International Transport Forum

Why SMS: An introduction and overview of safety management systems

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Discussion Paper 2017 • 16

Daniel Maurino

Independent Safety Consultant

OECD

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An introduction and overview of safety management systems

Discussion Paper 2017-16

Prepared for the Roundtable on
Safety Management Systems
(March 23-24 2017, Paris)

Daniel Maurino
Independent Safety Consultant

August 2017

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International Transport Forum
2 rue André Pascal
F-75775 Paris Cedex 16
contact@itf-oecd.org
www.itf-oecd.org

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Acknowledgements

The author is grateful to Mr Alain Lumbroso, Economist, International Transport Forum, OECD, Paris, France, Mr James Caton, CEO, Boyd Caton Group (BCG), Mr Ream Lazaro, Bus Safety Programme, BCG, Charlottesville, Virginia, United States, and Captain Robert Sumwalt III, Vice-chairman, National Transportation Safety Board (NTSB), for the in-depth review and valuable comments on the Discussion Paper.

Abstract

This discussion paper presents an introduction to safety management systems (SMS) as they apply to transportation organisations across modes and industries, and provides a broad overview of SMS and its processes, activities and tools. The discussion is grounded on conceptual foundations, but does not neglect the practical aspects of SMS implementation. The Discussion Paper draws to an extent – but not exclusively – on the experience of international civil aviation and the urban transit industry in the United States. The contents, however, are generic and presented in a fashion commensurate to the nature of SMS as a management system, the principles, processes and activities of which cut across inter-mode and inter-industry boundaries.

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Why SMS

This Discussion Paper presents an introduction to safety management systems (SMS) as they apply to transportation organisations across modes and industries, and provides a broad overview of SMS and its processes, activities and tools. The discussion is grounded on conceptual foundations, but does not neglect the practical aspects of SMS implementation. The Discussion Paper draws to an extent – but not exclusively – on the experience of international civil aviation and the urban transit industry in the United States. The contents, however, are generic and presented in a fashion commensurate to the nature of SMS as a management system, the principles, processes and activities of which cut across inter-mode and inter-industry boundaries.

The Discussion Paper builds upon historical perspective as means to set the scene and provide a frame of reference for perspectives on the conceptual and practical aspects of SMS introduced in subsequent sections. Scene setting and historical perspective are sometimes questioned on the assumption that they may distract from the bottom line. However, on the subject of this Discussion Paper, scene setting and historical perspective are of particular relevance, lest the dictum of the Spanish philosopher Jorge Ruiz de Santayana y Borrás, known in English as George Santayana, come true for SMS: "Those who do not remember the past are condemned to repeat it".

Defining SMS

Historical perspective: The "world before SMS"

This section provides a historical perspective of what the "world before SMS" looked like, safety-wise, in transportation industries. The section discusses the safety principles that prevailed and the disciplines that nurtured the prevailing safety principles, from which SMS would eventually evolve.

System safety

On May 25 1961 President John F. Kennedy stood before the United States Congress, and proposed that the nation should commit itself to achieving the goal of landing a man on the Moon and returning him safely to Earth before the decade was out. The goal was ambitious; the technology necessary to support achievement of the goal was brittle.

From the point of view of technology design, early space exploration in 1950s had built on the "fly-fix-fly" approach to aircraft design safety then prevalent in aviation: fly the aircraft, fix aircraft design problems after a safety mishap occurred, and continue flying the "fixed" aircraft until the next mishap, when the "fix-fly-fix" cycle would be reinitiated thus engaging in a vicious circle of sorts. President Kennedy's "call to arms" allowed a grass roots movement, incipient among the engineering

community in the 1940s and which had gained momentum during the 1950s, to become established in the aerospace industry in the early 1960's. The movement, system safety, was effectively a shift towards designing and manufacturing safer technology. By applying a formal and proactive approach to design and manufacture, a major milestone and a turning point in aerospace technology were achieved.

System safety is an engineering discipline. The objective of system safety is to make technical systems safe by "designing" safety into the technical system during its development: safety is essentially built into the system to cover the entire system life cycle, including manufacturing, testing, operations and maintenance. System safety's credo can be summarised in three words: safety by design.

The contribution of system safety to the aerospace industry development has been nothing short of phenomenal. System safety was a major contributor to the realisation of President Kennedy's dream of landing humans in the Moon. More relevant to this historical perspective, system safety became aviation's safety textbook for the ensuing 30 years, and the significant progress in technology accomplished by aviation between the 1960s and the 1980s was in no small degree due to the contribution of system safety.

System safety did not remain within aviation, and travelled across transportation inter-modal and inter-industry boundaries, becoming the safety framework for transportation industries to the present day. A point of historical perspective relevant to upcoming discussions on the development of SMS is that the notions of hazard, risk and mishap are a legacy (perhaps *the* legacy) of system safety to transportation safety.

System safety proposes a four-step architecture of intervention, based on hierarchical precedence:

- Design for minimum risk: eliminate the safety concern (the hazard) through design.
- If unable, incorporate safety devices: include design that automatically prevents the safety concern from becoming a mishap.
- If unable, provide warning devices: include devices that alert personnel to the safety concern in time to take remedial action, and
- If unable, develop procedures and training: provide instructions so that personnel will use information available to control the safety concern.

The first conclusion to draw from this historical perspective is two-fold. Firstly, as an engineering discipline, system safety was conceived for application to, and improvement of, *technical* systems (an aircraft, a ship, an engine, etc.) *exclusively*. Secondly, within the strong engineering notion integral to the fabric of system safety, the human operator is considered a liability to safety, due to the potential for human mishandling or mismanagement of technology (human error) during actual operations. This is evident in the hierarchical precedence of the four steps of intervention outlined in the previous paragraph.

Human Factors

Towards the end of the 1970s, a perception of diminishing returns regarding safety through design, and system safety's contribution to further safety improvement, had established within the aviation industry, and concern about human error in aviation operations was gaining headlines. Human Factors (with *caps*), a multi-disciplinary field of endeavour that had its origins – evolving from ergonomics – after World War II, and that had so far experienced a lukewarm reception in aviation, became a centrepiece of aviation safety during the 1980s, the 1990's and well into the first years to the 21st Century. Like system safety, Human Factors also travelled across transportation inter-industry

boundaries, and was adopted by other transportation industries, *albeit* not so quickly, enthusiastically and broadly as in aviation.

Human Factors is a field of endeavour[1] concerned with optimising the relationship between people and the operational environment by the systematic integration of human sciences and systems engineering. It is a scientific approach that deals with what people do in operational contexts, and aims at optimising operational human performance during transportation service delivery activities, thus contributing to the safety and efficiency of transportation operations.

Four scientific disciplines converge into the core of Human Factors: ergonomics (human-centred design of displays and controls), systems engineering (integration of system components, with operators' requirements as foremost consideration, to generate an homogeneous and functional entity), physiology (fatigue, stress, noise, temperature, pressure, vibration and similar human performance-related considerations that may affect transportation operations), and psychology, which branches out into social, organisational and cognitive psychology.

The second conclusion to draw from this historical perspective is also two-fold. First, as multi-disciplinary field of endeavour, Human Factors was conceived for application to, and improvement of, *socio-technical* systems (systems encompassing people and technology, in which people must actively interact with technology to achieve the system production goals). Transportation industries, regardless of mode, are prime examples of socio-technical systems. Second, within the multi-disciplinary notion of Human Factors, and in particular under the auspices of organisational and cognitive psychology, the human operator is considered an asset to safety, due to the ability of humans to "think on their feet" and provide response to safety deficiencies and operational situations unforeseen by design and planning. Closely linked to this consideration, human error, which had long been maligned as "cause" of safety breakdowns and had therefore been the stop point of the safety investigation, is considered a symptom of deficiencies deep in the architecture of the system rather than a cause, and is the starting point of the safety investigation. Under Human Factors, operational error is considered much in the same way as the medical science considers fever: an indication of problem(s), but never the problem(s) itself.

Business management

A federal law of the United States provides the third and last milestone in this historical perspective: the Aviation Deregulation Act of 1978, signed by President Jimmy Carter, which introduced the notion of free market into commercial aviation. Deregulation has been praised and demonised in similar proportions and with equal fervour and conviction among different quarters. Whatever the case may be, the historical fact remains that deregulation is the reason why business management practices were introduced into aviation safety: organisations that throughout their history had been subsidised by governments, directly or indirectly, had now "to earn their place under the sun".

The integration of business management practices into aviation safety forced the safety community into soul-searching and re-evaluation of long-established safety dogma. So far, the paradigmatic safety goalpost in aviation (and in all transportation industries) had been the absence of low frequency, high-severity events: safety was viewed as freedom from accidents (or freedom from harm). Under the influx of business management thinking, the safety community began prospecting higher frequency, lower severity events in search of alternative safety goalposts. Most important, business management led the safety community to explore ways to give sense to the safety dollar: was safety truly the first priority of the organisation, or must the safety return be worth the safety investment?

The extents to which business management practices have effectively been integrated into aviation safety, and to which they have travelled to transportation industries outside aviation, are open to discussion.

The third and last conclusion to draw from this historical perspective is also two-fold. First, the notion that "you cannot manage what you cannot measure" led to the development of multiple sources of organisation-specific data acquisition during operations. So far, the limited data points provided by accident investigation (and eventually serious incident investigation) as sole sources of safety data had generated valuable information for accident prevention, but did not generate data in volume enough for safety management. This forced, in the early days of business management, data aggregation (in many cases at regional and even worldwide level) to obtain data volume, thus removing specificity and therefore relevance of the data to a single organisation. Second, the fact that data acquisition must not be random, and that safety data collection must be performed by reference to defined parameters, which led to the development safety performance indicators and safety performance targets.

In summary and conclusion, "before SMS", the safety world of transportation industries had progressed along parallel tracks, under the piecemeal guidance provided by three defined but unmerged interventions: system safety, Human Factors, and business management. At the dawn of the 21st Century, the three parallel tracks began converging towards an intersection or point of confluence, and the challenge ahead for transportation industries became the coordinated integration of the three interventions into a coherent, intact whole. The result of this integration would be a new discipline named *safety management*, and the vehicle for the operationalisation of safety management would be SMS.

Developing the "world of SMS"

This section is divided into three parts that incrementally develop the "world of SMS". In following this development, it is important to keep in mind the difference between *safety management* as the discipline upon which SMS rests and that feeds conceptually its processes and activities, and the *institutional arrangements* that shelter, provide direction and operationalise what otherwise might be a set of disjointed processes and activities into a coherent management system.

The section kicks off – building upon the historical perspective in the previous section – by presenting how safety principles prevailing across transportation industries over a half-a-century evolved and were modified to become the fundamental processes and activities of the new discipline of safety management.

No processes or activities can take place or can be implemented effectively and efficiently in an organisational vacuum. Thus, the section secondly provides a perspective of how safety management processes and activities coalesce into a management system, by virtue of the protective and guiding shelter provided by specific institutional arrangements.

The section concludes by formulating a snapshot of what an effective and efficient contemporary SMS looks like, by merging the processes and activities with the institutional arrangements.

Two conclusions result from the section. One, the safety management processes discussed hereunder can be conducted piecemeal, without the need of a management system. In this case, the value of safety management processes to a transportation organisation will be limited. Two, the institutional arrangements discussed in this section may be implemented without delivering, in actuality during transportation operations, the safety management processes. In this case, the resulting SMS will be no more than an empty shell, and will bring no benefit at all to the transportation organisation. A

performing SMS must seamlessly integrate safety management processes and institutional arrangements.

SMS: Processes and activities

Safety management

Safety management is an evolutionary discipline that aims at turning safety and its management in socio-technical systems into a business function, along lines similar to those through which finance, legal, human resources, quality and any other business of the organisation are managed as business functions.

Socio-technical systems operate and, most important, fail in unique ways. An appreciation of success and failure of socio-technical systems operations requires a different perspective as compared to success and failure of purely technical systems. This section provides for such appreciation, by first presenting the role of compliance and performance within safety management and discussing a conceptual foundational block of safety management known as Practical Drift. The section then moves on to the two fundamental processes underlying safety management: safety risk management and safety assurance.

Compliance and performance

Most transportation industries operate under strict regulatory frameworks that provide direction to a broad spectrum of activities, ranging from technology design through equipment requirements to operational personnel training. Consider, for example, international civil aviation and the International Civil Aviation Organization (ICAO).

ICAO is a specialised agency of United Nations. It is a worldwide regulator supporting 191 Member States in achieving worldwide standardisation in international civil aviation practices. ICAO has promulgated over 12 000 Standards and Recommended Practices (SARPs) published in 19 Annexes to a baseline document called the Convention on International Civil Aviation, which sets forth the fundamental principles that govern international civil aviation operations. The Annexes in turn dictate over all aspects of civil aviation and must be complied with for legal engagement in international aviation transportation operations. ICAO has established a Universal Safety Oversight Audit Programme (USOAP) that audits Member States on a periodic basis to verify compliance with SARPs. Beyond the example of ICAO, all transportation industries rely on regulatory frameworks, either internationally or nationally. The belief of compliance with regulations as a cornerstone of safety is evident in transportation industries.

Compliance-based safety relies on conforming to established requirements regarding personnel, technology, equipment and procedures as conduit to safety, and on administrative controls – inspections and audits – to provide confidence that established requirements are met, thus ensuring safety.

Four basic assumptions underlie compliance-based safety. It is assumed that:

- Transportation operations can be fully anticipated during planning, including all possible eventualities and interactions that may take place among the different components of the operational context.
- Technology can be provided, procedures can be developed, and training can be delivered to cover for all eventualities and interactions in operational settings.
- Once operations start, safety is assured if front-line professionals observe established requirements, utilise the technology as predicated by procedures, and perform their operational duties according to the training received.
- Professionalism – by conforming to established requirements and prescribed operation of technology, to the execution of procedures as proposed, and by performing according to training received – further guarantees safety.

Simply put: follow the rules and safety is ensured. Under compliance-based safety, the safety paradigm is that non-conformances are damaging to safety. Recalling that the system safety credo can be summarised into three words (safety by design), it follows that compliance-based safety interfaces conceptually well with system safety. The conceptual interface between system safety and compliance-based safety is determinant in the belief among transportation industries – that rely on system safety as the framework for safety – that compliance is *the* cornerstone of safety.

Human Factors and business management challenge the notion of compliance as *the* cornerstone of safety on two counts. First, compliance provides evidence of possession of a required tool, but does not necessarily provide evidence of either knowledge or proficiency in the use of the tool in actuality. In simple terms: possession of a hammer is not synonymous with proficiency in hitting nails. Second, compliance lends itself to what in aviation has been called "cosmetic" compliance: the tool required is available to show during inspections and audits, but it is not used in actuality.

The wisdom in broadening compliance as single source for safety and complement it with performance seems beyond challenge, so that evidence regarding meeting requirements established for safety achievement is augmented with evidence regarding *actual* safety achievement. Actual demonstration of safety achievement is the objective of performance-based safety.

Five basic assumptions underlie performance-based safety. It is assumed that:

- Transportation operations cannot be fully anticipated during planning, nor can all possible eventualities and interactions that may take place among the different components of the operational context.
- Technology, procedures and training cannot cover for all eventualities that may arise during interactions among the different components in operational settings.
- Once transportation operations start, observing established requirements, utilisation of technology according to predicated procedures and training received, and professionalism are baseline factors for safety during operations.
- Nevertheless, situations unforeseen during planning (i.e. deviations from planning) will inevitably arise during operations, forcing front-line professionals to "improvise" and giving way to potential non-compliances with respect to planning.
- Therefore, transportation operations should be planned based upon the expectation of compliance, but must include provisions to allow for the active management, both at

individual as well as organisational level, of situations unforeseen during planning (non-compliances).

Simply put: the real world of transportation operations does not operate "by the book". Under performance-based safety, the real safety concern is the effective management during operations of situations unforeseen by planning, rather than non-compliances in and by themselves. Recalling that organisational and cognitive psychology both foster consideration of human operators as asset to safety, due to the ability to "think on their feet" and provide response to deficiencies and operational situations unforeseen by design and planning, it follows that performance-based safety interfaces well with Human Factors. Performance-based safety advocates for real-time monitoring of safety achievement, and this generates another interface, this one between performance-based safety and business management.

Compliance-based safety and performance-based safety were at a time considered from an adversarial, "either/or" perspective. This is a mistaken perspective: compliance and performance are parts of a continuum. Compliance sets the baseline; performance provides confidence not only that the baseline is met, but also that the intent of compliance is achieved during transportation operations. One does not replace the other; each one, by and in itself, is not enough to provide for safety in transportation operational contexts. Both are necessary. In fact, compliance and performance are both sides of the modern safety coin, a notion that will bear on further discussions as the Discussion Paper continues developing the "world of SMS".

The Practical Drift

The notion of the Practical Drift (PD) was first proposed by Scott A. Snook, and later adopted and adapted by ICAO as a conceptual pillar of safety management. The PD graphically captures both compliance and the performance and their contribution to safety, and shows why performance drifts away from compliance under operational conditions.

