved in the process of achieving a safe flight from A to B. This attitude is supported by descriptions such as “quality in all parts of the process”, “same attitude in all areas” and “focus on quality/safety in all parts, for employees, customers and authorities”. Respondents, and in particular aviation engineers, also define aviation safety as performing work tasks in accordance with regulations, procedures, documents and routines from authorities, airlines and aviation fabricants. This focus on “technical diligence” is supported by respondents valuing task qualification, training and motivation. Overall, the value of a safe flight and the protection of human lives and materials involved are strongly expressed by all respondents.

Safety practice: Within line maintenance, informants describe three distinct mechanisms that support the safety practices in the organization. One is the utilization of practical and experience-based informal knowledge, where technicians through trial and error seek the right person with required knowledge to address grey zones in formal documentation, for example in terms of resolving what a component’s normal situation is. In other words, informal competency and practical skills compensate for grey zones in formal documents, procedures and thus a lack in the basis for decision-making. Another safety mechanism is the use of slack resources, where experienced conflicts between work pressure and safety concerns are resolved by the technicians by valuing and employing a slower pace to address safety issues and increase reliability, particular in critical situations, even though this may lead to flight delays. The third mechanism, flexibility, is a product of the two former, in that the focus on slack resources and knowledge seeking creates a work organization with flexibility and ability to judge errors and solve problems.

Change perception: The following 7 change categories are described by informants and respondents: (1) Restructuring, (2) development in reporting systems, (3) development in technology, systems and equipment, (4) development in competency, (5) development in international regulation, (6) development in security, and (7) economy and efficiency. In this paper, categories 1, 2 and 3 are discussed to illustrate main results.

Within the line maintenance organization, several restructuring processes seemed to affect safety practices. The organization went from being a technical division integrated in an airline to sale and merger with a competing airline as a result of falling income and increased competition. As a result, the line maintenance organization became part of a larger independent technical unit separate from the airline. A consequence of the separation from the airline was reduced communication between the line organization and the maintenance control center of the airline, a coordinating unit responsible for overview and specialized information flow. Reduced communication in turn affected the competency base of the line organization, reducing access to experience, knowledge and resources that were crucial elements in technicians’ safety practices. According to several informants, fewer refreshing courses also followed the restructuring processes, reducing technicians’ knowledge on both technological developments and on new failure types and solutions. Finally, restructuring of the organization also meant that the line base was relocated from the airport itself (3 minute drive), forging a physical detachment between line technicians and operative personnel and thereby reducing the previous ability to exchange information between technicians and pilots. As a contrast to the negative changes within the line maintenance organization, respondents from the questionnaire survey describe improvements in routines for reporting and reporting in general and improvements in technical (computer-based) solutions for reporting. These changes seem to have affected reporting and follow-up positively. Technical developments within other areas, like new equipment in airplanes and helicopters and new airplanes, navigation and radar systems, are also perceived as safety enhancing by respondents.
4.2 Results across cases

4.2.1 Safety perception
In all three cases procedures, rules and regulations are seen as beneficial to safety, although the understanding differs between informants and respondents in each case. For example, within the civil aviation authority case and the air traffic control/airport operation case rules and regulations are seen as a market stabilizing mechanism and an important factor in achieving a safer air traffic respectively, while within maintenance the work on safety is concerned primarily with how regulations, procedures and documents regulate job descriptions and practices. Despite variations, all informants and respondents share common descriptions and definitions of safety as ensured through (a) the absence of incidents or accidents and (b) the common focus on achieving a performance or safety level of flight traffic that do not pose a threat to individuals and materials. The main difference between cases are evident from the more generally oriented understanding of safety within the civil aviation authority case (beneficial to society, $10^{-7}$ risk level) and the more specific understanding of safety in the air traffic control/airport operation and maintenance cases (what safety should include and how to achieve it). These variances in safety understanding can naturally be attributed to the supervisory tasks of the former and more specific tasks of the latter cases.

