

## **The challenges in defining aviation safety performance indicators**

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**Abstract:** Many States are moving away from a very active role in the supervision of aviation activities. The reasons for this include the large number of inspectors required to perform this function, confusion over safety responsibilities and the need for a large enforcement organization, factors are assumed to contradict the safety culture that is promoted as being an important factor in safety management. Instead of the active supervision of aviation activities, regulators require that aviation service providers such as aerodrome operators, air traffic service providers, aircraft operators and maintenance organisations, implement and maintain a safety management system. The performance of those safety management systems are then monitored by means of safety performance indicators. The development and measurement of proper safety performance indicators in an organisation is not straightforward however, and many important issues are still very much in the open. Which indicators represent the true safety performance of an organisation? What are the results if each organisation defines their own set of safety performance indicators, and how does this relate to indicators defined at other organisations? How can the reliability and quality of the data and data analysis be preserved? It is also vitally important to understand the interaction of safety management systems with other management systems for e.g. quality, occupational safety and environmental protection. And while safety culture is being regarded as essential for a safety management system, the constituents of a healthy safety culture are not entirely clear. This paper describes how a safety management system is related to a quality management system and how it is related to safety culture. Particular emphasis is placed on the difficulties for the development of safety performance indicators in an organisation as part of a successful safety management system.

**Keywords:** Safety management, Quality management, Safety culture, Safety Performance indicator.

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### **1. INTRODUCTION**

Aviation safety management is becoming a regulatory requirement rather than an industry best practice. This means that aviation authorities must find ways to oversee safety management activities of the industry to determine if they are compliant and the industry must achieve means to demonstrate compliance with existing regulations. Many States are moving away from the traditional forms of supervision by large numbers product inspections and are emphasising inspections of the industry's safety management systems (SMS). The performance of those safety management systems are then monitored by means of safety performance indicators. As of yet, the operational experience with measuring the effectiveness of safety management systems is very limited and there are many questions yet to be answered on measuring safety performance, demonstrating compliance with safety management regulations and the relation between safety management, quality management and safety culture. This paper provides an overview of the associated issues.

### **2. MANAGEMENT SYSTEMS IN AVIATION**

Aviation organisations may have to satisfy various regulations, including requirements of management systems for e.g., safety quality, environment and occupational safety. Current standards for quality, environment and occupational health and safety (ISO, 2008, 2004) and (BS OHSAS, 2007) have been made compatible with each other to enable organisations to align or integrate the various management systems in case they wish to do so. The common requirements in (European Commission, 2011a) for air navigation service providers (ANSP's), allow organisations to integrate the different management systems into one overall management system. Whether or not an organisation integrates the different management systems into one overall management system, it is vitally important to understand the interaction of safety management systems with these other management systems.

For example there is a difference between safety in an SMS and occupational safety in an Occupational Health and Safety Management System (OHSMS). The focus of safety in an SMS at an aviation organisation is on safety of the operation and the types of hazards that are identified in an SMS are the ones that can contribute to a catastrophic accident. The focus of occupational safety in an OHSMS is on the health and safety of employees or other workers, the types of hazards are directly related to individual workers and typically address risks of various types of physical injuries, including slips, falls, struck-by incidents, physical strains, electrocution, and vehicle incidents. There might be overlap between causes of hazards related to safety and causes of hazards related to occupational safety, therefore it is important to supply and share such kind of information between the applicable management systems.

It is also important to understand and recognize whether there are any conflicts between the requirements of the different regulations. In case of such conflicts, an organisation can solve this internally and if necessary agree it with the relevant regulators. There should be a correct balance between the different management systems within an organisation. For example when SMS is integrated into an existing QMS, the focus of quality should not be dominating at the cost of safety and some fundamental aspects which are relevant for SMS should not be lost. In case of proposed amendments or changes in one of the management systems, an assessment on the feasibility and consistency with the other management systems should determine whether it can be adopted, adapted or rejected.

## 2.1. Safety management systems in aviation

Safety management is considered by the International Civil Aviation Organization (ICAO) as a managerial process, with responsibilities at two levels: the state level and the level of the individual service providers. States are responsible to establish a safety program, which is an integrated set of regulations and activities aimed at improving safety. As part of such program individual actors such as aircraft operators, maintenance organizations, air traffic service providers and airport operators are required to implement an SMS (ICAO, 2010a, 2010b, 2009a) acceptable to the State that, as a minimum:

- identifies safety hazards;
- ensures the implementation of remedial action necessary to maintain agreed safety performance;
- provides for continuous monitoring and regular assessment of the safety performance; and
- aims at a continuous improvement of the overall performance of the safety management system.