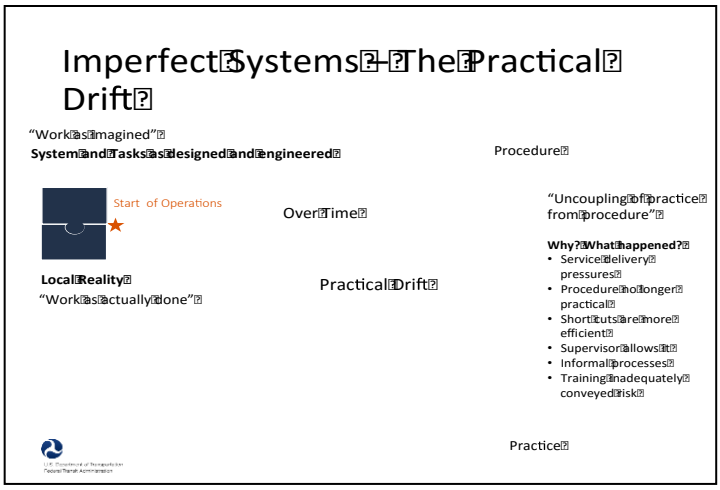
The PD is the slow but steady uncoupling between procedure and practice during transportation operations, and it is inconspicuous to the "naked eye". The PD proposes that a drift from compliance or procedure (work as imagined) to operational performance or practice (work as actually done) is unavoidable during transportation operations, no matter how careful and well thought out planning of operations might have been.

There are multiple reasons for the drift, including technology that does not always operate as advertised; procedures that cannot be executed as planned under real-time conditions; unmanaged changes in operating conditions; addition of new components to the operation; under-evaluation of the problems that changes to components of the operation might introduce; front-line employee shortcuts and local adaptations to procedures in an attempt to make the job easier; unforeseen consequences in shortcuts and local adaptations, and so forth.

Under close scrutiny, the reasons for the PD ultimately become a litany of attempts by front-line personnel to improve the effectiveness and efficiency of work, and to contribute positively to the organisation when confronting obstacles in the achievement of their operational tasks (i.e. getting the task done no matter what).

Thus, the PD is not necessarily bad, provided it is under the control of the organisation: shortcuts and adaptations by front-line personnel may turn out to be more productive, may save time and energy, may be easier, or safer. However, the PD can also work the other way around and put transportation operations close to a safety breakdown, because shortcuts and local adaptations are necessarily micro interventions, based upon a limited field of view, and more often than not lack the macro perspective necessary for effective management of changing conditions.

Figure 1. **The Practical Drift**



Source: United States Federal Transit Administration (FTA).

A shortcut to a procedure, or a practice that at face value seems harmless and efficient, could have a negative or damaging impact on another facet of the operation. This goes back to the interconnectivity of transportation operations – one small change in one aspect of procedure could lead to practices with potential for damaging outcomes on the whole of the operation. Control of the PD by the organisation is therefore essential. By actively controlling the PD, the organisation can learn about unsuccessful shortcuts and adaptations by front-line personnel, and eradicate them. Most important, the organisation can learn about successful shortcuts and local adaptations by front-line personnel, remove the micro component, and integrate them into the macro picture of safety management activities, thus strengthening the resilience of operations.

The PD represents the ultimate reality of the operational context of a transportation organisation: the world as it is and not as it should be. In fact, the PD *is* the operational context. This is because while procedures are "owned" by the organisation, practices are "owned" by front-line personnel, and transportation operations are delivered following practices. For this reason, capturing "what goes on" within the PD is fundamental under safety management.

If a transportation organisation is to be successful in controlling the PD, an approach to the management of safety that combines compliance (procedure) and performance (practice) is essential. Under safety management, two processes provide guidance to the activities to capture the PD under a combined compliance and performance approach: safety risk management and safety assurance. The Discussion Paper introduces now the first of these processes.

Safety risk management

Safety risk management (SRM) is a process[2]. SRM provides guidance to the execution of activities[3] aimed *initial control* of the PD. SRM aims at the capture of the greater amount possible of data reflecting what routinely "goes on" within the PD, and the analysis of the data to extract information.

SRM uses four entities to guide the collection of data for the initial control of the PD: safety deficiency, hazard, consequence and safety risk. Safety management borrows partially from system safety for the definitions of hazard and safety risk, but introduces broadening changes to the system

safety definitions. The changes are necessary to accommodate the expanded scope of a process applicable to socio-technical systems. Safety management also introduces two entities that are not considered by system safety: safety deficiency and consequence.

A *safety deficiency* is a system-wide condition with negative or damaging potential on safety during transportation operations. Safety deficiencies are a characteristic of an organisation or an operational context, and not a characteristic of a specific individual or group of individuals. Examples of safety deficiencies across modes of transportation include shortcomings in training curricula; inaccurate documentation; deficiencies in key activities such as safety inspections; ambiguity in operational procedures; staffing operational positions with personnel not meeting required qualifications, and so forth. Safety deficiencies are related to downsides in organisational processes that are largely under the direct control by the organisation.

The introduction of safety deficiency as a distinct entity is one of the differences between safety management and system safety. This distinction is necessary because the concern of safety management – success of socio-technical systems – starts with the design of the organisational processes that define the operational context within which people and technology interact. It is not considered necessary by system safety because its concern – success of technical systems – starts with the design of the technology itself.

A *hazard* is a condition or object – always present – with the potential of causing injuries to personnel, damage to equipment or structures, loss of material, or a reduction of ability to perform a prescribed function during transportation operations. Aviation examples of hazards include unclear/confusing airport signage, a hill in the take-off/landing path of aircraft, blowing dust/drifting snow, and so forth.

Transportation operations confront three types of hazards during their service delivery operations: environmental hazards (adverse terrain, wildlife and so forth), weather hazards (storms, icing, snow and so forth), and technical hazards (deterioration in the condition of facilities, equipment and materials since start of operations).

Any hazard classification proposed would face an inevitable question: What about the human in the system? Should the human be considered as a type of hazard? The answer is a most emphatic “no”. The last of the potential consequences of in the definition of hazard is a reduction of ability to perform a prescribed function during transportation operations, i.e. a reduction in operational human performance. Under safety management, lapses in operational human performance during transportation operations are the result of shortcomings in the operational context. This is in fact one of the distinguishing traits between safety management and system safety, as discussed earlier in the paper.

The definition of hazard under safety management is close to definition proposed by system safety[4]. However, there are three differences in the safety management definition of hazard that make it distinct from the definition by system safety: first, a hazard is always present (there are no potential hazards); second, the safety management definition of hazard excludes events (mishaps), and third, hazards are scoped down to conditions or objects could generate consequences during the delivery of transit operations exclusively.

A *consequence* is the potential outcome(s) of the hazard. Continuing with the aviation example, unclear airport signage (technical hazard) may lead to a runway incursion (potential consequence); a hill in the take-off/landing path of aircraft (environmental hazard) may lead to an inflight-collision (potential consequence); blowing dust/drifting snow (weather hazard) may lead to a loss of directional control of the aircraft (potential consequence).

During the early stages of exposure to SRM under safety management, analysts sometimes experience difficulties in hazard identification, confusing a hazard as one of its potential consequences. This is known as incorrect naming of the hazard, and brings difficulties in the identification of the specific components of the hazard while at the same time interfering with the identification of multiple potential consequences. In the examples above, the hazard "unclear/confusing airport signage" may lead to multiple potential consequences, of which runaway incursion is just one: other consequences may be taxiway incursion, collision among ground vehicles, collision between aircraft and ground vehicles, collision between aircraft, and so forth. If instead of correctly naming it "unclear airport signage" the hazard is named "runway incursion", all the other potential consequences will be left out of the analysis.

Thus, properly naming the hazard allows for identification of its specific components, accurate evaluation of the potential consequence(s), including magnitude, and effective mitigation of the potential consequence(s). The simplest and most effective consideration for distinguishing hazards and consequences lies within their respective definitions: hazards belong in the present, while consequences are potential outcomes, and therefore, belong in the future.

Safety risk is the quantification – expressed in terms of predicted probability and severity – of the potential consequence(s) of a hazard taking as reference the worst foreseeable (but credible) situation.[5]

Again, the definition is close to the definition of risk by system safety[6], but there are subtle yet important differences.

First, safety management scopes the notion of risk down to safety risk. This is because risk is not exclusive to safety: there is financial risk, quality risk, legal risk and so forth. Safety management is only concerned with safety risk.

Second, while system safety limits the evaluation of risk associated to mishaps (accidents), safety management broadens the scope to index the safety risk associated to low-consequence operational conditions (a runway incursion is an operational condition that is neither nor will necessarily lead to an accident).

Third, safety management evaluates probability of the potential consequence first, and then severity; system safety observes the opposite order of precedence. This is because safety management is essentially concerned with high probability/low consequence events; therefore, the safety risk evaluation and indexing under safety management aims at reducing the higher probability, since reduction in [lower] severity is quite difficult – when not impractical – in transportation operations. Under system safety, the risk evaluation and indexing is limited to mishaps, which by definition are low probability/high consequence events[7]. The "fat pickings" lie therefore in reducing severity rather than probability, which is low to start with.

The differences discussed in the three previous paragraphs are evident when comparing the definitions by ICAO (based on safety management) and by Military Standard (MIL-STD) 882E (based on system safety). United States defence standards, often called military standards or MIL-STD, are used to help achieve standardisation objectives by the U.S. Department of Defense. They are approved for use by all United States military departments and defence agencies within the Department of Defence (DoD). MIL-STD 882E is a key element of systems engineering that provides a standard, generic method for the identification, classification, and mitigation of hazards. It is a system safety standard practice that identifies the United States DoD adopted approach for identifying hazards and assessing and mitigating associated risks encountered in the development, test, production, use, and disposal of defence systems.

An important point of consideration is the fact that safety risk does not exist in the physical world; only hazards do. Hazards are *identified* and *analysed*; safety risk is *evaluated*. Safety risk is an

alphanumeric index that "puts a number" to the potential consequences of hazards. By quantifying the potential consequences of hazards, taking into account existing defences when evaluating probability and severity of the potential consequence(s), safety risk provides for prioritisation and thus a basis for senior management decision-making on the allocation of safety resources: safety risk helps prioritising allocation of resources to mitigate the potential consequences of hazards with the highest safety risk index. Safety risk evaluation offers a data-driven approach to safety resources allocation, which makes it easy to explain and defend.

In concluding this section, a caveat is necessary. The comparison between system safety and safety management should not be perceived as a confrontational comparison. It portrays a historical evolution, and differentiates the safety problems for which each discipline is a dedicated solution.

Safety assurance

Safety Assurance (SA) is the companion process to SRM. Under safety management, SA provides guidance to the execution of activities aimed at control of the PD. While SRM provides guidance for execution of activities aimed *initial control* of the PD, SA provides guidance for execution of activities aimed at *on-going control* of the PD.

SA encompasses activities to ensure that mitigations for safety deficiencies and hazards in the operational environment implemented under SRM work as expected. SA achieves this objective through analysis of data that allow for routine monitoring, during transportation operations, of the effectiveness of initial mitigations. As part of SA, alternative mitigations are implemented if initial mitigations are evaluated, through routine data monitoring, as ineffective.

Thus, while SRM looks into the future trying to anticipate safety problems, SA controls the present, providing confidence that safety problems are indeed under organisational control. The heart of SA is safety performance monitoring, an activity that generates the evidence necessary to provide an organisation confidence that the mitigations it has put into place are effective in controlling the PD. But before discussing safety performance monitoring, the Discussion Paper briefly addresses the notions of management and risk.

A word about management and risk: The terms *management* and *risk* are common currency in the safety language among transportation industries, but they are oftentimes applied in their colloquial rather than their dogmatic sense. Therefore, a word about their meaning and scope of application under safety management is relevant to this section.

The term *management* comes from the Italian verb *maneggiare*, meaning, "to ride a horse with skill". At face value, the definition appears as a metaphor that is unrelated to the imperative of managing safety during transportation operations. However, on deeper consideration, the implications of the meaning of the term in providing *direction*, *control* and *supervision* to safety activities become explicit.

The term *risk* is not limited to safety. Risk may be related to finance, legal, economics, quality or any other business of a transportation organisation. In fact, the term *enterprise risk* is used to encompass overall the risks faced by an organisation, and to underline the importance of their management.

The reason why the management of overall enterprise risk through dedicated management systems is important is because it managing enterprise risk ensures the continued viability of an organisation. Along this line, from a safety standpoint, the management of safety risk (i.e. providing direction, supervision and control to safety activities) through a dedicated management system is one contributor to organisational viability, and it is therefore the essential organisational process to be delivered by a transportation organisation to support safety as a business function.

There is nothing unique, distinct or specific to safety in the management of safety risk. The management of safety risk by a transportation organisation follows the three basic elements of organisational control theory, just as these elements apply to the management of finance, quality, human resources or any other management system that supports other business functions within the transportation organisation:

- setting risk management targets; in this case, safety risk management targets
- collection and analysis of information leading to risk monitoring; in this case, safety risk monitoring
- allocation/re-allocation of resources based on the analysis of information, to achieve the risk management targets set; in this case, safety risk management targets.

Setting safety risk management targets provides *direction* to the management of safety risks; the collection and analysis of information leading to safety risk monitoring provides *supervision* to the management of safety risk, and the allocation/re-allocation of resources based on monitoring to achieve the safety risk management targets established provides *control* to the management of safety risk. Providing direction, supervision and control to the management of safety risks lies at the heart of safety performance, through safety performance monitoring.

Safety performance and safety performance monitoring

For the management of safety risk to contribute to the continued viability of the organisation, it must take distance from traditional safety mind-sets long established among transportation industries, such as for example, safety first. The management of safety risk as an organisational process that supports safety as a business function must be situated at the same level of other organisational processes and business functions that contribute to the continued viability of the organisation: not above, not below.

The success of organisational processes and their interventions in achieving established targets compared to the investment required for such achievement allows assessing the performance of the interventions in question. From a safety standpoint and conceptually, safety performance is the joint consideration (i.e. the balance) between the safety achievements of a transportation organisation, and the effectiveness of the interventions implemented to realise the safety achievements[8].

Three steps are necessary to "engineer" safety performance according to organisational control theory. First, *direction* must be provided. This is accomplished by establishing the safety achievements sought, on the basis of regulatory requirements, industry trends and internal organisation data, and by implementing interventions to accomplish established safety achievements. Second, *supervision* must be conducted. This is accomplished by defining monitoring parameters that are representative of the effectiveness of the interventions that will be implemented to realise the safety achievements. Third, *control* of the effectiveness of the interventions to realise the safety achievements must be exercised, by reference to monitoring parameters.

Once safety performance has been "engineered", its monitoring must be conducted as close to real time as possible. Thus, safety performance monitoring is defined as the joint consideration in real-time [or as close to real-time as practical] of the actual safety achievements by transportation organisation and the effectiveness of the interventions implemented to realise the safety achievements. At is bottom-line, safety performance monitoring provides a scale of magnitude between efforts involved (including money) and safety achievements obtained.

In transportation operations, safety performance monitoring is conducted by reference to three entities: safety objectives, safety performance indicators (SPIs) and safety performance targets (SPTs). The Discussion Paper progresses now to the discussion of these three entities.

Safety objectives

A simple portrayal of the respective roles of safety objectives, SPIs and SPTs in safety performance monitoring is that safety objectives provide the *roadmap* for safety performance monitoring, while SPIs and SPTs are the *markers* that allow to track the status of progress on the roadmap. Safety performance monitoring requires a surrounding dimension that provides "shelter" to the direction SPIs and SPTs, and safety objectives provide such "shelter".

Establishing safety objectives for safety performance monitoring provides a vital blueprint for implementing and directing a transportation organisation's resources to achieve agreed SPIs and SPTs. Safety objectives likewise represent the organisation priorities regarding the management of safety risk.

In aviation, safety objective has been defined as "Brief, high-level statement of safety achievement or desired outcome to be accomplished by the State safety programme (SSP) or service provider's safety management systems (SMS)"[9]. Safety objectives must be concise and overarching; yet, they must convey an understanding of the potential activities that are necessary to achieve the desired SPIs and SPTs.

Safety objectives may be process-oriented, i.e., stated in terms of safe behaviours expected from operational personnel or in terms of safety interventions to be implemented by the organisation. Safety objectives may also be outcome-oriented, i.e., actions and trends regarding containment of accidents or operational losses. In order for a set of safety objectives to provide an effective surrounding dimension to "shelter" SPIs and SPTs, it must integrate both process-oriented and outcome-oriented safety objectives.

An example of a process-oriented safety objective and a related SPT – regarding a safety intervention by the organisation – would be as follows:

- Safety objective: [organisation] will implement and maintain an employee safety management training programme.
- SPT: During the current fiscal year, [organisation] will provide four monthly safety management training classes to which 90% of the employees shall attend.

An example of an outcome-oriented objective and a related SPT – regarding action for containment of operational losses – would be as follows:

- Safety objective: [organisation] will minimise adverse safety events during ramp service delivery operations through the introduction of appropriate ramp safety measures.
- SPT: During the upcoming eighteen months, [organisation] will experience no more than 0.63 events of damage to equipment per 10 000 ramp service delivery operations.