4.2.2 Safety practice
The enactment and practice of safety in the civil aviation system as a whole have characteristics that are common for the three cases. However, the characteristics also involve aspects that are unique to the particular case. Among the shared characteristics, the strong sense of responsibility, professionalism and safety awareness are common occurring traits across the cases, contributing to a higher understanding of safety challenges as well as aiding the integration of safety in actual work tasks. However, the civil aviation authority case differs from the two other cases, in that the safety responsibility has a tendency to be dependent on the individual rather than the collective. Another shared characteristic is the high respect, status and normative value of procedures, rules and regulations, making these aspects an important part of the informants’ and respondents’ safety perceptions and practices in all three cases. However, all cases demonstrate that the transition from the formal system (rules, regulations etc.) to practice is problematic, caused by for example problems of enactment (procedural deviations), sometimes insufficiently defined procedures (grey zones) and conflicts between safety and other priorities (conflicting goals). To manage the transition from “theory” to practice, all case organizations demonstrate informal mechanisms that aid the transition process. For example, in line maintenance practical experience transfer, easy access to individuals and competencies and learning across organizational units have facilitated improvisation, adaptation and flexibility as means of handling increased time pressure and conflicting priorities.

4.2.3 Change perception
The perception of changes both varies and co-varies across the three cases, where for example changes related to technology are given solely positive associations while changes related to restructuring almost exclusively are viewed negatively. In the middle of these extremes, the change categories of competency and international developments receive mixed descriptions by respondents. Specifically, negative perceptions of restructuring changes are attributed to relocation of the civil aviation authority and to processes of efficiency and airline merging, while positive perceptions of changes to technology are attributed to improvements in reporting systems, equipments and tools. Furthermore, in all three cases downsizing, cost-cuts and increased demands on profit represent negative associations to economy and efficiency. Concerning mixed change impressions, these relate to for example how competency in air traffic control/airport operation is seen both as beneficial to safety (via updates, courses, CRM) and as a “threat” to safety (lack of education). Similarly, international developments of rules and regulations are described both as a strength to safety in the air traffic control/airport operation and maintenance cases, improving standardization and harmonization, and as a negative influence on practices in the civil aviation authority case, creating conflicts between existing and new regulations in terms of translation delays and resources required to update legislation.

4.3 Lessons learned
From the results within and across the three cases, we identify four “lessons” of importance to the civil aviation system:

➢ The management of change and safety is achieved through a combination of both formal rules and procedures and informal mechanisms.
➢ An individual approach to safety is important to handle specialized roles and functions, while a collective approach improves change coping, coordination and goal awareness among individuals and organizations.
➢ The focus on professionalism and professional pride helps individuals and organizations to adapt to changes and stabilize consequences of changes (e.g. the safety mechanisms within the aviation maintenance case).
Processes of restructuring, such as relocations, mergers and downsizing, represents a challenge to safety in all three cases, and requires higher awareness both by the individuals and organizations initializing them and by those affected.

5 ANALYSIS

Based on the results, we discuss the different complexity categories within our civil aviation transport case. In addition, we point to aspects our study shares in common with previous case studies within aviation (Snook 2000, Vaughan 1996; 2005, Woods 2005).

**Technological complexity** and **work situation complexity** are best illustrated through the aviation maintenance case, where technicians interact with specialized (aircraft) computer systems and equipment. To handle this complexity, the case organization utilizes practical and experience-based knowledge and resource slack. This flexibility means that when the organization faces a new situation where systems or components act in unforeseen ways, potentially hiding critical system functions and dependencies, the right person for the particular task is searched for throughout the organization and across organizational boundaries. In other words, the informal coping mechanisms of seeking individuals with specific knowledge and/or of reducing the pace of a particular operation help improve the transparency of the interface between individuals and technology. This reduces work situation complexity and thereby also prevents possible unintended or unwanted “side effects” of the particular operation that might adversely affect safety.

All cases show **organizational complexity** elements that fall within the definition of organizations as open systems, where individuals, technology and structures interact within and outside the organization, seeking ways of adapting to the environment. For example, in all cases individuals and organizations seek adaptation to changes in national and international regulations and legislations, by integrating new safety protocols in current operations (the air traffic control/airport operation and line maintenance cases) or by implementing additional rules and regulations for inspection (the civil aviation authority case). Similarly, new market conditions, such as increased competition and demands for profit, has led to the development of new inspection methodologies (the civil aviation authority case) and a focus on efficiency and cost-cutting (the air traffic control/airport operation and line maintenance cases). Overall, both examples illustrate how the particular organization interacts with local, national and global aspects of its environment, and seeks way of countering the effects of changes in the environment.