An SMS shall clearly define lines of safety accountability throughout the organisation including a direct accountability for safety on the part of senior management.

ICAO provides a framework in (ICAO, 2009b) representing the minimum requirements for the implementation and maintenance of an SMS by an organization, which includes the four components and twelve elements as shown in Table 1. Within the aviation community these four major components of an SMS are generally accepted as a means of compliance to satisfy SMS requirements (e.g., (European Commission , 2011a), (FAA AC, 2010) and (UK CAA, 2010)).

Table 1. ICAO SMS framework components and elements

SMS framework components	SMS framework elements
1. Safety policy and objectives	1.1 Management commitment and responsibility 1.2 Safety accountabilities 1.3 Appointment of key safety personnel 1.4 Coordination of emergency response planning 1.5 SMS documentation
2. Safety risk management (SRM)	2.1 Hazard identification 2.2 Risk assessment and mitigation
3. Safety assurance (SA)	3.1 Safety performance monitoring and measurement 3.2 The management of change 3.3 Continuous improvement of the SMS
4. Safety promotion	4.1 Training and education 4.2 Safety communication

Whereas ICAO has harmonized the SMS requirements for the different types of operators, at European level still different requirements exist, e.g., SMS requirements including details for implementation for air traffic

service providers are given in the common requirements (European Commission, 2011a); accident prevention and flight safety programme requirement (i.e. requirement EU-OPS 1.037) for aircraft operators is given in the EU-OPS requirements in (European Commission, 2008a). This should be solved by the European Aviation Safety Agency (EASA) regulations for management systems, which are currently under development (EASA, 2011). EASA is also developing and Implementing Rules which will be adopted by the EC in the form of Regulations initially in April 2012 for air operations and flight crew licensing, and will be progressively extended to other domains of the aviation system, i.e., in December 2012 for air traffic management / air navigation services (ATM/ANS) and air traffic controllers and in December 2013 for aerodromes (Basic Regulation and its amendment (European Commission, 2008b, 2009)).

## **2.2. Relation between ICAO SMS and ISO QMS**

The International Organisation for Standardisation (ISO) standard (ISO, 2008) provides QMS requirements and a framework which consists of QMS documentation and four major areas: management responsibility, resource management, product realisation, and measurement, analysis and improvement. The Common Requirements considers this standard as a sufficient means of compliance for an ANSP to have a QMS in place which covers all services they provide, whereas the EU-OPS 1.035 requirement on quality systems for aircraft operators does not refer to ISO, and ICAO does not even give any QMS requirements, with the sole exception for approved maintenance organizations. The management system requirement as proposed by EASA (requirement OR.GEN.200 in (EASA, 2011) does not explicitly differ between an SMS and a QMS. This shows that the different requirements do not handle the relation between SMS and QMS in the same way.

To understand the relation between the two management systems, an analysis has been performed between the general internationally accepted standards (ISO, 2008) and (ICAO, 2009b). The general management system requirements for quality and safety in these standards show that:

- QMS requirements in (ISO, 2008) are applicable to any organisation and are focused on processes for product realisation in an organisation. The various types of products, which can consist of a (combination) of services, software, hardware and/or processed materials, can be measured rather straightforward by verifying whether product requirements are satisfied. ISO standard (ISO, 2008) does not require the identification of hazards.
- SMS requirements in (ICAO, 2009b) are applicable to aviation operators and are focused on identification of hazards in a reactive, proactive and predictive manner, and are focused on safety performance and continuous improvement of the overall performance of the SMS, which have to be monitored by means of safety performance indicators. The development and measurement of proper safety performance indicators in an organisation is not straightforward however, and many important issues are still very much in the open as is discussed in Section 4.

The detailed frameworks for implementation of the management systems for quality and safety in the considered standards show that that there are both similarities and differences.