There is a potential for confusion between safety objective and SPTs if the terms are used in a colloquial sense instead of observing their "safety management meaning". The basic differentiation is that safety objectives are final and non-measurable/non-quantifiable, while SPTs are intermediate and measurable/quantifiable. Safety objectives convey an overarching statement of desired outcome related to the management of safety, while SPTs convey specific statements of desired improvement for a related SPI, where the inclusion of a specified time frame is essential.

Safety performance indicators (SPIs) and safety performance targets (SPTs)

ICAO defines safety performance indicators as "A data-based parameter used for monitoring and assessing safety performance" [10], and safety performance targets as "The planned or intended objective for safety performance indicator(s) over a given period"[11].

The notions of performance indicators and performance targets are neither new nor exclusive to aviation or transportation operations safety. They have been used outside transportation operations safety for many years; for example, they have been widely used by economists as a means to measure the "health" status of an economy. Transportation safety has adopted the notions, and adapted them as a means to measure the "health" status of safety. This section presents a discussion on the premises that must underlie the development of SPIs/SPTs, the potential pitfalls involved, and the types of SPIs/SPTs. The section wraps up with examples of safety objectives, SPIs and SPTs from the aviation and transit industries.

Premises in SPI/SPT development

There are five premises encompassing aspects of importance for SPI/SPT development.

The first premise refers to the importance of the transportation system description. A system description generates an initial snapshot on potential safety concerns associated to specific transportation activities. A system description also generates a catalogue of the processes and activities existing within the organisation to address safety concerns and provides a valuable and realistic initial baseline for SPI/SPT development.

The second premise refers to the importance of accurate identification and selection of organisation-relevant safety concerns to define SPIs. If the safety concerns selected are indeed those prevailing during transportation operations, SPIs will reflect valid and meaningful safety performance of the operations. Furthermore, SPTs development will be an easy task and will flow logically. The opposite is true. If SPIs do not reflect organisation-specific safety concerns, this might lead a transportation organisation to address issues of lesser impact on safety, leaving issues of larger detrimental impact on safety unaddressed. Additionally, irrelevant SPIs hold the potential to squander valuable resources (including money) in addressing low-priority or meaningless safety concerns.

The third premise refers to the degree of simplicity or complexity desirable for SPI definition. Complex SPIs may be perceived as "better", but complexity does not necessarily mean relevance. Simple SPIs may reflect relevant safety concerns within a transportation organisation. The determinant factor in deciding on SPI simplicity or complexity must be how commensurate SPIs are to the transportation organisation in terms of the size and nature of the organisation, the services provided, and the complexity of the operations in support of service provision.

The fourth premise refers to the clarity in the definition of intent. SPI development must be based upon clear definitions of the events, operational interactions or processes that the SPIs intend to reflect. Whenever possible, SPIs definitions must be consistent with standardised safety measurement(s) within the transportation industry to allow for benchmarking.

The fifth and last premise refers to the gradual implementation of SPIs. It is evident that data and data management capabilities are necessary to develop SPIs. Neither might initially be available to a transportation organisation to the extent necessary to develop meaningful SPIs. Therefore, SPIs development may follow a phased approach, whereby initial SPIs might reflect measurement of broad safety concerns, and as experience is gained, SPI development might progress to reflect measurement of more specific safety concerns. This approach, however, does not necessarily mean that SPIs must,

over time, become more complex measurements of more specific safety concerns. SPI may remain simple, yet entirely relevant, in perpetuity.

Pitfalls in SPIs development and selection

Commonly observed pitfalls in SPIs definition include:

- High analyst workload: creating an excessive amount of SPIs, or the necessary data to monitor the SPIs is difficult to access.
- Considering a partial safety management profile: SPIs that only reflect high severity/low probability events do not provide insights into those conditions that are less conspicuous but with potential for severe consequences.
- Unclear time frame: it is important to be clear how often SPI measurement must take place. This avoids misinterpretation and allow meaningful comparison over time.
    - Choosing metrics to suit the data: measuring what is easiest rather than what is most valuable.
- Consequences to failure in achieving SPTs: failure in achieving SPTs should not bring consequences, provided it is obvious that (a) due diligence was exercised in terms of allocation of resources and execution of action plans to achieve proposed SPTs, and (b) shortcomings in either allocation of resources or action plans are being addressed. The only foreseeable situation where consequences may apply is when there is unambiguous evidence of inaction in allocation of resources, implementation of action plans or their review.

Types of SPIs and SPTs

Two generic types of SPIs/SPTs are common in classifications adopted by different transportation industries: lagging SPIs/SPTs and leading SPIs/SPTs.

Lagging SPIs/SPTs – sometimes known as "Outcome SPIs/SPTs" – reflect negative outcomes that the organisation aims to prevent. Lagging SPIs are valuable for aggregate, long-term trending, either for specific occurrence types or locations. Because lagging SPIs reflect safety outcomes, they are a way of validating at a high-level the safety performance of the organisation. Two types of lagging SPIs/SPTs are generally defined:

- SPIs/SPTs for high severity/low probability negative outcomes, such as accidents or serious incidents. The low frequency of high severity negative outcomes means that aggregation (at industry segment level or regional level) may be necessary for meaningful analyses. An aviation example of a high-severity lagging SPI would be the number of runway excursion accidents/10 000 landings.
- SPIs/SPTs for lower severity/higher probability outcomes that did not manifest themselves in serious incidents or accidents. Such SPIs/SPTs reflect "precursor" events. SPIs for lower severity/higher probability outcomes monitor the effectiveness of safety risk controls place for mitigating the safety risk associated with the potential consequences of hazards. An aviation example of a lower severity/higher probability lagging SPI would be the number of non-stable approaches/1 000 landings.

Leading SPIs/SPTs – sometimes known as "Process SPIs/SPTs" – measure conditions that have the potential to become or contribute to either a high severity/low probability negative outcome, or a lower severity/higher probability outcome, but which have not realised such potential.

Leading SPIs/SPTs are particularly relevant from a safety management perspective, because they may be used to influence decisions on safety management priorities, including the allocation of safety resources. Leading SPIs support proactive development of the organisation's safety management capabilities because they inform the organisation about the dynamics of its operations and how the organisation copes with changes in its operating environment. The focus of leading SPIs/SPTs is on anticipating emerging weaknesses and vulnerabilities to determine the need for action, or on monitoring the extent to which specific activities required for safety are performed. An aviation example of a leading SPI would be the number of aircraft runway touchdowns beyond the 1 000-foot runway marker per 1 000 landings. Examples of aviation and transit safety objectives, SPIs and SPTs include:

Aviation

Example 1

- Safety objective: Minimise adverse safety events during ramp operations through the introduction of appropriate ramp safety measures.
- SPI: 0.90 events of foreign object damage to aircraft per 10 000 ramp service delivery operations.
- SPT: Reduce to 0.65 events of foreign object damage to aircraft per 10 000 ramp service delivery operations by the [date].

Example 2

- Safety objective: Eliminate controlled-flight-into-terrain (CFIT) accidents.
- SPIs
  - Ten events of activation of an EGPWS (Enhanced Ground Proximity Warning System) "Pull Up" type alarm related to terrain closure per semester.
  - Fifteen events of RA (Radio altimeter) activations below 10 000' AAL (Above Airport Elevation) until glideslope interception per semester.
- SPTs
- Reduce events of activation of an EGPWS by 30 % per semester.
- Reduce events of RA activation below 10 000' by 20% per semester.

Example 3

- Safety objective: Reduce long landing events.
- SPIs
  - [Number] events of touchdown > 1200 m from runway threshold per [number] landings.
  - [Distance] from runway threshold at landing.

- SPTs
  - Reduce number of touchdown > 1000 m from runway threshold by [percentage] by [time frame].
  - [Distance] from runway threshold at landing reduced by 20%.

Transit

Example 1

- Safety objective: Minimise fire/smoke events in tunnels by implementing specific and effective safety measures related to the traction power electrification system.
- SPI: [number] arcing events per quarter.
- SPT: Reduce number of arcing events per quarter by XX% within the next [time period].

Example 2

- Safety objective: Minimise passenger slip and fall events on the vehicle.
- SPI: [number] slip and fall events on the vehicle per [number] vehicle revenue movements.
- SPT: Reduce number of slip and fall events on the vehicle by XX % per [number] vehicle revenue movements per quarter over the next 24 months.

Example 3

- Safety objective: Minimise roadway worker fatalities.
- SPI: [number] roadway protection (RWP) non-consequential events related to incomplete job safety briefings per [number] inspections.
- SPT: Reduce number roadway protection (RWP) non-consequential events related to incomplete job safety briefings per [number] inspections by [percentage] over the next 24 months.

SMS: Institutional arrangements

The scope of the discussion has so far been limited to the safety management processes and activities underlying SMS, but has not discussed SMS as such. The Discussion Paper has already alluded to the fact that safety management activities can be delivered piecemeal; they do not necessarily require the protection of a management system for their execution. In fact, as discussed under the historical perspective, some of the activities performed under today's safety management processes have been performed – *albeit* with conceptual differences – across different modes of transportation since the 1950's, under the system safety discipline, namely as stand-alone safety programmes. The

drawback of implementing stand-alone safety programmes lies in the potential for lack of cohesiveness among the programmes.

It is relevant to make the distinction between *system* as a noun (a group of related parts or assembly of components), and *systemic* as an adjective (something that affects a whole). The term as used in system safety is a noun: it aims at safety of the technical *system* (for example, a spacecraft). System safety does not necessarily neglect, but certainly does not focus, on *systemic* safety, i.e. how the different components of the larger operational system – within which the individual technical system is deployed – interact among themselves, and how these interactions can affect safety as a whole, beyond the technical component.

Herein lies the fundamental consideration at the foundation of SMS, and the *raison d'être* for its implementation in transportation industries: the focus on how parts or components can affect the whole, safety-wise. As a first layer for cohesiveness and integrity of the whole (in this case, the transportation organisation), SMS' conceptual discipline, safety management, introduces two processes (SRM and SA) that provide guidance for the coordinated, cohesive execution of specific activities. As a second layer for cohesiveness and integrity of the whole, the two processes are surrounded by specific institutional arrangements necessary to support SRM and SA and ensure that the resources provided for the two processes are appropriate, timely available, and allocated based upon identified and agreed priorities.

Merging the institutional arrangements with the processes results in a management system: an organisational decision-making resource to ensure that parts are not introduced in such a way that the whole may be affected. Because the system is used by the transportation organisation to manage safety risk, it is named safety management system.

There are five fundamental institutional arrangements that are germane to SMS: the development of a safety management policy statement, the definition of safety management accountabilities and responsibilities, the establishment of a system of records for safety management activities (SMS documentation), the implementation of a safety management training programme, and the definition of channels for safety management communication. A discussion on each arrangement follows.

The safety management policy statement

The development and communication of a safety management policy statement (SMPS) formally signals the start of a transportation organisation's commitment and transition to managing safety as a business function through SMS. The SMPS serves to explicitly communicate to relevant personnel in a transport organisation that executive management has made a commitment to adopt SMS, thus placing the management of safety risk at an equal footing with other business functions of the organisation, such as financial risk management, legal risk management, quality risk management and so forth.

The SMPS must frame the fundamental principles upon which a transportation organisation will build its two safety management processes. Furthermore, as clearly and simply as possible, the SMPS must communicate the organisation's commitment to provide key resources for SMS, and executive management's expectations of employees regarding safety management processes and activities as appropriate.

The top executive in the organisation must sign the SMPS to convey the importance that safety management under SMS has for the highest level of the organisation. The SMPS must be communicated, with visible and explicit support from executive management, throughout the organisation.

The key elements to be considered in a SMPS include:

- Frame SMS, within the broader context of the organisation's business mission, as the means to meet the commitment to the management of safety as a business function.
- Explicitly commit the organisation to the implementation and sustained operation of SMS.
  - Commit executive management to ensuring availability of necessary resources (including people) to implement and operate SMS.
  - Commit the organisation to defining accountabilities and responsibilities, and to holding individuals accountable for delivery of safety performance and the performance of the SMS as appropriate.
- Safety Risk Management
  - Commit the organisation to developing an effective employee safety reporting programme.
  - Communicate the expectation that front-line employees are expected to use the safety reporting programme.
  - Commit the organisation to encourage safety reporting, clearly outlining the conditions for the protection of safety information, while explicitly framing unacceptable operational behaviours outside the conditions of protection.
- Safety assurance
  - Commit the organisation to safety performance monitoring.
  - Commit the organisation to continuous improvement of SMS.
- Safety promotion
  - Commit the organisation to provide safety management training as appropriate to prepare employees to carry out their roles and responsibilities in SMS.
  - Commit the organisation to communicating effectively about safety and safety management activities.

Sample SMPS

The management of safety risk one of our core business functions. [Organisation] is committed to implementing, maintaining, and constantly improving processes to ensure that our service delivery activities take place under a balanced allocation of resources, aimed at achieving the highest level of safety performance and meeting established standards.

Designated levels of management and employees are accountable for the delivery of this highest level of safety performance, starting with the Chief Executive Officer [or as appropriate to the organisation]. [Organisation] commitment is to:

- **Support** the management of safety through the provision of appropriate resources, to generate organisational context that manages safety risk with the same attention to results as that to the results of the other risk management systems of the organisation;
- **Integrate** the management of safety risk among the primary responsibilities of designated managers and employees;
- **Define** for designated staff, managers and employees alike, their accountabilities and responsibilities for the delivery of the organisation's safety performance and the performance of our safety management system;
- **Establish** hazard identification and analysis, and safety risk evaluation activities, including an employee safety reporting programme as a fundamental source for the identification of safety concerns and hazards;
- **Ensure** that no action will be taken against employees who disclose safety concerns through the employee safety reporting programme, unless disclosure indicates, beyond any reasonable doubt, an illegal act, or a deliberate or wilful disregard of regulations or procedures;
- **Comply** with, and wherever possible exceed, legislative and regulatory standards;
- **Monitor** safety performance against realistic and data-driven safety performance indicators and safety performance targets;
- **Continually improve** the performance of the SMS;
- **Ensure** that sufficient trained human resources are available to implement safety management processes;
- **Ensure** that designated staff are provided with formal safety management training;
- **Ensure** that channels for exchange of safety management information are established; and
- **Ensure** externally supplied systems and services to support our operations are delivered meeting our safety performance standards.

_____
Accountable Executive

_____
Date

Source*:* US Federal Transit Administration (FTA).

Safety management accountabilities and responsibilities

The operation of a management system requires that the organisation formally establish the accountabilities[12] and responsibilities[13] of senior management for the system's operation. The organisation must also formally establish the responsibilities of supervisors and front-line employees in the management system's operation, as appropriate. This premise applies to SMS.

The order of precedence proposed here above in the definition of SMS responsibilities is not random: the organisation must establish first senior management responsibilities; then the responsibilities of supervisors and front-line employees.

The responsibilities of senior management in running a management system – regardless of its nature and objective – are clearly different from the responsibilities of supervisors and front-line personnel in supporting the operation of the management system, and they are commensurate to the respective functions within the organisation. Once established, responsibilities at different levels for SMS operation and their differences must be explicitly communicated to the incumbents.

Three important caveats apply to the definition of senior management SMS responsibilities. First, the definition of safety management accountabilities and responsibilities must not become an exercise in piecemeal, random allocation of duties – oftentimes based on opinion and precedent – but rather a definition of organisational structures that optimise decisions on safety risk. In fact, what is being sought through this institutional arrangement is the definition of a *safety management governance structure* that ensures a desired flow of safety management information to support senior management decision-making on the allocation of resources to manage safety risk. This is further discussed under the sub-sections *Who does what under SMS* and *Safety management governance structure* hereunder.

Second, establishing safety management responsibilities for senior management does not mean turning senior management into safety experts or involving senior management in hands-on activities regarding safety management. Responsibilities for the technical activities under the safety management processes remain in the hands on subject-matter experts in the specialised departments, as it could not otherwise be. The responsibilities of senior management regarding safety management are limited to supporting the integration of the same principles of organisational control that apply to any other management system (direction, supervision and control) into the management of safety, and exercising such principles.

Third, when defining senior management responsibilities for safety management, it is essential to observe a fundamental notion about risk management: risk *evaluation* is t*echnical*, and therefore belongs in a specialised unit (i.e. the safety department); risk *mitigation* is *legal*, *political* and *administrative*, because risk *mitigation* involves costs. It and therefore belongs in the executive leadership levels.

The accountable executive

It is a basic tenet that management accountabilities flow top-down. Therefore, as a management system, SMS requires that safety management accountability reside with the top executive of the organisation.

Regardless of the size of the organisation, executive management plays a determinant role in developing and sustaining effective and efficient safety management processes. Absent conviction by executive management, attempts for integration of safety management processes into the business functions of the organisation will likely fall short.

Executive management is ultimately accountable for the management of safety because it controls the allocation resources to address business functions, including the management of safety risk.