In all three cases, **political/economical complexity** plays a major role. One example is how changes in international rules and regulations require the civil aviation authority to handle two parallel and coexisting legislations (national and international). Another example is how deregulation at a national level has created new market conditions, with restructuring demands (downsizing, cost-cutting etc.) occurring in both the air traffic control/airport operation and line maintenance cases. A more specific political complexity aspect can be seen in how an increase in the number of actors competing within the civil aviation market has lead to the development of a risk based inspection methodology, aimed at capturing systemic safety concerns. Results of the civil aviation authority case suggest that the development of the new methodology is challenged by changes at a national (deregulation) and international (new/modified rules and legislations) level, thus adding further layers to the picture of political complexity.

Overall, both our results and analysis support a methodological approach to civil aviation, based on identifying and understanding unique traits of the individual parts of the system (the particular case) as well as traits common to two or more parts (across cases). Specifically, by comparing the unique individual, organizational and economical/political aspects of the particular case, we gain better understanding of how unique and common elements interact, creating a complex system that affects change perceptions, safety perceptions and practices and change implementation. In sum, the use of complexity to understand change and the effects of change on safety is similar to and support the complexity perspectives applied by Snook (2000), Vaughan (1996, 2005) and Woods (2005) in understanding the factors involved in several specific accident scenarios.

6 CONCLUSION

Next, we address the research objectives of the paper, followed by our future concerns for safety in the civil aviation transport system of Norway.

6.1 The research objectives

Objective 1: “To explore whether changes in different parts of the Norwegian aviation system affect the safety work within each organisation (internally)”

Within each case, the results above suggest that safety work within all three organisations has been influenced by one or several changes, in both positive and negative direction. Negative tendencies are first and foremost illustrated by views on relocation processes and how they affect competence transfer and development of risk-based supervision (regulator), and by views on restructuring processes and how
they increase the focus on costs and downsizing, and how they change flexibility and safety practice (airport operation/air traffic control, maintenance). However, data also suggests that negative tendencies are counteracted by positive change initiatives, where learning abilities, reporting frequency, competence level, and technical standard are strengthened by changes related to reporting routines/systems, equipment, technical facilities, technology, competence, and harmonisation and standardisation.

Objective 2: “To explore whether changes in the aviation system affect the relations between organisations that contributes to aviation safety (crosswise)”

Across the studied cases, we find that a number of qualities contribute to unite and strengthen the safety work within the civil aviation system. Characteristic features are employees’ professionalism, safety consciousness, and responsibility related to occupational practice. In addition, there is a strong emphasis on regulation, procedures, and new technology combined with a focus on learning and improving existing competence. At the same time, and as a contrast to these features, the empirical material indicate that relations across organisations are influenced by new organisational and physical interfaces (relocation of regulatory authority, separation of maintenance from airline company, relocation of line maintenance base away from airport) that may reduce the conditions for how safety work is practiced in the aviation system. More specific, this concerns the premises for how each organisations and the aviation system as a whole are able to attend the collective approaches and mechanisms shown to be essential for safety.

6.2 Future concerns

In our opinion, new organisational and physical interfaces that affect the relations between the different actors of the Norwegian aviation system represent the main challenge regarding implications of changes for aviation safety in the future. In addition, the results clearly document how societal characteristics in forms of developments within market and technology, safety regulation, and internationalisation have both direct and indirect consequences for the different actors’ safety work and in turn for the overall aviation safety. The results also demonstrate that a combination of internal and cross-wise studies of actors and levels provide insight into system traits as well as individual traits, with implications for the system as a whole. An example is how our results indicate that informal mechanisms for coping with change (system trait), like flexibility, slack, utilization of knowledge (line maintenance case) and transfer of tacit knowledge (the aviation authority case), can become threatened by larger structural changes, such as relocation or efficiency programs. This supports a system approach to understanding changes and implications to safety that we believe should be continued in future research endeavours focusing on understanding and managing changes.

ACKNOWLEDGEMENTS

We wish to thank the Norwegian Research Council for financing this work as part of the RISIT (Risk and Safety in the Transportation Sector) program. We also wish to thank our network within Norwegian civil aviation that contributed with enthusiasm and knowledge in planning and accomplishing the project. Special thanks go to Avinor and the Sola Conference for their financial contribution to the project. Access to a questionnaire survey within the Norwegian civil aviation transport system, was made available to us by the Accident Investigation Board Norway and Institute of Transport Economics. Finally, we wish to thank our research colleagues at DNV Norway and the International Research Institute of Stavanger (IRIS) for inputs and discussions, and Preben Lindøe who stepped in as a project manager in the difficult initial research phase.

REFERENCES