- Both management systems include several similar types of elements (e.g., policy and objectives, management commitment, training, education, communication throughout the organisation) and where similar tools can be used such as internal evaluations, internal and external audits. Though for each of these elements the management systems have a different focus, i.e., a QMS focuses on product realisation and customer satisfaction, whereas an SMS on safety satisfaction. Therefore the differences are found in the way how these elements are implemented. The similarities enable an efficient way of working between the two management systems, for example through exchange of information between quality manager and safety manager, and solving any conflicts of interest between quality and safety related aspects.
- An essential difference can be found in the safety risk management component, it is a fundamental component in an SMS though is not a QMS requirement. Safety risk management (SRM) consists of reactive, proactive and predictive approaches to hazard identification, risk assessment and mitigation. Safety risk is expressed in terms of predicted probability and severity of the consequences of a hazard, taking as reference the worst foreseeable situation. An SMS investigates safety hazards and all contributing factors that might lead to incidents or accidents. A QMS does not require such hazard investigation nor does it require a proactive or predictive approach, and QMS requirements do not include the terms hazard or risk. A quality system does not investigate incidents or accidents for risk

assessment. Product realisation is a fundamental component in a QMS, which is about fulfilling requirements related to the product or services.

### **3. SAFETY CULTURE IN AVIATION**

Safety culture is being regarded as essential for a safety management system, though the constituents of a healthy safety culture are not entirely clear. The recital of EASA Basic Regulation (European Commission, 2008b) promotes the concept of a ‘culture of safety’, which requires incidents and occurrences to be reported such that there is a non-punitive environment and protection of such information and of those who report it. This means putting emphasis on just culture, which is actually a component of safety culture (Reason, 1997). In aviation, there are no requirements for the implementation of a safety culture in existing regulations today, with the exception of Performance Scheme Regulation and its amendment (European Commission, 2010, 2011b) which requires measurement of the level of implementation of a safety culture at an ANSP, though without giving a definition for safety culture. The Regulation also requires measurement of the level of presence or absence of a just culture at State level and ANSP level and includes a definition for just culture.

#### **3.1. Safety culture assessment tool ASC-IT**

Currently there is no unique definition of safety culture that is commonly used in literature. A review of the main existing and emerging safety culture definitions and their properties in aviation and beyond has been performed in (Montijn and De Jong, 2006) and (Montijn and Balk, 2010), and resulted in the following high-level definition of safety culture, i.e.,

*Safety culture is the enduring set of values and attitudes regarding safety issues, shared among all members at every level of an organisation.*

A more detailed definition of which in (Montijn and De Jong, 2006) refers to six safety culture characteristics, i.e., commitment, justness, information, awareness, adaptability and behaviour, and reads as follows:

*The safety culture of a group is the set of enduring values and attitudes regarding safety issues, shared among the members of the group. It refers to the extent to which the members of the group are positively committed to safety; consistently evaluate safety related behaviour; are willing to communicate safety issues; are aware of the known risks and unknown hazards induced by their activities; are willing and able to adapt themselves when facing safety issues; and are continuously behaving so as to preserve and enhance safety.*

The detailed definition of safety culture including its characteristics formed the basis in (Montijn and Balk, 2010) to develop a safety culture framework and safety culture assessment tool, called the Aviation Safety Culture Inquiry tool (ASC-IT). This tool has been developed to assist organisations in aviation with the assessment and management of their safety culture and is applicable to the entire civil aviation sector for both operational (like airlines, airports, ground handling providers, maintenance repair organisations, air navigation service providers) as well as non-operational bodies (like policy making agencies, regulators and inspecting agencies). The tool can be applied to all categories of organisations in aviation and to different levels within such organisations and provides a capability for benchmarking against similar organisations or other sectors within the aviation industry.

To enable a measurement of the safety culture of an organisation, the high level safety culture characteristics can be expressed in more detailed safety culture indicators, as is shown in Table 2. More detailed descriptions of these indicators are provided in (Montijn and Balk, 2010).

Table 2. ASC-IT safety culture characteristics and indicators

Safety culture characteristics	Safety culture indicators
1. Commitment	1.1 Management concern 1.2 Personal concern 1.3 Investment in safety
2. Justness	2.1 Evaluation of (un)safe behaviour 2.2 Perception of evaluation 2.3 Passing of responsibility
3. Information	3.1 Communication of safety related information 3.2 Safety training 3.3 Safety reporting system 3.4 Willingness to report 3.5 Consequences of safety reports
4. Awareness	4.1 Awareness of job induced risk 4.2 Attitude towards unknown hazards 4.3 Attention for safety
5. Adaptability	5.1 Actions after safety occurrences 5.2 Pro-activeness to prevent safety occurrences 5.3 Employee input
6. Behaviour	6.1 Job satisfaction 6.2 Working situation 6.3 Employee behaviour with respect to safety 6.4 Mutual expectations and encouragement