For this reason, SMS requires explicit lines of decision-making accountability at the senior management levels. Within SMS, the individual with ultimate accountability for its performance is known as the *Accountable Executive*. Typically, the Accountable Executive is the head of the organisation: its CEO, President, General Manager, or Executive Director. Regardless of title, the Accountable Executive plays a central role in the development, implementation, and operation of SMS.

The Accountable Executive does not need to hold special qualifications or be a safety management expert. The Accountable Executive simply must:

- Understand how SMS works, what it seeks to achieve, the potential benefits it will generate for the organisation, and his or her role in the management system operation.
- Have a broad understanding of the significant safety concerns that the organisation faces during delivery of services.

For an Accountable Executive, safety management information – like financial, schedule, planning, and service information – is an integral component of the overall information necessary to allocate resources, set budgets, and manage safety risks.

The responsibilities of senior management in SMS operation

The overall responsibility of senior management[14] in SMS operation is – ultimately – the management of safety risk. The management of safety risk by senior management must follow the three basic elements of organisational control, as discussed under the subsection *A word about management and risk* in the previous section, just as these elements apply to the management of finance, quality, human resources or any other management system within the organisation. Senior management's role in safety management is an enabling role. Senior management must:

- Provide for the implementation of structures and resources that allow subject matter experts to perform hazard identification and analysis and safety risk evaluation activities.
- Provide for resources that allow subject matter experts to monitor safety performance through SPIs and SPTs.
- Approve the SPIs and SPTs submitted by subject matter experts.
- Analyse the results of the results of safety performance monitoring activities.
- Decide on the allocation of resources to allow the organisation to achieve established SPTs and safety objectives.

The responsibilities for the operation of SMS among senior management must be established with due consideration to the authorities held by the position to which specific responsibilities are allocated, since lack of an appropriate level of authority inevitably leads to shortcomings in discharging responsibilities. Some exemplary questions regarding existing authorities that may guide allocation of responsibilities for SMS operation include, without being limited to, the following:

- What level of management ultimately decides about the allocation of resources for safety risk mitigation?
- What level of management decides whether safety risk mitigation should be based upon senior management intervention, or based upon supervisor/front-line employee action?

- What level of management decides on the nature of information needed for effective safety risk decision-making, i.e. to avoid appropriate solutions to be "attached" to the wrong problems, or wrong solutions to be attached to real problems?
- What level of management decides on criteria to show the link between resources committed and successful safety risk mitigation (i.e. return on the safety investment)?
- What level of management evaluates success or failure of safety risk management activities, and how (i.e. based upon what parameters)?
- What level of management decides on the priorities – overall – when more than one department is affected or involved in safety risk mitigation activities?
- What level of management decides on the balance regarding assigning safety risk management to a specialised department or specialised management unit (i.e. the safety department), integrate it into general management activities (i.e. operational departments) or any intermediate combination thereof?

The responsibilities of supervisors and front-line employees in SMS operation

Transportation organisations deliver their services, regardless of mode, in "turbulent" environments, where – no matter how careful the planning – operational events cannot be always fully predicted in advance to the actual initiation of service delivery operations, as discussed under the subsection *The Practical Drift*. In "turbulent" service delivery environments, answers to critical safety questions that may be troublesome for senior management are oftentimes readily apparent to supervisors and front-line employees who perform the organisation's day-to-day operations, because of their routine exposure to the safety concerns.

If the organisation's environment is such that senior management is unwilling or not open to listening and acting upon the safety messages from supervisors and front-line workers, the following will take place:

- Senior management's outlook of the way in which procedures that support operations are followed (i.e. the way senior management *believes* transportation operations are conducted or "work as envisioned") will be inconsistent with the actual practices that constitute "work as delivered" (i.e. the way transportation operations are *actually* conducted).
- Senior management commitment to procedures that fit into its outlook of how the organisation's transportation operations are conducted will result in guarding against *known* safety concerns, but will lead to crucial oversight in the identification of *unseen*, *unknown* and/or *unforeseen* safety concerns.
- Shortcuts and "tricks of the trade" that substitute for the contents provided by established procedures and formal training will likely evolve among supervisors and front-line employees. Shortcuts and "tricks of the trade" will be efficient – and therefore ignored by senior management – under most normal conditions but, under special circumstances, may lead to negative outcomes.

Senior management must therefore be prepared to solicit opinions about safety concerns from supervisors and front-line personnel and to institute positive reinforcement to safety reporters, if the organisation is to take advantage of a fundamental source of information for effective safety risk management decisions. It follows that – bottom line – the role of supervisors and front-line employees in the operation of SMS is one of messengers, and their responsibility is the prompt and accurate reporting of safety concerns, as they see and perceive them.

Depending on organisation-specific employee safety reporting arrangements, front-line employees may report their safety concerns direct to the department managing the safety reporting programme, or safety-report through their supervisors. This identifies a further responsibility of supervisors in SMS.

Supervisors are the immediate link between front-line employees and senior management. As such, supervisors may become either multiplier agents or "predators" of safety reporting. If supervisors believe in, adhere to, and support safety reporting, they will become multiplier agents. Front-line employee safety reporting will be encouraged, and the organisation's safety reporting programme will be effective in supporting senior management safety risk management decisions. If supervisors do not believe in, do not adhere to, and do not support safety reporting, they will become "predators" of safety reporting. Front-line employee safety reporting will be discouraged, and the organisation's safety reporting programme will be ineffective in supporting senior management safety risk management decisions.

Who does what under SMS?

Within the governance structure necessary to manage safety risk as a business function, the concept of a safety *services* office is key. Under an SMS environment, the safety services office fulfils seven essential corporate functions:

- Runs the employee safety reporting programme.
- Manages and oversees the hazard identification and analysis activities.
- Manages and oversees safety risk evaluation activities.
- Supports as necessary safety risk mitigation activities.
- Monitors safety performance during service delivery operations.
- Advises senior management on safety management matters.
- Assists line managers on safety management matters.

In the perspective provided by system safety predominant in transportation industries for over half a century, the safety office was the exclusive "owner" of the entire safety process within the organisation. The safety officer, sometimes known as accident prevention officer, was the person in charge of identifying the safety concerns, proposing the solutions, participating in the implementation of the solutions, and monitoring the effectiveness of the solutions. In recent years, the notion that "ownership" of the safety process was exclusive of the safety officer was unwillingly reinforced by a widely adopted practice establishing a direct reporting and communication link between the safety officer and the CEO of the organisation. The intention behind this practice was to provide unimpeded access to the CEO by the safety officer.

This widespread practice was propelled by a double justification. First, it aimed at raising the hierarchical level and conspicuousness of the safety office, by establishing a direct link between the safety office and the CEO. Second, the direct link intended to generate neutrality in the consideration of safety concerns and their resolution, by removing line managers from evaluation and resolution of safety concerns. Since there is a strong likelihood that line managers can be, to different degrees, interested parties in the consideration of safety concerns, this could lead to potential conflict of interest in their evaluation and resolution. The direct relationship between the safety officer and the CEO was established as a means to defuse this potential conflict of interest.

Clearly well intentioned, this practice presents two downsides. First, by putting the entire ownership of the safety process in the safety office, it gives a "free ride", safety-wise, to line managers. The direct link between the safety office and the CEO removes line managers from safety decision-making, and nurtures the perception that "*safety problems are not my [line manager] problem, safety problems belong to the safety office and to the safety officer*". The line of accountability thus shrinks considerably, and becomes reduced to a two-party dialogue between the CEO and the safety officer. Given the workload associated to a CEO position, this dialogue has all the potential to become a monologue. Second and most important, it squanders the valuable input to the resolution of safety concerns, in terms of know-how, that the operational units can bring to safety decision-making.

The SMS environment brings a different perspective. The name safety office is changed to safety *services* office, to reflect that the office in question provides a service to senior managers and line managers, in regard to the management of safety risk during service delivery activities. The axiom "one cannot manage what one cannot measure" comes to fruition under SMS. The safety services office becomes fundamentally a safety data collection and analysis unit. Through a combination of proactive and reactive sources of data generation, the safety services office captures what takes place within the PD, by continuously and routinely collecting safety data on hazards during service delivery activities.

Once hazards have been identified, their potential consequences analysed, and the safety risks of such consequences evaluated, the safety information is delivered to line managers for resolution of the safety concerns thus defined. Line managers are the true subject matter experts in their respective areas, and therefore those in the best position to design effective and efficient solutions and implement them.

The primary responsibility for safety risk mitigation rests with those who "own" the production activities. It is during the production activities where hazards and the organisation are directly confronted, where deficiencies in organisational processes contribute to unleash the damaging potential consequences of hazards, and where direct supervisory control and resource allocation can mitigate safety risks. Moreover, production activities owners are the domain technical experts in any organisation and thus the most knowledgeable about the technical activities of production.

After the safety information is delivered to the appropriate line manager(s), the safety services office resumes its routine monitoring through safety data collection and analysis activities. At time intervals agreed between the safety services office and the line manager(s) in question, the safety services office presents new sets of safety information about the safety concern under consideration to the line manager(s) of the area(s) to which the safety concern pertains, and must therefore be involved in its resolution. The safety information will indicate if the safety risk mitigation solutions implemented by the line manager(s) addressed the safety concern, or if the safety concern persists.

In the latter case, further mitigation solutions are deployed, new time intervals are agreed, safety data is collected and analysed, safety information is delivered, and this cycle is repeated as many times as necessary until safety data analysis substantiates that the safety concern has been solved. Throughout all this process, the line manager(s) of the area(s) in question do not report progress to the safety services office, but to the Accountable Executive, as accountable for the organisation's SMS, through the safety management governance structure discussed hereunder.

The safety management governance structure

The safety manager is, in most organisations, the person whom the Accountable Executive has assigned the day-to-day administration functions of the SMS. In an SMS environment, the safety manger is the person responsible for the collection and analysis of safety data and the distribution of safety information among line managers.

Distributing safety information is only an intermediate step in the SRM process. Line managers must act upon this information. The mitigation of safety concerns inevitably requires resources. Sometimes such resources are available to line managers. Other times mitigation of safety concerns requires additional allocation of resources, and the authorities for such allocation may not be within the authorities of the line managers, and must be approved by senior levels of the organisation. Likewise, there needs to be some formal organisational process to ensure a neutral assessment of the effectiveness and efficiency of the mitigation strategies. All the above highlights the need for a safety management governance structure. In general terms, two committees conform a safety management governance structure, together with the Accountable Executive and the safety services office: a strategic committee and a tactical committee.

The strategic committee is a very high level committee, chaired by the Accountable Executive and composed by senior managers, including line managers responsible for functional areas, as well as senior managers responsible for support functions and indirectly involved in SMS operation. The safety manager participates of the strategic committee meetings in an advisory capacity only. The strategic committee deals with very high-level issues in relation to resource allocation and safety performance monitoring, and meets infrequently, unless exceptional circumstances dictate otherwise. The strategic committee ensures that appropriate resources are allocated to achieve the established safety performance and provides strategic direction to the tactical committee.

Once strategic direction has been developed, coordinated implementation of safety risk mitigation must take place across the organisation. The coordinated implementation of safety risk mitigation is the primary role of the tactical committee. This is an operational-level committee chaired in turn by line managers, and composed by line managers and representatives of front-line personnel. The safety manager actively supports the tactical committee, which following direction provided by the strategic committee, deals with safety risk mitigation implementation to satisfy the strategic directives received. The tactical committee deals with the coordination of "grass root" implementation issues, to ensure coordination of efforts and consistency with the direction provided by the strategic committee.

The development and effective sustenance of a safety management governance structure, with its associated, explicit allocation of safety management accountabilities and responsibilities, is in actual practice one of the most important, if not *the* most important, institutional arrangement in support of safety management activities and the operation of an effective and efficient SMS.

Safety management documentation

The rationale that justifies safety management documentation is three-fold. First, safety management activities must be explicit because they are formally reported to and monitored by the organisation's safety management governance structure on a routine basis and according to a schedule. The activities must be documented, visible, and defensible.

Second, safety management activities and the resulting safety management know-how must be explicitly recorded in formal documentation, so that it is available for staff involved in safety management activities to access to. Under this perspective, the safety management documentation becomes a sort of "public safety library" of the organisation.

Third, the formal record of safety management documentation plays a fundamental role in ensuring that safety management activities and thus safety management know-how do not reside in the heads of individuals. An organisation that allows a situation where safety management know-how resides in the heads of individuals exposes itself to a highly volatile situation in terms of preservation of corporate safety memory.

The size and complexity of the safety management documentation structure must be commensurate to the organisation's size and complexity. The guiding premise, regardless of size and complexity, is that safety management documentation must be readily available to those with responsibilities for SRM and SA activities.

The preferred structure or format for safety management documentation is largely an individual organisation's decision: it may be unified under a single document – the safety management system manual (SMSM) – or it may be incorporated as relevant into existing organisation documentation. Regardless of the medium selected, safety management documentation must as a minimum include the SMPS, a description of the safety management governance structure including safety management accountabilities and responsibilities, as well as a description of the safety management processes, activities and tools implemented and utilised by the organisation.

The safety management documentation must also preserve the records of the outputs of SRM and SA activities, including the periodic reports to the organisation's safety management governance structure. It must also include the records of employee safety management training, safety management training plans and curricula, and safety management communication activities.

Lastly, as part of this institutional arrangement, the organisation must develop and maintain a safety management document maintenance and control system, which ensures document standardisation in term of identification, legibility, storage, retrieval, protection, archiving and retention time. Safety management documentation must be in a suitable format for staff involved in safety management activities.

Safety management training

Formal safety management training for staff involved in safety management activities that encompasses roles and responsibilities regarding SMS operation is among the critical drivers for successful SMS operation. Developing the necessary knowledge by staff involved enables the consistent application of safety management processes. One word of caution, however, is appropriate: since training has been a hobbyhorse of sorts in transportation industries, it is essential to approach sensibly to safety management training to prevent unnecessary training.

Since SMS is a management system (i.e. a system to be used by managers), the target audience for the training must be limited to those in management positions who have a link to the activities of management system. Second, the training under consideration is safety *management* training, not *safety* training. It bears no relationship with technical knowledge/skills development and maintenance training necessary for safe operation of equipment and/or facilities as it might pertain to the particular mode of transportation. The bottom-line is evident: even in large organisations, only a relatively small number of staff will require full-fledged safety management training.

Consistent with the responsibilities of supervisors and front-line employees discussed under the relevant sub-section of this section, safety management training for supervisors and front-line employees should provide for a very high-level, brief overview of SMS, and focus on safety reporting. Supervisors and front-line employees should receive formal training on the expected contents of employee safety reporting (what to report; what not to report) and the procedures established for reporting. Extending safety management training beyond this, to the details of safety management processes and activities or the institutional arrangements necessary to support them (with the exception of the employee safety reporting programme), will result in training contents that are irrelevant to front-line personnel, beyond their interest, and quite probably their comprehension.

For senior management that is indirectly involved or fulfils a support function in SMS operation (for example, finance, human resources, quality, legal and so forth), safety management training should

be limited to a high-level, brief overview of SMS and the extent of the participation of the departments indirectly involved in SMS operation in the safety management governance structure. This could be a briefing rather than a formal training session.

For senior management that is directly involved in SMS operation (typically operations, maintenance and engineering), safety management training should include a moderately detailed overview of SMS, its processes and institutional arrangements. The emphasis of this training should be on the departments' role and responsibilities in daily SMS operation, their participation in the safety management governance structure, and the importance of the employee safety reporting programme.

The prime audience for safety management training is the safety management staff designated by the organisation with the responsibility for the operation and administration of SMS. The contents of the formal safety management training for this audience must encompass the safety management processes, activities and tools, as well as in-depth knowledge regarding the institutional arrangements. This training should also develop safety data management competencies, i.e. how to analyse safety *data* and extract *information* from the safety data, for senior management decision-making regarding the allocation of resources.

Safety management communication

The value of communication is an underrated aspect of SMS operation. Ideas "in the head" are of little value unless they are formally communicated. Considerable planning and resource allocation efforts regarding SMS implementation activities – and later operation of the system – may fall short of achieving desired results unless executive leadership, senior management, and front line employees are aware of them. Every effort must be made to avoid communication regarding SMS "by word of mouth," because such communication is an invitation to misunderstandings and the perpetuation of misrepresentations.

A two-way feedback loop between front line employees and management about safety management information is crucial in effective and efficient SMS operation. Safety management communication makes front line personnel aware of safety management priorities and initiatives and ensures that feedback is captured and acted upon as appropriate. Safety management information actively and routinely communicated raises awareness on hazards on the workplace and during service delivery operations.

Most important, safety management communication promotes an environment that encourages employees to report safety concerns and supports effective employee reporting. No one knows how an organisation *really* delivers its services better than front line personnel do. Front line personnel occupy a front row seat to observe developing conditions that have the potential to weaken safety defences. They can tell what works as planned and what does not. Most importantly, based upon their collective professional experience, they can assist senior management in devising alternative ways to make work what does not work as per original plan.

Effective safety reporting by frontline operational personnel is an essential source of safety data for an organisation, and effective safety management communication is one critical activity for turning front line personnel into the "eyes of SMS".

What does a "good" SMS look like, and operate like?

"Baking" an effective and efficient SMS: A recipe

The Discussion Paper has so far presented a historical perspective on the progressive evolution of safety in transportation towards safety management and SMS; it has discussed the safety management processes underlying SMS; and it has outlined the institutional arrangements necessary for cohesiveness in safety management activities. This section integrates the safety management processes with the institutional arrangements, resorting to a cooking analogy to describe what a "good" SMS looks like.

The section presents a recipe (of sorts) that combines the ingredients necessary – as discussed in previous sections – to "bake" a pie: a contemporary SMS. The recipe follows an "inside-out" strategy to "bake" the SMS pie: it first "cooks" the core ingredients (the safety management processes) which provide the true flavour for the SMS pie, and then adds the external ingredients, which provide consistency and ensure integrity to the SMS pie (the institutional arrangements). While going through the recipe, occasional reference to figure 2 (What a "good" SMS looks like) may be helpful.

First, borrow from system safety its basic entities of hazard and risk. Introduce in between them a third intermediate entity (potential consequence), modify the definition of hazard to fit socio-technical systems, and scope the definition of risk to just safety risk. The result is the first ingredient of a "good" SMS pie: safety risk evaluation. Add a portion of approximately 15% of safety risk evaluation as the first core ingredient of the pie.

Second, take Human Factors, peel off and discard clinical, behavioural and social psychology. Retain organisational psychology (the notions of the organisational accident and systemic failure causation) and cognitive psychology (the notions of human reliability and operator's performance as an asset rather than a liability, as depicted through the Practical Drift). The result is the second ingredient of a "good" SMS pie: Human Factors in operational context. Add a portion of approximately 15% of operational Human Factors as the second core ingredient of the pie. The integration of safety risk evaluation and operational Human Factors provides the conceptual guidance for the first of the two processes underlying SMS: SRM.

Third, take business management and borrow the notion of risk management following the basic elements of organisational control theory to define, monitor and achieve risk management targets. Modify the notions to feed the needs of a specific field of endeavour (safety). The result is the third ingredient of a "good" SMS pie – safety performance monitoring – that is in turn the result of three sub-ingredients: safety objectives, safety performance indicators and safety performance targets. Add a portion of approximately 15% of safety performance monitoring as the third core ingredient of the pie.

The integration of safety objectives, SPIs and SPTs into safety performance monitoring provides the conceptual guidance for the other process underlying SMS: SA. The integration of SRM and SA results in safety management, the discipline that provides the conceptual foundation for SMS.

At this point in time, the SMS pie is about 45% ready. If the cook is in a hurry, if the guests are inclined towards simple food, or if the guests do not have refined taste, the pie may be served, and while it might appear and even taste digestible, it will be flabby and will lack consistency. Interrupting the cooking analogy and reverting to technical terms, it is emphasised yet once more that an organisation does not need a management system to engage in SRM and SA. Transportation industries, regardless of mode, have conducted safety risk evaluation activities (*albeit* in rudimentary forms), and safety monitoring (but not safety *performance* monitoring) for decades, under the form of safety

programmes. Nothing prevents an organisation from performing an *aggiornamento* of their existing safety risk evaluation and safety monitoring programmes to meet safety management criteria. But such *mis-a-jour* does not mean that the organisation has implemented an SMS. In fact, part of the argument at the heart of this Discussion Paper is that engaging in safety risk evaluation or safety performance monitoring activities does not mean that the organisation operates under SMS.

More ingredients are necessary to bake a "good" SMS pie, to protect the flavour of the core ingredients by providing integrity and consistency to the pie. Therefore, fourth, commit the organisation to define – formally – safety management as a business function to be considered at the same level of other business functions that ensure the viability of the organisation; to a prioritised, data based allocation of safety resources, and to the implementation of an effective and efficient employee safety reporting programme. The result is the fourth ingredient of a "good" SMS pie – the safety management policy statement (SMPS). Add a portion of approximately 10% of SMPS as the fourth core ingredient of the pie.

Fifth, review responsibilities for safety as they exist or have been perpetuated within the organisation. Get rid of "philosophical" responsibilities such as *safety is everybody's responsibility*, *in this company safety is the first priority* and similar "bumper-stickers", which sound great but are hollow, misguiding and do nothing more than passing the safety buck and hiding it where it is hard to find. Define and document a safety management governance structure with explicit individual and departmental accountabilities, responsibilities, authorities and actions for safety management. The result is the fifth ingredient of a "good" SMS pie: the safety management accountabilities and responsibilities. Add a portion of approximately 15% of safety management accountabilities and responsibilities as the fifth core ingredient of the pie.

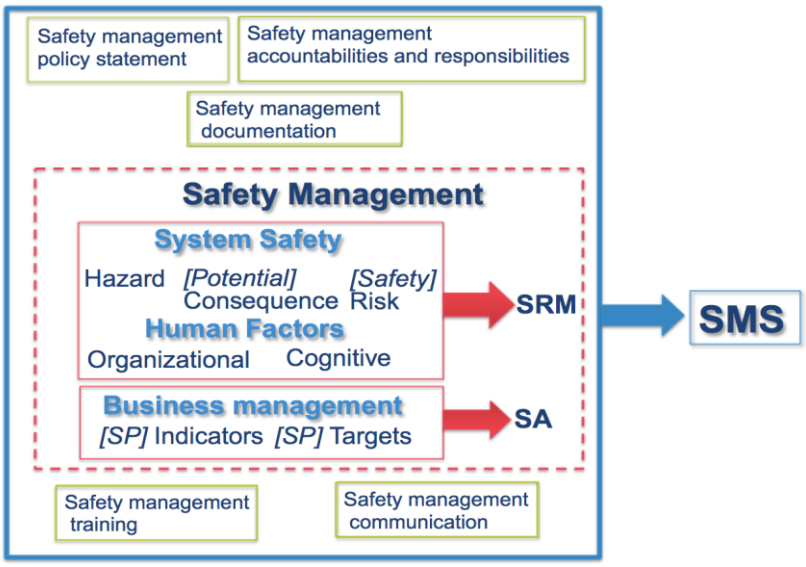
Sixth, evaluate the need for safety management training and its extent. Safety management is neither common sense nor intuitive. SMS is not "another name for the way we do things about safety around here." SMS builds on knowledge borrowed from strict disciplines and adapted to fit the needs of a distinct and unique management system. As such, formal safety management training for personnel involved in SMS is a critical need. Add a portion of approximately 10% of safety management training as the sixth core ingredient of the pie.

Seventh, having the best ideas but failing in carrying them into practice may end up being as good as not having ideas at all. One of the most lamented organisational processes – across the board – is communication management: senior management has splendid ideas, but does not communicate them to front line personnel. Nature abhors vacuum, and vacuum in information is filled with assumptions that, regrettably, are way off base more often than not. Following up on the notion presented by the previous ingredient – SMS is neither common sense nor intuitive – safety management communication becomes another critical ingredient in providing integrity and consistency to a "good" SMS pie. Add a portion of approximately 10% of safety management communication as the seventh ingredient of the pie.

Eighth, SMS knowledge, know-how and accumulated experience must reside in the organisation. Therefore, define a safety management documentation system that encompasses and explicitly preserves in corporate memory the provisions established for the two safety management processes, their outcomes, as well as the institutional arrangements in support of safety management processes. Add a portion of approximately 10% of safety management documentation as the eighth and final ingredient of the pie.

Upon completing this eighth step, the SMS pie is ready to retrieve from the oven, its flavour intact, its integrity and consistency assured.

Figure 2. **What a "good" SMS looks like**



The Discussion Paper has [over] emphasised that engaging in safety risk evaluation or safety performance monitoring activities does not mean that the organization operates under SMS. Neither does implementing the institutional arrangement without engaging into the activities. In fact, this latter option represents cosmetic compliance with established requirements, should they exist. To round up the argument at the heart of the Discussion Paper: the integration of safety management processes under the surrounding, protective envelope provided by the institutional arrangements, as discussed in the previous sections overall and synthesised in this section, is what constitutes the management system, thus defining what a "good" SMS looks like.

An effective and efficient SMS in operation

How does a "good" SMS, which seamlessly integrates safety management processes with the institutional arrangements necessary to support the processes, operate? The Discussion Paper resorts to another analogy to address this question (Figure 3).

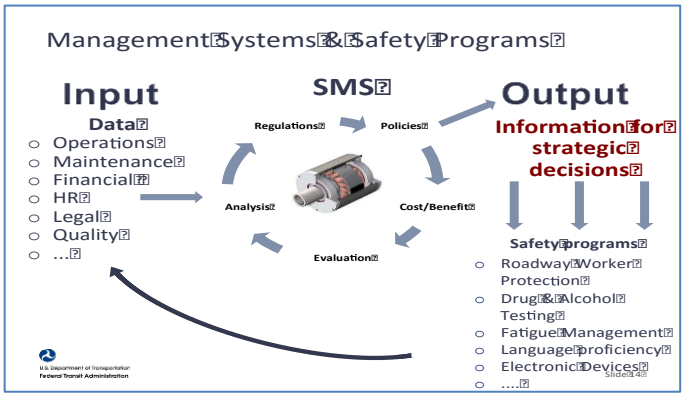
Consider a generator (a device that produces or creates an output from an input). A generator needs to be connected to a source of power (input) in order to produce its output. In this analogy, the source that powers the generator, the input, is data. While this is broad-ranging data, it is mainly – but not exclusively – operational data.

The broad-ranging data is fed into the generator where it is analysed taking into account a variety of factors such as policies, regulations, and so forth. The output of the generator is information for strategic decisions by senior management of the organisation on the allocation of resources to address safety concerns.

The strategic decisions by senior management of the organisation regarding allocation of resources to address safety concerns are executed in practice through dedicated safety programmes.

The feedback acquired by the organisation as consequence of the operation of the dedicated safety programmes becomes in turn input to the generator, thus allowing to monitor effectiveness and efficiency of safety programmes in addressing safety concerns.

Figure 3. **The "SMS generator"**



Source: United States Federal Transit Administration (FTA).

In this analogy, SMS is the *generator*. An SMS does not, by and in itself, resolve safety concerns. Safety programmes resolve the safety concerns. An SMS is a management system that generates information to support an organisation's senior management strategic decision-making regarding allocation of resources to address safety concerns, through the prioritised implementation of safety programmes

The "SMS generator" supports *data-based* strategic decision making, which allows an organisation to effectively and efficiently *prioritise* the allocation of its safety resources based upon a balance compromise between the magnitude of the safety concerns as analysed, the availability of organisational resources to address such concerns, and the projected safety benefit the safety programmes bring to the organisation. Because it is data based, such allocation of resources is easy to explain and defensible.

SMS today

The normative component of SMS

The subsection on compliance and performance in the previous section argues that transportation industries operate under regulatory frameworks that provide direction to a broad spectrum of industry activities, ranging from technology design to operational personnel training. Therefore, the normative component of SMS must not be overlooked, and it is a valid question to consider what are the policy, legislative and regulatory requirements necessary to support successful implementation of SMS.

Policy requirements

A policy provides broad specifications regarding the manner in which an organisation expects its departments to conduct the various business functions of the organisation. From the viewpoint of safety as a business function as discussed, safety management under SMS introduces significant changes when compared to long-established ways of conducting the safety business in transportation industries.

The changes range from the safety management processes themselves (SRM and SA) and the underlying shift towards performance monitoring as opposed to exclusive reliance in compliance; thru the definition of safety management as a business function and its reinsertion at a commensurate level of the organisation, to the re-organisation of departmental interfaces and responsibilities for the implementation the safety management processes under SMS.

Thus, a normative requirement imposing individual organisations to adopt a policy that provides broad specifications regarding the manner in which the organisation expects relevant departments to conduct safety as a business function is desirable (if not mandatory). Such policy must articulate topmost management's view of how to conduct the management of safety and its processes within the organisation. The placeholder for such articulation is a safety management policy statement (SMPS) as discussed in this section under the institutional arrangements necessary to support SMS operation.

Beyond a normative requirement for an SMPS at the individual organisation level, a normative requirement for a policy at the national level is also desirable. A safety management policy at the national level must be articulated by the government agency in charge of regulation and/or oversight of the particular mode of transportation. A national policy is necessary because the shift from an exclusive compliance-based approach to safety performance monitoring reshapes the relationship between regulator and industry. What was mostly a one-way communication must become a dialogue; what was an enforcement-based relationship must become a prudent partnership aimed at achieving agreed safety performance. These changes can certainly be supported by regulations and training of personnel involved, but such regulations and training must take place, if they are to be effective, within the protective cocoon provided by a high-level national policy.

Legislative requirements

Legislation is the means to provide fundamental guarantees that could not be provided through other means. One vital resource for SMS operation – an employee safety reporting programme (ESPRP) – will face considerable difficulties in its successful operation if its implementation does not take place under guarantees provided by legislation.

The notion of the "generator" graphically attests to the importance of data and information for the operation of SMS. Data has been likened to the blood of SMS. While there are various sources of safety data/information available to a transportation organisation, the single most important source of information for the management of safety is an ESPRP, as discussed in the sub-section under safety management communication. Most transportation organisations, regardless of mode, have set up ESRPs. However, a regret frequently expressed is how scarce front-line employees' contribution to ESRPs is. There are several reasons for this and they are discussed in a later section; the one relevant to this discussion has to do with preoccupation regarding administrative or retaliatory action by the organisation against reporters as a consequence of safety reporting.

The issues surrounding the protection of the sources of safety information are complex and multi-dimensional, since such protection is a subject that lies at the intersection of law, politics and safety. Organisation-specific provisions to protect sources of safety information can neither ignore nor exceed national provisions, lest they place the organisation and its workforce into a collision course with the legal system. In plain language, organisations should not promise what they cannot possibly deliver. For this reason, national legislation that provides a framework for the protection of sources of safety information from uses other than those for which the information was solicited – in all applicable national modes of transportation – while not the easiest, remains the most effective alternative to accomplish such protection in support of ESRPs.

The legislation should frame, in bold strokes, what is meant by protection and its scope, the rules of protection and exception, and the responsibilities in terms of protection and release of the information of those involved in safety data management.

Regulatory requirements

Regulations communicate the manner in which a regulatory agency expects organisations to perform specific activities, including the resources necessary to perform the activities. Based upon the history and expectations of transportation organisations, the regulatory aspect is likely the most significant in the normative component of SMS: the expectation of transportation organisations – regardless of mode – will likely be "to be told" the *what* and *how* of SMS through regulations.

The depth and granularity of SMS regulations depend on the approach to regulation prevailing in different modes of transportation, and even among different national contexts within a single mode of transportation (for example, rail versus bus). SMS regulations may drill drown to a considerable level of prescriptiveness, or may lay out the general rules in a broad manner. Each approach has strengths and weaknesses, the discussion of which is beyond the scope of the Discussion Paper because each approach responds to local possibilities and limitations. However, experience from both international aviation and the transit industry in the United States suggests the importance of regulating – at a minimum – an SMS framework that captures, at a glance, the building blocks of SMS in terms of safety management processes and institutional arrangements.

An SMS framework SMS is also the basis for the national safety management policy statement previously discussed. A national SMS framework guides transportation organisations, as well as oversight agencies, by:

- Providing a brief overview of key SMS concepts.
- Describing attributes of an effective SMS.
- Presenting SMS components and sub-components.

Figure 4. **FTA SMS Framework**

Safety Management Policy **1.** Safety Management Policy Statement **2.** Safety Accountabilities and Responsibilities **3.** Integration with Public Safety and Emergency Management **4.** SMS Documentation and Records	Safety Assurance **7.** Safety Performance Monitoring and Measurement **8.** Management of Change **9.** Continuous Improvement
Safety Risk Management **5.** Hazard Identification and Analysis **6.** Safety Risk Evaluation	Safety Promotion **10.** Safety Communication **11.** Competencies and Training

Source: United States Federal Transit Administration (FTA).

By sharing an SMS framework, a regulatory agency contributes to standardise the understanding of SMS and support its implementation through communication. Figure 4 provides an example of the components and sub-components of SMS, as adopted by the United States Federal Transit Administration (FTA). ICAO has adopted a similar framework for aviation. The level of detail of the framework should be commensurate with user audience expectations.

Prescriptive regulation, performance-based regulation and SMS

The notions of performance-based regulation and of moving away from prescriptive regulation are monikers that often go with SMS. These notions are misconceptions that need to be briefly addressed.

Regulation is always prescriptive, because it communicates the manner in which a regulatory agency expects organisations to perform specific activities, including the resources necessary to perform the activities. Within its inalterable prescriptive nature, however, some regulations may address *compliance requirements* (for example, "[organisation] must develop a [specific] manual") while other regulations may address *performance requirements* (for example, "[organisation] must develop safety performance indicators relevant to its operations"; or "[organisation] must develop means for demonstrating achievement of safety performance targets").

Regardless of their object (compliance or performance) both examples of regulations above *prescribe* specific activities: developing a manual, developing safety performance indicators, developing means to measure safety performance. Taking as further example figure 2 (What a "good" SMS looks like) or figure 4 (FTA SMS Framework) the institutional arrangements (or components one and four of the FTA SMS Framework) encompass compliance-based prescriptive regulation; while SRM and SA (or components two and three of the FTA Framework) encompass performance-based prescriptive regulations.