### 3.2. Relation between ASC-IT safety culture and ICAO SMS framework

The relation between SMS and safety culture is considered in (Eurocontrol/FAA, 2008) as inter-dependent, where SMS embodies the competence to achieve safety, and safety culture represents the commitment to achieving safety. Though, commitment is not only specific in a safety culture, as it is also one of the elements in an SMS. The relation between a safety culture and a safety management system can be illustrated by comparing the relation between safety culture indicators of ASC-IT and the safety management system elements of the ICAO SMS framework, which shows that:

- *Commitment* – Management commitment and responsibilities in an SMS are laid down in processes and procedures as part of the safety policy and objectives component, describing how commitment should be achieved. Whether in practice, individuals are really committed to safety is not part of the SMS framework, it is however an essential element of safety culture. Commitment in a safety culture reflects the extent to which every level of the organisation has a positive attitude towards safety and recognizes its importance.
- *Justness* – Just culture is an SMS requirement for aircraft operators (Sect. 3.3.7 in (ICAO, 2010a)) which requires that a flight data analysis programme is non-punitive and contains adequate safeguards to protect the source(s) of the data, and for voluntary incident reporting systems (Sect. 8.3 and App. E in (ICAO, 2001)) which are required to be non-punitive and for which sources of information shall be protected. However, just culture is not an SMS requirement for other operators in aviation. The safety policy in an SMS requires to clearly indicating which types of operational behaviours are unacceptable.
- *Information* – All safety related information in an SMS is documented in official documents. In addition, the safety promotion element in an SMS includes safety training and education and safety communication throughout the organisation. Whether in practice all employees know about all safety related information, and are willing to report is not part of the SMS framework, but is an essential element of safety culture. Information in a safety culture reflects the extent to which information is distributed to the right people in the organisation.
- *Awareness* in a safety culture reflects the extent to which employees and management are aware of the risks the organisation's operations imply for themselves and for others. All individuals should always be aware that safety can be improved and look for ways to do so; be aware of known hazards, and also constantly be on the look for new ones. A high level of awareness has a proactive character and can

support both the SRM component (e.g., hazard identification) and the SA component (e.g., continuous improvement of the SMS) in an SMS.

- *Adaptability* in a safety culture reflects the extent to which employees and management are willing to learn from past experiences and be able to take whatever action is necessary in order to enhance the level of safety within the organisation (reactive); to be proactive to prevent safety occurrences and solving safety problems; and employees should be encouraged to suggest improvements. A high level of adaptability can support the SRM component in an SMS.
- *Behaviour* – An SMS may describe operational behaviours in official documents, though it is necessary to probe people's real beliefs about safety, including their values and perceptions of others' values too, especially their peers and superiors. This is not an SMS requirement, but is one of the safety culture characteristics. Behaviour in a safety culture reflects the extent to which every level of the organisation behaves such as to maintain and improve the level of safety.

Most of the safety culture characteristics and indicators are related to the SMS components and elements but with a different perspective, e.g., in a safety culture employees should be encouraged to a reactive and proactive attitude and improvement towards safety occurrences, whereas in an SMS this is by means of formal procedures and processes. A positive attitude towards safety culture is a means to improve an effective implementation of an SMS, though is not sufficient to implement an SMS. Clear processes, procedures, SMS documentation, proper communication of these elements in an SMS are means to support a positive attitude towards safety and thus to improve safety culture. So the relation between SMS and safety culture is through a feedback loop where each can have a positive influence on each other.

## **4. SAFETY PERFORMANCE INDICATORS**

### **4.1. Safety performance**

The problem of measuring safety performance has been a topic for discussion for at least 50 years (Kjellén, 2009). Traditionally, accident rates were used to measure the performance of aviation safety, but when safety increased accidents became rare events and a larger statistical base was required.

ISO defines safety as the freedom of unacceptable risk, where risk is a combination of the probability of occurrence of harm and the severity of the harm (ISO, 1999). Harm is physical injury or damage to the health of people either directly or indirectly as a result of damage to property or the environment. According to this definition, safety is subjective because what is acceptable to one group of people might be unacceptable to another group of people. Safety also has a probabilistic aspect, and this is one of the reasons why it is a difficult subject to measure, since absence of harm does not necessarily indicate the absence of risk.