The conclusion to this brief sub-section is that the notion of prescription is oftentimes confused with the notion of compliance when, in fact, they are not synonymous, at least under safety management and SMS.

SMS across modes of transportation

Safety management is a neutral process, conceptually and practically applicable to organisations across different transportation industries, regardless of the mode or of the service delivered. This is because during the operations necessary for the delivery of services and regardless of mode, transportation organisations face hazards that they need to identify and analyse. Transportation organisations need to evaluate the safety risk of the potential consequences of hazards, to be able to prioritise allocation of resources to safety risk mitigation activities. Transportation organisations need to monitor effectiveness of safety risk mitigations, through safety performance monitoring. Lastly, transportation organisations need to manage operational change and ensure that SRM and SA activities are effectively and efficiently performed.

Specifics in the nature of hazards – particularly technical hazards – may introduce peculiarities in their characterisation across different transportation modes, but the three types of hazards proposed by safety management (technical, environmental and weather hazards) are mode-free and relevant to any mode of transportation in their conceptualisation. The tools for hazard identification may also be different among transportation modes, but the activities (hazard identification and analysis), their mechanisms, and their conceptual underpinnings under SRM, are universally applicable. Safety risk evaluation is a neutral process, industry-independent, and it can be applied "tit-for-tat" across modes of transportation: at its essence, safety risk evaluation involves no more than the principled application of

pre-defined matrixes. Safety risk mitigation, as an activity that involves the deployment of defences to protect against the potential consequences of hazards, is universal. Lastly, the notion of SPIs and SPTs as parameters that reflect the particularities of the transportation mode in question, the criteria for SPIs and SPTs development, and their monitoring, are also universal.

As far as the institutional arrangements necessary to support SRM and SA are concerned, the arrangements must doubtless reflect practices established and resources available to the particular mode of transportation. Nevertheless, the SMSPS, the definition of safety management accountabilities and responsibilities and a safety management governance structure, safety management records and documentation, safety management training and safety management communication are across-mode requirements without which SRM and SA activities will unlikely be efficiently delivered.

In summary, a conclusion is apparent: while peculiarities specific to each mode of transportation need to be observed, the integration of safety management processes and the activities they guide, and the institutional arrangements necessary to support the safety management processes and their activities into a system for the management of safety, as proposed in the Discussion Paper, are multi-modal. SMS is transportation mode-free, and travels well across the boundaries of different transportation modes.

SMS across stakeholders

It is established convention among transportation industries that stakeholder groups play a role in safety endeavours, and that the resolution of safety concerns must take into consideration and integrate, at some point or other, the perspective of various stakeholders of the particular transportation mode. Typical stakeholders in transportation services delivery include the organisation itself (the operator), the regulatory agency, the oversight and enforcement functions (if separate from the regulator), the accident investigation agency, technology manufacturers, industry labour unions, the judiciary (in representation of the legal system) and the general public.

Under established convention, SMS should be communicated to the various stakeholders, and the inputs provided by stakeholders should somehow be taken into consideration and integrated into SMS implementation and operation. In actuality, very few of the stakeholders listed in the previous paragraph play a role or directly contribute to SMS, provided SMS is understood, implemented and operated as a management system.

SMS represents the first instance in which transportation industries have departed – safety-wise – from dealing with safety concerns through safety programmes *directly* and *exclusively*. SMS represents a first experience for transportation industries in resorting to a management system to prioritise resource allocation towards safety programmes. This departure from precedent fosters potential for confusion regarding which stakeholder groups can contribute to SMS, and what their roles are. A brief discussion follows, and it is paramount – while following the discussion – to keep in mind three defining traits of SMS, as proposed by the Discussion Paper:

- SMS is a decision support system for a transportation organisation senior management regarding data based priorities in the allocation of resources towards the implementation of safety programmes to address safety concerns.

- SMS is not a safety programme.

- SMS does not – by and in itself – solve safety concerns; the safety programmes that SMS leads to implement solve the safety concerns.

From the perspective provided by these three defining traits, the role and contribution of different stakeholders to SMS can be dimensioned. The discussion does not include the transportation

organisation/operator among the stakeholders since – being the "owner" of the management system – the contents of the Discussion Paper apply to the operator in their entirety.

The role of the regulator as stakeholder is fundamentally the definition of the scope of SMS through an SMS framework. Beyond this role, there is a distinct contribution from the regulator as stakeholder to the success in SMS operation: without relinquishing to its oversight responsibilities, the regulator must develop a relationship of support and partnership with the organisations operating under SMS. This is particularly important for the success of the safety performance monitoring activities, since exchange of information on SPIs and SPTs, their achievement or lack thereof, involves exchange of sensitive information, above and beyond what has been the exchange of information under compliance-based regulatory contexts.

The contribution of the oversight and enforcement functions, within or outside the regulator, is among the most important contributions from the various stakeholders. The implementation of SMS requires that the oversight/enforcement functions develop a flexible approach, in particular regarding safety performance monitoring activities, while at the same time carrying out enforcement functions in an equitable, practical and consistent manner. A flexible enforcement approach in an SMS environment should be based in two general principles. The first general principle is the development of enforcement procedures that allow transportation organisations to deal with and resolve safety concerns internally, within the context of the organisation, *albeit* to the satisfaction of the enforcement authority. Intentional contraventions of established regulations or deliberate non-compliance are excluded from this general principle, and must be dealt with through conventional enforcement action as appropriate. The second general principle is that no information derived from sources of hazard identification and safety collection and processing activities established under SMS must – in principle – be used as the basis for enforcement action.

There is no role or direct contribution of the accident investigation agency either to the implementation or operation of SMS. The investigation of an accident experienced by a transportation organisation operating under SMS does not differ from established accident investigation protocols. The accident investigation process should be broadened to include analysis of the operation of the organisation's SMS, if relevant, just as it would include the analysis of other relevant management systems and/or programmes of the organisation deemed to have contributed to triggering the accident.

There is no role or contribution of manufacturers of the technology used by transportation organisations to deliver their services to the implementation or operation of SMS.

There is no role or contribution of labour unions to the implementation of SMS, but there is an essential contribution in terms of one of the most valuable resources for the operation of SMS: the employee safety reporting programme (ESRP). Labour unions – just as line supervisors – are an important link between front-line employees and senior management. Thus, the discussion regarding line supervisors becoming either multiplier agents or "predators" of the ESRP applies equally to labour unions.

There is no contribution from the judiciary to the implementation of SMS, but there are two important contributions to the operation of SMS, which are linked to contributions of stakeholders already discussed. First and foremost, the judiciary may support the development of a high level legal instrument that provides fundamental guarantees for the development of provisions for the protection of sources of safety information that feed the "SMS generator". Second, the judiciary may support the enforcement function by facilitating the development a flexible enforcement approach in an SMS environment, which ensures proportionality of enforcement actions and proportionality of enforcement decisions and responses, based upon natural justice and accountability. There is no role or contribution of the general public either to the implementation or operation of SMS.

SMS across nations: The international scene

Transportation systems in industrialised nations are high-reliability systems: they experience less than one catastrophic safety breakdown every million-production cycle. From a global perspective, notwithstanding regional spikes, accidents in transportation systems among industrialised nations are infrequent to the extent of becoming exceptional events, or anomalies in the system. Serious incidents are also few and far apart. In fact, the challenge faced by transportation industries in industrialised nations is how to deal with the residual safety risk that is inherent to almost "perfect" safety. The shift towards the business management-like approach to the management of safety under SMS – based upon the routine collection and analysis of daily operational data and monitoring SPIs and SPTs – provides an effective alternative to face this challenge.

An evident conclusion is that SMS is a resource relevant among transportation systems in industrialised nations, but not so much so among transportation systems in developing nations.

In aviation, the implementation of SMS for airlines, airport, air traffic control, airframe, engine and propeller manufacturers, and approved training organisations that are exposed to safety risks during the provision of their services is a mandatory requirement established by ICAO in order for any of the service providers or organisations listed to be lawfully engaged in international civil aviation operations. The SMS requirements for aviation are contained in Annex 19 (*Safety Management*) to the Convention on Convention on International Civil Aviation. While industrialised nations' aviation systems have embraced SMS implementation attempts in good conscience, SMS implementation has yet to take hold in significant sectors of the developing world, which struggle to identify the benefits of SMS and engage mostly in fringe implementation activities – mostly centred around the institutional arrangements – in order to approach compliance with Annex 19.

In maritime transportation, the International Maritime Organization **(**IMO) has enacted the *International Management Code for the Safe Operation of Ships and for Pollution Prevention* (International Safety Management (ISM) Code). The ISM Code requires that every shipping company develop, implement and maintain a safety management system (SMS). The ISM Code is considered to be the first maritime regulatory instrument that establishes specific responsibilities for a company and its management with regard to safety. The ISM Code was adopted as mandatory in 1993, and was incorporated as chapter IX of the International Convention for Safety of Life at Sea (SOLAS).

Compliance with the ISM Code is monitored by national maritime administrations that provide a Document of Compliance to the operator. The validity of a Document of Compliance should be subject to annual verification by a government administration or by an organisation recognised by the government administration or, at the request of the government administration, by another contracting government within three months before or after the anniversary date. The Document of Compliance should be withdrawn by the administration or, at its request, by the contracting government that issued the Document, when the annual verification is not requested or if there is evidence of major non-conformities with the Code.

In addition, compliance with the ISM Code is monitored by Port State Controls, which have a central role in controlling the implementation of the ISM Code. In Europe, the Port State Control system represents an international inspection and monitoring system, according to which the member states inspect ships in national ports in order to verify that they are in a condition approved by international standards and that international provisions are complied with. Ship inspections, rectifying deficiencies and ordering the detention of ships, if necessary, are the different actions the Port State can perform if the deficiencies endanger the ship, the crew or the safety of the marine environment. During the Port State Control, inspections verify that the ship's SMS is compliant with the requirements of the ISM Code.

Attempts to determine the impact of the ISM Code on maritime safety and the compliance with the ISM Code have not produced conclusive results. There are indications that the safety of operations of shipping companies has improved due to the implementation of the ISM Code. There are still, however, issues in the management of safety by shipping companies. Safety reporting by front-line personnel is essential for the management of safety under SMS, and a major noncompliance with the ISM Code is related to safety reporting. Furthermore, the reference to "ship's SMS" being compliant with the requirement of the ISM Code opens an interrogation mark regarding the conceptualisation of SMS in maritime transportation: is it conceived as a management system of the ship-owning organisation along the lines of this Discussion Paper, or as a *systemic* safety programme of individual ships?

There is no international organisation equivalent to ICAO or IMO for surface transportation industries, and national or regional authorities enact SMS-related regulations. There is, however, a standard by the International Organization for Standardization (ISO) that addresses management systems and safety, ISO 39002, *Road traffic safety (RTS) management systems – Requirements with guidance for use.*

ISO 39001:2012 specifies requirements for a road traffic safety management system (RTSMS) to enable an organisation that interacts with the road traffic system to reduce death and serious injuries related to road traffic crashes that the organisation can influence. The requirements in ISO 39001:2012 include development and implementation of an appropriate RTS policy, development of RTS objectives and action plans, which take into account legal and other requirements to which the organisation subscribes, and information about elements and criteria related to RTS that the organisation identifies as those which it can control and those which it can influence.

Benefits identified within ISO 39001 include improved RTS performance and ensuring conformity with the organisation's stated RTS policy. Other benefits of ISO 39001 include:

- Reduce accidents
- Reduce staff absence
- Reduce repair bills
- Reduce insurance premiums
- Improve corporate social responsibility and credentials
- Reduce risk of being sued for negligence

ISO 39001 includes key requirements encompassing policy, objectives, resources, interested parties, legal compliance, RTS performance and continual improvement of the RTSMS, along with the definition of organisational roles, responsibilities and authorities to achieve the key requirements.

ISO 39001 also delineates RTS performance factors, subdivided in three categories: risk exposure factors (for example, traffic volume and traffic mileage by vehicle and road user type), final safety outcome factors (the number of deaths and serious injuries) and intermediate safety outcome factors (for example, the safe planning, design, operation and use of the road network). It also incorporates emergency preparedness and response requirements; road traffic crashes and other road traffic incidents investigation, and continuous improvement requirements.

The potential of ISO 39001 to contribute to road transit safety is beyond challenge. It is difficult, however, to dimension RTSMS as a decision-making support system for an organisation's senior management regarding the prioritised allocation of safety resources. The impression arising from information available on RTSMS is that it encompasses a quality-nurtured management system, wrapped around an accident prevention programme. Therefore, for all the value RTSMS can bring to

road transit safety, it would appear to fall outside the scope of SMS as proposed by the Discussion Paper.

SMS across nations: The national scenes

A brief status report on SMS across leading nations and modes of transportation follows:

- In Canada, Transport Canada (TC) has mandated SMS for aviation, railways and marine transportation. Motor transportation, while not under mandated SMS, operates under the principles of SMS. Canada has been recognised as the trailblazer of SMS in international civil aviation. It has at times experienced the misfortunes inherent to trailblazing, by not being afforded the opportunity of learning from others' mistake. Nevertheless, Canada remains an SMS stalwart, as worldwide reference and strong proponent of SMS across modes of transportation.

- In the United States, the Federal Aviation Administration (FAA) has mandated SMS for aviation, and the Federal Transit Administration (FTA) has mandated SMS for urban and sub-urban transit transportation (both rail and motor transportation, surface and underground). SMS endeavours in the transit industry of United States are recent and have yet to fully take hold, but progress is steady. The Federal Railway Administration (FRA) has proposed rulemaking (49 CFR Part 270) so that commuter and intercity passenger railroads develop and implement a system safety program (SSP) to improve the safety of their operations. SSP is proposed by the rule as a management system, but it retains all the connotations of a system safety-based overarching (i.e. systemic) safety programme. Lastly, SMS has been introduced in maritime transportation through US Coast Guard Regulations (Title 33, CFR 96.120).

- In Europe, the European Aviation Safety Agency (EASA) has mandated SMS for aviation, and under the European Railway Agency, the implementation of SMS for rail is legally binding after Articles 4(3) and 9(1) of the Directive 2004/49/EC. The European Maritime Safety Agency (EMSA) has published guidance for the application of SMS for the operation of traditional ships, which applies for traditional vessels up to 500 gross tonnages.

- In Australia, the Civil Aviation Safety Authority (CASA) has mandated SMS for aviation, and the Office of the National Rail Safety Regulator has made it a legislative requirement of accreditation that rail transport operators (RTOs) have an appropriate SMS in place. RTOs are legally obliged to implement and then comply with their SMS (RSNL s101). The Australian Maritime Safety Agency (AMSA) requires that owners of vessels must implement and maintain an SMS that ensures that the vessel and the operations of the vessel are safe.

- In New Zealand, the New Zealand Civil Aviation Authority (NZCAA) has been mandated SMS for aviation. Land Transport New Zealand requirements dictate that railways operate under safety system requirements; these are however closer to system safety than to SMS. Maritime New Zealand, the national regulatory and response agency for the safety, security and environmental protection of coastal and waterways, advocates the importance of SMS but has not regulated it.

SMS and safety data: what we have, what we need

The axiom that one cannot manage what one cannot measure has already been proposed in the Discussion Paper. Data – safety data – that allows for monitoring and measurement is essential for the successful implementation of an effective system for the management of safety by a transportation

organisation. Data is the blood that nurtures SMS and, simply put, no data, no SMS. It follows that "data-friendly" transportation organisations will likely experience a smoother progress through SMS implementation activities and will likely operate it efficiently, as compared to "data-averse" transportation organisations, which may face significant obstacles and might have difficulties in progressing beyond SMS fringe implementation activities.

Transportation organisations have a history of collecting safety data on accidents and incidents. These data inform about *outcomes* (bad ones) that, by definition, cannot be *managed* because they have already taken place and therefore belong in the past. In order to engage in effective management of safety during delivery of services, it is fundamental to expand the scope of safety data collection, and capture *process* safety data (i.e. safety data about precursor conditions and inconsequential events that take place in the transportation workplaces during delivery of services), in addition to *outcome* safety data (i.e. safety data about consequential outcomes that transportation organisations might experience occasionally).

Safety data collection must have depth enough to allow for identification of precursor conditions, and volume enough to allow establishing priorities in resource allocation to address precursor conditions with potential to trigger accidents and incidents.

It is a given during transportation operations that things frequently do not go according to plan. This notion has been presented under the section on the Practical Drift (PD), and does not – necessarily – imply shoddy planning. It is simply a reflection of the operational realities and the dynamic and ever-changing environment transportation organisations must face on a daily basis. Changes occur in the workplaces where services are delivered; equipment deteriorates; priorities in service demand are realigned; resources are reallocated; procedures are revised; regulations governing service delivery are amended, and so forth. While subtle and hard to see through the "naked eye", these changes are incremental and creep into the transportation organisation's workplaces up to a point where they can render established safety defences ineffective.

Transportation organisations that rely on planning and outcome safety data *exclusively* will learn about ineffective safety defences by experiencing consequential events (accidents and incidents). Transportation organisations that rely on routine monitoring of workplace in addition to planning, and capture process safety data in addition to outcome safety data, will learn about ineffective safety defences through precursor conditions and inconsequential events, thus enhancing safety performance.

Process data can be inexpensively obtained by monitoring normal workplace operations on a routine basis. This monitoring will generate the information a transportation organisation needs to deal with incipient conditions with the potential to degrade safety defences. A condition of chronic unease and healthy scepticism about safety defences, evidenced by the frequency and depth to which the transportation organisation routinely monitors its normal workplace operations, are trademarks of a successful SMS.

Effective safety reporting": Challenges and solutions

The cultural conundrum: The link among national, corporate and professional cultures

Culture can be described in the simplest terms as a "collective programming of the mind". One of the most graphic descriptions of culture portrays it as the "software of the mind" (Hofstede, 1997). Culture:

- Influences the values, beliefs and behaviours people share with the other members of various social groups.

- Binds people together as members of a group, and provides clues and cues as to how to behave in both usual and unusual situations.
- Sets the "rules of the game" and provides the framework for interpersonal interactions.
- It is the sum total of the way people conduct their affairs in a particular social milieu.
- Provides a context in which things happen.

It is a common pitfall when dealing with culture to engage in judgement, and portray one particular culture as perhaps "better" or "more suited" than another, or to propose one particular culture as "bad" or "unsuitable", for specific endeavours. This is inappropriate because consideration of cultural issues implies understanding of *differences* as opposed to pronouncement of *judgment*. It is also fruitless, because cultures are indeed different, and each and every culture has particular strengths as well as weaknesses. The consideration of cultural issues, when applied to the management of safety, aims at building on cultural strengths, as they relate to safety practices, while minimising the downsides of cultural weaknesses.

Therefore, in terms of the management of safety, understanding culture is important *only to the extent* that it contributes to the understanding of context, since culture – as discussed hereunder – is an important determinant of organisational performance. This is because organisations, being groups of people, are not immune to cultural considerations. Organisational performance is subject to cultural influences at every level. There are three levels of culture that have relevance to safety management, since the three levels are determinants of organisational performance:

- *National culture*, which differentiates the national characteristics and value systems of particular nations. People of different nationalities differ, for example, in their response to authority, how they deal with uncertainty and ambiguity, and how they express their individuality. People are not all attuned to the collective needs of the group (team or organisation) in the same way. In collectivist cultures, for example, there is acceptance of unequal status and deference to leaders. This may affect the possibility of questioning decisions or actions by elders — an important consideration in decision-making, for example.
- *Organisational culture*, which differentiates the characteristics and value systems of particular organisations: the collective behaviours of members of one company as compared to those of another company. Organisations provide a shell for national and professional cultures.
- *Professional culture*, which differentiates the characteristics and value systems of particular professional groups (for example, the typical behaviours of pilots in relation to those of maintenance engineers). Through personnel selection, training, on-the-job experience, peer pressure, etc., professionals (physicians, lawyers, pilots, engineers, bus operators, mariners and so forth) tend to adopt the value system and develop behaviour patterns consistent with their peers; they learn to "walk and talk" alike.

The three cultural sets are linked and interact in operational contexts. These interactions determine, for example and among others, how:

- Information is collected and shared.
- Particular technologies will be embraced.
- Authority will be acted upon and how organisations react to operational errors (for example, punish offenders or learn from experience).
- Standard Operating Procedures (SOPs) are developed and adhered to.

- Workplace practices, formal and informal, develop.
- Documentation is prepared, presented, and received.
- Training is developed and delivered.
- Work assignments are made.
- Different work groups relate.
- Management and unions relate.

Thus, culture impacts intra-organisational interactions. The greatest scope for creating and nourishing an effective culture for the management of safety is at the organisational level. Organisational culture sets the boundaries for accepted operational performance in the workplace by establishing the norms and limits. Thus, organisational culture provides a cornerstone for managerial and employee decision-making: *"This is how we do things here, and this is the way we talk about the way we do things here."*

The cultural conundrum and safety reporting

The point of significance of organisational culture to the management of safety is that it is the most powerful, single shaping factor for safety reporting practices by front-line personnel.

Effective safety reporting relies to a large degree on the voluntary reporting of experiences by the people who "operate the system". These are the operational personnel who deliver, through their daily activities, the services for which the organisation is in business. During activities related to the delivery of services, operational personnel must co-exist with safety deficiencies on a daily basis. For this reason safety reporting by operational personnel is a rich source of safety management information for organisations.

Voluntary reporting programmes were conceived during the late Seventies and early Eighties. They were developed as error reporting programmes rather than as safety reporting programmes, coincident with the deployment of Human Factors in aviation. The notion of voluntary error reporting as synonymous of safety reporting has perpetuated itself over time among transportation industries.

Since the inception of early voluntary reporting programmes, a growing understanding has led to view operational errors as the results of existing conditions or circumstances. Therefore, contemporary safety reporting programmes seek out to identify existing conditions or circumstances that are the genesis of operational errors, rather than operational errors themselves. The systematic identification of safety deficiencies pays a much higher dividend for safety management than simple error collecting and counting.

Nevertheless, the notion of voluntary reporting programmes as error reporting programmes instead of safety reporting programmes is pervasive across transportation modes. Many organisations have not yet transitioned to the realisation that safety management action can most effectively take place when aimed at material and identifiable components of the operational context (hazards) rather than to the vagaries associated with human performance. In other words, that it is easier, more practical and more effective to "fix" operational contexts than it is to "fix" people.

The difference between error reporting and safety reporting is fundamental. Error reporting is self-incriminatory and may thus lead to blame and punishment, while safety reporting is objective and neutral and has no consequences (or should not have) for reporters. Because of the early and pervasive emphasis on error reporting as opposed to safety reporting, the protection of reporters has been a hot topic since the inception of reporting programmes, while at the same time a source of controversy and debate. Inevitably, the debate has drifted into the wrong direction, on most fronts.

Various terms such as responsibility, accountability and liability have been used, unqualified, to refer to different aspects of a same concept; systemic failures have been used to dilute personal accountabilities within the impersonal dimensions of organisations; individual failures have been used to excuse the absence of clear definition of responsibilities that should delineate the boundaries of operational performance and duty; punishment has been used to shield the fact that professionals are oftentimes deprived of the means to perform operationally according to duty statements, and so forth. Beyond these considerations, the protection of sources of safety information remains a contentious issue, and one with the potential to turn into a significant obstacle for effective safety reporting, the effectiveness of safety management processes, and thus the implementation of SMS.

Probably the most significant aspect of the debate, and certainly its most controversial, is linking the protection of safety information with the protection of reporters. In the enthusiasm to realise the full potential of the collection of safety information, the need to protect safety information and the desire to protect individuals, *without properly qualifying exactly what should be protected and to what extent*, has been confused. Clearly, two significantly different considerations have been thrown into the same bag.

The unclear message from safety professionals intent on protecting safety information has therefore been frequently misunderstood, because it has too often challenged the intrinsic legitimacy of administrative action by the organisation. Opposing the use of safety information for administrative action arguing that safety benefits outweigh other interests, while understandable within safety circles, may only strengthen the conclusion that the argument equals a demand for undue immunity or an attempt to weaken organisational authority in responding to perceived wrongdoing.

Culture has not escaped this drift into the wrong direction and its underlying polemic debate. Throughout the years, transportation industries have witnessed a progression in attempts to interface culture with the protection of safety information, and the protection of reporters from retribution, as a means of improving safety. Early notions advocating for a "non-punishing culture" evolved into "non-blame culture" or "blame-free culture"; and eventually into "safety culture" and "just culture".

Safety culture and just culture have become broadly accepted labels that attempt to describe an organisational context that fosters safe practices and encourages active and effective safety reporting while affording protection to reporters. Nevertheless, unless a balanced perspective is adopted, such labels – like all folk labels – hold potential for misperceptions and misunderstandings, and ultimately for aberrant endeavours, for several reasons:

- The term *culture* is used loosely, if not liberally, to describe *context* (*safety culture* as opposed to *operational context within which effective safety reporting takes place*).
- Safety culture, just culture and similar labels are constructs (abstractions). These labels portray shortcuts that describe very specific, Anglo-Saxon values and beliefs representing what the building blocks of practices regarding fairness in safety management processes should consist of. Such dedicated practices are naturally underpinned by, and biased towards, the local values and beliefs of the specific culture that proposes them. They are therefore far from universal.
- As biased constructs, safety culture, just culture and similar shortcuts may not only be discriminatory and judgemental, but in addition they are not tangible: they are immaterial and do not exist in the physical world. They are a product of the human mind, and therefore, they are impossible to act upon *by and in themselves*.
- Safety culture and just culture are outcomes. They are the consequence of specific organisational practices or their absence thereof. Organisations engage or do not engage in certain specific practices, as a consequence of which they achieve or do not achieve these outcomes. As

outcomes, and just like with constructs, neither safety culture nor just culture can in themselves be acted upon, only the practices leading to them can be.

- While the notions of both safety and just culture as well as their predecessor notions are multi-block constructs, the common thread is the contention that a safety culture or a just culture is one in which operational personnel can report their errors without fear of reprisal, as long as negligence or wilful disregard for safety is not evident. Herein lays the most significant drawback of espousing very practical activities aimed at the acquisition of safety information on safety deficiencies and its supporting procedures, to constructs.

By linking safety culture and just culture to the protection of people, the administrative argument takes precedence – as clearly demonstrated by the aviation industry – over any technical or safety-related argument. The perception is created that the objective of a safety culture or a just culture is to preclude the so-called "criminalisation of error". This is an endeavour that, while of understandable moral and ethical relevance, is of lesser relevance, strictly speaking, for purposes related to the management of safety. While arguably abhorrent in certain circles, the so-called "criminalisation of error" is legally, ethically and morally within the rights of any organisation, provided established safeguards are observed. Strictly speaking, for purposes related to the management of safety, the activity that needs to be promoted, nurtured and defended is *effective safety reporting.* But then, the achievement of this activity can be materialised in many different ways and following many different strategies.

Therefore, *how* effective safety reporting is achieved should be left to the preferences, possibilities and constraints of specific contexts, local values and beliefs, rather than proposing off-the-shelf recipes reminiscent of what social anthropologists call *cultural imperialism* and that hold the potential to clash with local values and beliefs. As long as an organisation develops and nurtures effective safety reporting activities to support the management safety, *how* it does is irrelevant, provided effective safety reporting *is* indeed achieved.

A last argument in favour of effective safety reporting as an activity and against the constructs of safety culture and just culture should be noted. The notion of an off-the-shelf safety culture or of a just culture underpinned by specific building blocks inevitably drifts into a classical stereotypical situation: those organisations which do not adhere to the specific building blocks proposed would by logical reasoning exhibit an *unsafe* culture or an *unjust* culture. This is a highly questionable cause-effect relationship, and a very dangerously loaded one. Organisations may not adhere to the specified building blocks of the accepted constructs, yet they may arguably develop effective safety reporting activities to support the management of safety, following building blocks attuned to local values and beliefs.

In summary, this Discussion Paper does not adhere to the stereotypical branding of local values and beliefs, nor does it allocate supremacy to one set of particular values or belief over another. Therefore, the Discussion Paper distances itself from the constructs of safety culture and just culture, and advocates for the development of *operational contexts that encourage active and effective safety reporting,* through whichever means or building blocks it might be achieved.

Effective safety reporting – Some potential solutions

The subsection on safety management communication under the section on SMS institutional arrangements provides an early perspective on the importance of safety reporting and the value of an employee safety reporting programme. Effective safety reporting of workplace conditions by operational personnel is a cornerstone of the management of safety. Therefore, an organisational environment in which operational personnel have been trained and are encouraged to report substandard workplace conditions is a fundamental source of process information, and a definite contributor to efficient SMS operations.

Effective safety reporting builds upon five basic attributes:

- The organisation explicitly recognises and communicates the importance of the employee safety reporting programme as part of the strategy for the management of safety, and as a consequence there is an awareness of the importance of communicating safety information among front-line employees.

- Operational personnel are formally trained on safety reporting and hold an informed view of the safety concerns faced during the organisation's service delivery activities. As a consequence, safety reporting is relevant and supports safety management activities by the organisation.

- Safety reporting has a clearly defined scope and explicit procedures, and as a consequence front-line employees know what to report and what not to report. Safety reporting is easy and facilitated by the use of simple and flexible means of reporting.

- The organisation exhibits a receptive attitude towards employee safety reporting and implements, to the best of its abilities, measures to address the safety concerns reported by front-line personnel. The best possible feedback for front-line personnel is to observe that safety reports concerned are solved.

- The organisation ensures that safety data is safeguarded to the extent allowed by prevailing legal and administrative constraints, and promotes a system of checks and balances so that reporters feel confident that safety reporting will not be put to uses others than for which it was implemented (the management of safety) unless the scope of the "protected area" has been exceeded.

SMS tomorrow: *Quo vadis* SMS?

"It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity…" The well-known opening sentence of Charles Dickens' *A Tale of Two Cities,* a novel published in 1859 and set in London and Paris before and during the French Revolution, appears to have been written – speaking tongue in cheek – with SMS in mind. An analogy of SMS to the French Revolution is not quite inappropriate, because well-understood SMS represents what might be called an "evolutionary revolution" about how to conduct the business of safety in transportation industries. On one hand, SMS represents the end of the line of an evolution that started in the 1950s and which landed gradually and incrementally in transportation industries. On the other, SMS underlies a significant shift in how transportation industries should go about conducting the business of safety and the associated roles and responsibilities.

It is the best of times because SMS has become a Holy Grail of sorts for transportation safety and, through an empowered campaign of communication, SMS has captured the attention of levels of management of seniority such as no other safety initiative in transportation industries had been able to capture previously. It is the worst of times because SMS is definitely *not* the Holy Grail for transportation safety; but because it is thought to be, many unrelated organisational processes are being

tied (or attempted to be tied) to the SMS bandwagon. Nowhere is this more evident than in the aviation industry, as the example provided at the end of the section illustrates. The potential for unreasonable expectations – which SMS will not be able to meet – is clear and present, and unless such unreasonable expectations are checked out, they will inevitably lead – when SMS fails to deliver – to the conclusion that SMS does not work or that it is just another passing fad.

It is the age of wisdom because SMS, as proposed by its "founding fathers" and presented in the Discussion Paper, encompasses the laborious integration of three well-grounded disciplines with proven safety track records. Multiple professions and industries have contributed to the development of SMS, and SMS has been enriched in practice by operational experience product of more than 20 years of trial and error, finally shaping into the first management system transportation organisations have to address safety as an integrated business function as opposed to a series of piecemeal programmes. It is the age of foolishness, because among sectors of different transport industries there persists the simplistic notion that SMS is "just the way we have been doing things around here, but under a fancy name".

It is the epoch of belief, because SMS provides, for the first time in the history of transportation industries, a business-like platform for data based decision making regarding allocation of resources to address safety concerns in a principled manner, and using parameters other than total failure (accidents). It is the epoch of incredulity, because it is hard to understand why concrete and tangible activities, which combine knowledge from the engineering and human sciences and business management, are watered down to a point of dilution by resorting to "folk" science, simplistic common places and constructs that, ultimately, belong more in academia and research labs than in activities related to the management of business enterprises.

While the outlook does suggest that turbulent times lie ahead for SMS, the strengths of safety management under SMS hold a potential of such magnitude that it will only take a few truly successful instances of SMS implementation to overcome obstacles and challenges. What are, then and succinctly, the key challenges that remain for SMS implementation?

The obstacles and challenges in SMS implementation

The implementation of safety initiatives within any transportation industry, it has already been argued, is frequently confronted by established mind-sets about the "way we have always done business around here". Such mind-sets often attempt the implementation of new safety initiatives by "cloning" the notions and processes of those endeavours already established that are conceptually closer to the new initiative. While this is to be expected – organisations, like people, hate change and try to minimise its implications – this mind-set creates roadblocks to the implementation of new initiatives, it may lead implementation efforts astray, and end up in flawed new initiative implementation. The potential consequences of flawed implementation are many-fold, including squandering of organisational resources (not the least of which is money) and, most importantly, generating scepticism and eventually disbelief in the new initiative, thus denying the improving benefits that the new initiative might bring for the industry.

SMS implementation within the transportation industry, regardless of mode, is no exception to this scenario. For this reason, the Discussion Paper concludes by outlining a few "tricks of the trade" to clarify potential confusions that may eventually arise among transportation organisations facing SMS implementation, alerting about "things to watch", particularly when subcontracting SMS implementation, and offering an example of how the benefits SMS can offer transportation industries can be squandered by misconceptions, mistaken beliefs, complacency, or plain lack of information.

Understanding the true nature of SMS

Meek as it may sound, shortcomings in understanding the true nature and scope of SMS may become the most significant challenge – by large – for the implementation of an effective SMS. SMS is most definitely *not* another iteration – a 21st century version – of safety/accident prevention programmes. SMS is neither an accident prevention programme, nor a safety programme, nor a safety plan. SMS, as its name clearly indicates it, is a *management system* (i.e. a *system* to be used by *management*). Its objective is the same objective as that of any other business management system (financial, quality, legal, human resources, etc.): to support decision-making by the leadership of the organisation on how to run the business.