In case of aviation safety, the severity of the harm is described by ICAO's definition of an accident as an occurrence resulting in fatalities, serious injuries or severe damage to the aircraft (ICAO, 2001). Using this definition, we can define aviation safety as the absence of an unacceptable accident probability, and safety performance can be described as the accident probability that is achieved in relation to the accident probability that is considered acceptable. Therefore, aviation safety performance indicators should provide an indication of the probability of an accident.

### **4.2 Accidents as event sequences**

Tarrents (1963) proposed incidents as a basis for safety performance indicators. ICAO defines an incident as an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of the operation (ICAO, 2001). This definition fits well with the assumption that accidents involve the occurrence of a set of successive events that produce unintentional harm. The start of this sequence is a deviation or perturbation that disturbs the existing equilibrium or state of homeostasis. Heinrich developed a theory that introduces an additional dimension to such accident chain model. He compared the occurrence of an accident to a set of lined-up dominoes (Heinrich et al., 1980). Central to Heinrich's original statement of the model is the assertion that the immediate causes of accidents are of two different types; unsafe acts and unsafe conditions. Heinrich's domino model was also useful to explain how by removing one of the intermediate dominoes, the remaining ones would not fall and the injury would not

occur. Safety performance can be described according to the domino model as the number of dominoes that have fallen. The likelihood of all dominoes falling over (which defines an accident) is increasingly higher the more dominoes are already down. According to this model, incidents are cases where a few but not all dominoes have fallen and they can indeed be considered as indicators of safety performance.

Reason (1990) took Heinrich's unsafe acts and unsafe conditions a step further by refining the distinction between different types of failures that line up to create an accident. Building upon work by Rasmussen (1983), Reason describes an accident as a situation in which latent failures, arising mainly in the managerial and organisational spheres, combine adversely with local trigger events (weather, location etc) and with active failures of individuals at the operational level. Latent failures are failures that are created a long time before the accident, but lie dormant until an active failure triggers their operation. Their defining feature is that they were present within the system well before the onset of an accident sequence. This concept is often graphically illustrated as slices of holed cheese, each slice representing a barrier at a different organisational level. The holes in the cheese are barrier failures and an accident occurs when the holes line up. Since the holes determine the likelihood of an accident they can be considered as indicators of safety performance.

The models of Heinrich and Reason are conceptual models and do not provide detailed descriptions of falling dominoes or barrier holes that can be used directly as definitions or descriptions of safety performance indicators. However, models that are used in risk assessments often apply those concepts and they contain the necessary detail to derive safety performance indicators directly. Examples of such accident sequence models are the Integrated Risk Picture (IRP) of Eurocontrol (Perrin et al., 2006; Kirwan, 2007) and the Causal Model for Air Transport Safety (CATS) of the Dutch Civil Aviation Authority (Ale et al., 2006). These models are based on phenomenological knowledge and operational experience and are quantified with operational performance data and expert judgement. The model elements could be potential safety performance indicators.

Event sequence models like IRP and CATS are predominantly constructed of active failure events and do not contain many latent failure events. Modelling and quantifying the influence of management on safety is notoriously difficult (Lin, 2011). This characteristic in combination with the fact that accident sequence models are mainly quantified from (past) operational data means that event sequence models are a source of lagging indicators as they capture failure results from a past time period and therefore characterise historical performance. Leading indicators on the other hand are identified through comprehensive analysis of the organisations. Although the distinction between leading and lagging indicators is subject to confusion (Hopkins, 2009; Ale, 2009) it is relevant to consider other measures of how well the safety controls are functioning than just undesired outcome events. The difficulty with many leading indicators is that they are associated with organisational and managerial issues which are difficult to quantify and whose relation with accident risk is less obvious.

### **4.3 Characteristics of good safety performance indicators**

Rockwell (1959) identified the following characteristics of a good measure of safety performance:

- Quantifiable and permitting statistical inferential procedures
- Valid or representative to what is to be measured.
- Provide minimum variability when measuring the same conditions.
- Sensitive to change in environmental; or behavioural conditions.
- Cost of obtaining and using measures is consistent with the benefits.
- Comprehended by those in charge with the responsibility of using them.

The International Atomic Energy Agency (IAEA) adds to this that the accuracy of the data should be capable of quality control and verification and the total set of indicators should remain manageable (IAEA, 1999). Although the ability to quantify is often mentioned as a required characteristic (e.g. in Rockwell, 1959 and Øien et al., 2011), it is difficult to develop quantifiable indicators for some performance areas, such as safety culture. The desire to limit the amount of safety performance indicators often leads to attempts to develop composite indicators as using a large number of indicators can result in a lack of focus, but constructing composite indicators is difficult because any weighting process is value-laden and not necessarily neutral (Hakkert et al, 2007).

#### **4.4 Safety performance indicators for air navigation service providers**

The introduction of safety management systems in aviation has apparently triggered the European Commission to require ANSPs to measure safety performance by the following three indicators (European Commission, 2010):

- The effectiveness of safety management as measured by a methodology based on the ATM safety maturity survey framework.
- Application of the Risk Analysis Tool on the reporting of three categories of occurrences: separation minima infringements, runway incursions and ATM-specific occurrences.
- The level of presence or absence of just culture as measured through a questionnaire.

There are several potential problems with these indicators. First of all they are composite indicators and therefore not necessarily neutral. They do not fulfil the requirements for safety performance indicators as listed in the previous section. It is unclear if these indicators were derived by a systematic process and how they link to the risk control process. Such an approach is of limited value (HSE, 2001). The second performance indicator uses information gathered by manual reporting systems which have a weakness in the possibility of (invisible) underreporting.

Another difficulty may arise if a safety performance score is used to compare between different stakeholders. Unless the safety performance can be measured really objectively, such comparisons are a potential source of much confusion because it may be unclear if the difference is really caused by a difference in safety performance or because of the difference in measuring the safety performance. Such a difference in measuring can exist even when the indicators seem to be identical, for instance when there is a difference in interpretation of the definition of an indicator. Differences in safety performance will first have to be thoroughly investigated and understood before any conclusion on relative safety performance is drawn.

Measuring safety performance from indicators will require some time to be able to understand the mechanisms that determine how the indicators represent safety performance. Regardless of the theoretical and practical groundwork that was done to set up the system, the initial period of actual implementation should really be used for interpretation. Regulators themselves should be technically competent and should show good judgement in evaluations of safety performance indicators (Dahlgren et al., 2001).

## **5. CONCLUSION**

Aviation operators and service providers are subject to legislation and regulation concerning safety management systems and generally to other management systems as well, e.g. for quality, security, occupational safety and environmental protection. This requires a correct balance of the implementation of the different management systems within an organisation. It is vitally important to understand and recognize whether there are any conflicts between the requirements of the different regulations. In case of such conflicts this should be solved within the organisation and if necessary agree upon it with the applicable regulators. Regulations allow the integration of the different management systems into one overall management system, though it should be kept in mind that each individual management system should be implemented in a different way as they handle different issues. This requires a vital understanding of such differences both at the level of requirements and at the level of implementation. For example safety risk management is a fundamental component in an SMS, though not in QMS and product realisation is a fundamental component in a QMS; aviation safety in an SMS is concerned with safety of the operation, whereas occupational health and safety in an OHSMS is concerned with the health and safety of employees or other workers.

Safety culture is being regarded as essential for a safety management system, though there are no requirements for the implementation of a safety culture in existing regulations today, with the exception of the Performance Scheme Regulation for air navigation services which puts requirements on the measurement of both safety culture and just culture. The relation between a safety culture and an SMS can be described as a feedback relation, where each has a different perspective and proper implementation of both can support the other in a positive way.

The performance of safety management systems are monitored by means of safety performance indicators. Aviation safety performance indicators should provide an indication of the probability of an accident, the development and measurement of proper safety performance indicators however is not straightforward. Event sequence models like IRP and CATS are based on phenomenological knowledge and operational experience and are quantified with operational performance data and expert judgement, so they could be used for the development of lagging indicators. Leading indicators are associated with organisational and managerial issues, though are difficult to quantify and their relation with accident risk is less obvious. Though, it should be noted that the distinction between leading and lagging indicators however is still subject to confusion.

The Performance Scheme Regulation includes requirements for safety performance indicators, though there are several potential problems with these indicators. They are composite indicators, but its weighting process is value-laden and therefore not necessarily neutral. It is unclear how they link to the risk control process. Reporting on separation minima infringements, runway incursions and ATM-specific occurrences is based on information gathered by manual reporting systems which have a weakness in the possibility of (invisible) underreporting. Another difficulty may arise if a safety performance score is used to compare between different stakeholders. Unless the safety performance can be measured really objectively, it is necessary that differences in safety performance will first have to be thoroughly investigated and understood before any conclusion on relative safety performance is drawn.

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