An organisation's financial management system, for example, acquires and analyses financial data to support the organisation's leadership decision-making regarding allocation of resources to manage financial affairs during provision of services. An organisation's safety management system acquires and analyses data to support a transit agency leadership decision-making regarding allocation of resources to manage safety affairs during provision of services. SMS helps a transportation organisation in prioritising the allocation of resources towards those areas where safety concerns during delivery of services are higher, or where the activities to address safety concerns are ineffective or unnecessary. Once the organisation's leadership has made decisions, they are implemented through safety plans, safety programs, and other accident prevention activities.

SMS and system safety

There is the conviction among certain transportation industries that SMS is system safety by another name. This is not so, as discussed during the historical perspective that opens the Discussion Paper and further elaborated under the discussion on the discipline of safety management. System safety has provided the foundations upon which transportation industries have built their safety activities for over five decades. It is therefore expected – and even logical – for transportation organisations to trip into the confusion that SMS is an iteration of system safety. This is not so. Stopping SMS implementation at the stage of system safety requirements will result in a "cosmetic" SMS.

As discussed, system safety is an engineering discipline that was created to address issues regarding brittle technology. Its main area of concern was to "design safety" into technology (a notion known as *safety by design*), thus preventing technological failure and contributing to successful technology design. While SMS borrows the notions of hazard and risk from system safety for the purpose of safety data collection and analysis, the similarities stop right there.

SMS scope goes beyond technology improvement aimed at preventing accidents caused by erroneous operation of the technology by people. SMS includes consideration of the organisation as a whole, including its processes, activities and resources, in the scope of collection and analysis of data to support leadership's decision making. It aims at safety performance monitoring in real-time. It considers people as an asset that definitely contributes to safety, as opposed to a liability to the safe delivery of services. These, among others, reflect an obvious fact that underlies the need for the introduction of SMS in transportation industries: the problems system safety was created to address during space exploration in the 1950's, or associated to the practices required for identifying hazards and assessing and mitigating associated risks encountered in the development, test, production, use, and disposal of defence systems, are vastly different to the problems transportation industries face in managing safety during routine operations for mass delivery of services in the 21st century.

SMS and quality management systems (QMS)

Just like with SMS and system safety, there is the pervasive idea – particularly in the aviation industry – that SMS is QMS by another name. This confusion originates for reasons similar to the confusion previously discussed: like system safety, QMS "was just there" (in aviation) before SMS. Therefore, why not adjust bits and pieces of QMS to conform to SMS needs, and kill two birds with one stone? As frequently heard, if an organisation has QMS, why does it need SMS?

While enticing and apparently efficient, this approach will not be effective. It is true that SMS and QMS share similarities in processes and activities (and rightly so, since they are both management systems), such as early identification of problems, establishing performance targets, performance monitoring, managing change and so forth. But once again, the similarities stop right there.

The object of QMS is the control of *defects* during *design of products and delivery of services* to satisfy customer expectations. QMS contributes to the viability of the enterprise by addressing quality risk. The object of SMS is the control of *hazards and their potential consequences* during *delivery of services* to satisfy safety management expectations. SMS contributes to the viability of the enterprise by addressing safety risk. This introduces significant conceptual and practical differences in processes that, at face value, appear similar, but which under closer scrutiny reveal a significant difference in focus. The main one: while QMS mainly pursues compliance, SMS mainly pursues real-time performance monitoring. Thus, although complementary, both management systems differ in their object and their specific conceptual underpinnings. The bottom line: one management system does not replace the other; a transportation organisation needs both.

Perception of the costs associated to SMS implementation

Money is always an obstacle, and a mistaken belief about the costs associated to SMS implementation may become an obstacle on its own right. It is generally believed that SMS implementation is expensive. Actually, following proper guidance, SMS implementation by a transportation organisation is a rather inexpensive undertaking. A number of the activities underlying SMS, and the resources needed for the operation of an SMS, already exist, to a greater or lesser degree, within a transportation organisation. Transportation organisations have a safety department and safety personnel, including safety data analysts; they conduct hazard identification and analysis and safety risk evaluation activities, they implement safety plans, they publish safety manuals and related documentation, and so forth.

Implementing SMS within a transportation organisation does not involve acquisition of new/additional technology, creation of new structures within the organisation nor (necessarily) hiring of additional personnel. At its core, implementing SMS within a transportation organisation involves reorienting and refocusing existing safety process and activities under the safety management umbrella, and redeploying existing safety resources, following specific safety management criteria aimed at the generation of data for leadership safety decision-making.

Bias towards compliance and safety outcomes

Any proposal for SMS implementation that relies mostly on compliance and safety outcomes should be closely scrutinised. A focus of SMS is safety data collection, which is a two-fold focus: safety data from *activities* during delivery of services rather than on the *outcome* of the activities; and safety data regarding the *presence* of activities rather than the *absence* of activities.

Once collected, safety data analysis aims at identifying shortcomings in safety controls during normal, daily workplace activities. The shortcomings the SMS safety data analyses look for are not limited to shortcomings regarding compliance, but rather shortcomings in the integrity, strength and

effectiveness of safety controls during provision of services. Because SMS captures safety data from workplace activities on an on-going basis, it generates a significant volume of data that allows senior leadership to reallocate safety resources, add further safety resources or remove those safety resources identified as unnecessary or ineffective.

Lack of emphasis in the importance of employee safety reporting

Employee safety reporting is the centrepiece of SMS safety data collection for leadership decision-making. This is because no matter how much one might attempt to "design safety" in anticipation through planning, it is simply impossible to cover all bases without holes in dynamic and constantly changing contexts such as those within which transportation operations take place. There will always be a piece of technology that will not work as expected or advertised, some procedure that will not be possible to apply as designed, or some operational condition that was not anticipated or foreseen by planning. The first to witness these discrepancies are the folks at the "tip of the arrow", those who deliver transport operations on a daily basis.

Employee safety reporting is the single most valuable activity for safety data collection under SMS, and the employee safety reporting programme is the most valuable (and cheapest) tool an organisation has at its disposal to run effective and efficient SRM and SA activities.

A workforce which has been made aware of the importance of safety reporting, and has been instructed on how to report, what to report and what *not* to report, becomes the eyes of the organisation. A workforce of "trained messengers" is both an asset and an irreplaceable source of safety data for leadership decision-making. If follows that an SMS implementation proposal that falls short of "engineering" a contemporary employee safety reporting programme will be missing a fundamental building block without which the proposed SMS will unlikely be effective nor efficient.

Focus on prevention rather than informed safety decision-making

A proposal for SMS implementation that gears its processes and activities around a focus in accident/incident prevention is probably repackaging old ideas into a new-looking envelope. The essence of SMS as a management system has been [over] emphasised throughout the Discussion Paper. Its realm is data acquisition and analysis to support leadership safety decision-making, and the benefit this brings to an organisation is rationalisation of safety resources. Accident/incident prevention is the realm of safety programmes and safety plans. To put it under simple terms, SMS tells a transportation organisation *what* to do, safety-wise, while safety programmes and safety plans represent *how* to do it.

The argument might be advanced that, by informing an agency's leadership what to do safety-wise, SMS contributes to prevent accidents and incidents. The argument is quite likely true. By supporting a rationalisation of safety resources SMS likely contributes, down the line, to prevent accidents and incidents. This, however, is a *by-product* of SMS, and not the *reason* for an organisation to implement SMS. A focus on accident/incident prevention would turn SMS into a resource-consuming redundancy within the organisation: SMS will likely be "competing" with safety programmes for resources. Furthermore, a focus on accident/incident prevention instead of on supporting informed safety decision-making by the organisation's leadership would bias safety activities towards the "how", denying the organisation knowledge of the "what". In other words, the organisation would be swallowing medicine based upon symptoms, but without true certainty about the diagnosis of what the illnesses really are.

Reliance on the appropriate terminology

Tradition and history play a role on this challenge. All transportation industries, regardless of the nature of the industry and the service it delivers, share common "safety bumper-stickers": *If it ain't*

broke why fix it; *No news is good news*, *If you think safety is expensive, try an accident*, and the like. These slogans attest to a reactive attitude towards safety: wait until the system breaks, then figure out how to fix it.

While there is nothing inherently wrong with reaction as one of the avenues for dealing with safety risk, the problem arises when reaction becomes the main avenue or, worse, the only avenue. The reliance on terms or clauses such as *accident prevention; hazard elimination; zero tolerance; indiscipline; blame and punishment, human error and* the like suggest, once again, repackaging of old ideas into a new-looking envelope. When considering an SMS implementation proposal, key terms to look for should include *management*, *data*, *context*, *tolerance*, *monitoring*, *performance*, *accountability*, *organisation* and the like, which are keywords common to any management system.

Coda: Squandering the potential of SMS: An aviation example

ICAO Annex 19 sets forth the SMS requirements for international aviation operations, and stipulates which aviation organisations must implement SMS. Broadly speaking, there are two types of organisations in the aviation industry: organisations that provide a service (service provider organisations) and organisations that design and/or manufacture a product, or maintain it (design/ manufacturing organisations and maintenance organisations).

Airlines, airports, air traffic service providers and flying schools are the aviation service provider organisations encompassed under Annex 19. Airframe design and manufacturers, engine manufacturers, propeller manufacturers and approved maintenance organisations (AMOs) are the design/manufacturing and maintenance organisations encompassed by Annex 19. According to Annex 19, all of the organisations listed in this paragraph are required to implement SMS.

The justification for the requirement is the imperative of *safety first*, a philosophical superlative loudly proclaimed in aviation. In the specific case of SMS, this imperative/superlative lays down the groundwork for aberrant endeavours. A brief discussion follows that illustrates the contention that the benefits SMS can offer transportation industries can be squandered by misconceptions, mistaken beliefs, misplaced over-enthusiasm, or unclear guidance.

While delivering their services, airlines, airports, air traffic control facilities and flying schools must deal, on a routine basis, with *hazards* that can generate potentially negative safety consequences to the provision of the service(s) in question. The safety risk of the potentially negative consequences of hazards may give rise to safety concerns that, if uncontained, may compromise the viability of the enterprise. Hence, a system for the management of safety (SMS) during provision of services is the adequate resource to manage safety risk *at source* by aviation organisations that provide a service.

While designing and/or manufacturing airframes, engines or propellers, or maintaining them, design/manufacturing organisations and AMOs must deal, on a routine basis, with *defects* (in design, manufacturing or maintenance activities). These defects may also have potentially negative consequences on the safety of the product, but only *after it is deployed in operational contexts and utilised by service provider organisations*. At source, however, this is a quality concern (quality risk); there is no safety risk that could possibly be dealt with by the organisation while the product is in the manufacturing/design or maintenance stage. The quality risks, if uncontained, may lead to compromise the viability of the enterprise. Hence, a system for the management of quality (QMS) is the adequate resource to manage quality risk *at source* by aviation organisations that provide a product.

When confronted with the perspective outlined above, aviation safety zealots' argue that problems during design, manufacturing or maintenance may affect safety. Integral to this argument is the misperception of SMS as a safety/accident prevention programme as opposed to a management system. This is the wrong argument to espouse when evaluating the relevance of SMS to an

organisation. The question to be asked is not "*May this particular shortcoming in this activity affect safety*?" Under the safety zealot's limitless enthusiasm, everything may affect safety in aviation: design and manufacturing problems, maintenance problems, operational problems, training problems, financial problems (both organisational and individual), personal problems, legal problems, problems related to personal emotional stability, interpersonal relations problems, etc. The list is never-ending. Under this perspective, all management systems in an aviation enterprise might as well be subsumed under SMS, since everything going on in an aviation organisation and among its personnel is likely to affect safety.

It is accurate to postulate that problems in design, manufacture or maintenance may have an effect on safety once the product is operationally deployed. The question to ask, however, is not whether a particular problem may affect safety, but rather "*Which is the management system that the organisation has that is best equipped or positioned to deal with and contain the problem at source*?" Differently put, *defects* during design, manufacturing or maintenance may become *hazards* during operations. However, the management system that a design, manufacturing or maintenance organisation has and that is best equipped or positioned to deal with and contain defect problems *at source* is QMS, not SMS. If the problem is not contained at the product design, manufacturing and/or maintenance stage by QMS, then the service provider's SMS takes over once the product is deployed into service delivery operations. This is a clear inter-relationship that speaks volumes about the fundamental need of interfacing as opposed to confrontational management systems in transportation industries.

Practical experience in aviation supports the discussion above. SMS fits like a glove to airline flight operations, flight training, airport operations and air traffic services. Design of safety management processes and implementation of activities, development of guidance material, drafting training guides and similar resources for service providers are easy tasks for subject matter experts, and flow consistently and coherently. The same tasks, when intended for organisations that deliver products, become an uphill battle, resulting more often than not in the imaginative emulation of strategies originally developed for service provider organisations, which are often alien, irrelevant and incompatible for design, manufacturing and maintenance organisations.

The outcome of the situation discussed is a *déjà-vu*, at least in aviation: because the regulatory imperative exists, design, manufacturing and approved maintenance organisations will implement SMS. More than likely, implementation will not progress beyond institutional arrangements, because the processes are incompatible with the source activities of these organisations. Therefore, SMS will not bring these organisations any benefit that QMS does not already provide. The conclusion will be obvious: SMS does not work. Thus, the huge benefits that SMS can bring to the aviation industry – and to transportation industries overall – will be squandered.

Conclusion: Why SMS

The answer to the question is interspersed throughout the Discussion Paper. However, succinctly put and beyond technical "bells and whistles", the answer to "*Why implement SMS"* is "*Because it is a social imperative for transportation organisations"*. The paradigm of safety as an organisational afterthought grounded on lofty philosophical meanderings such as *safety is our first priority* and the like, and the approach of protecting safety during transportation operations through piecemeal safety programmes, which respond more to broad ranging and oftentimes alien regulatory requirements than

to organisation-specific, contextual needs, will not contribute to the expectations from society in the Twenty-first Century: transportation will unlikely support economic growth or foster social inclusion.

Transportation, regardless of mode, has long ceased being a pioneering industry; there is no trailblazing left to do. Safety in transportation in the Twenty-first Century must be perceived and approached to as yet another business function of transportation organisations. The transformation from safety as an organisational afterthought to safety as a business function must be evolutionary, since transportation industries loathe revolution. SMS represents a unique means for this transformation.

Back now to technical "bells and whistles", the Discussion Paper comes full circle in proposing an alternative to the challenge of framing SMS as an evolutionary approach to safety as a business function of transportation organisation. From the technical standpoint, SMS is necessary *because*:

- The development of the conceptual foundations of SMS, safety management, has been evolutionary, thereby catering for an essential "comfort" need of transportation organisations;
- SMS incorporates the lessons of both success and failure of countless endeavours and multiple scientific disciplines, over half a century and across modes of transportation, in search of "bringing safety down to earth". In so doing, SMS brings safety "down to earth";
- SMS distances itself from oblique reference and provides, in a fashion that makes it transportation mode-neutral, clear guidance for the integration of safety as an organisational process that adheres to basic notions of organisational control theory;
- SMS develops a language for safety communication with organisational leadership that falls in line with management language and relates to the needs associated to the management of an enterprise; and
- SMS portrays "life as it is" – not "life as it should be" – during transportation service delivery operations.

The potential SMS holds for the transportation industry is clear and present. The potential SMS holds for the transportation industry must be realised among transportation industries. If the potential SMS holds for transportation industries is realised, blue skies lie ahead, safety-wise. If the potential SMS holds for transportation industries is not realised, safety will continue sweeping up the leftover garbage at the rear end of the organisational parade. It is the closing conclusion and parting thought of the Discussion Paper that SMS deserves better than that.

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Notes

[1] Strictly speaking, Human Factors is a *technology*, i.e., a method of applying knowledge for practical purposes.

[2] A process is a conceptual framework that provides principled guidance for the execution of specific activities to achieve an objective(s).

[3] An activity is an action(s) that follows for its execution the principled guidance established by a process, thus facilitating achievement of the objective (s) sought by the process.

[4] Hazard. A real or potential condition that could lead to an unplanned event or series of events (i.e. mishap) resulting in death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment. (MIL-STD 882E)

[5] Safety risk. The predicted probability and severity of the potential consequences or outcomes of a hazard (ICAO, Annex 19 – *Safety Management*).

[6] Risk. A combination of the severity of the mishap, and the probability that the mishap will occur. (MIL-STD 882E)

[7] Mishap. An event or series of events resulting in: unintentional death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment. (MIL-STD 882E)

[8] Safety performance. A State or service provider's safety achievement as defined by its safety performance targets and safety performance indicators (ICAO, Annex 19 – *Safety Management*)

[9] Safety Management International Cooperation Group (SMICG).

[10] ICAO Annex 19 – *Safety Management.*

[11] ICAO Annex 19 – *Safety Management.*

[12] Accountability. A statement of what an individual is required to achieve, directly or through those to whom the individual has delegated responsibility, with regard to the operation of the SMS.

[13] Responsibility. Functions and duties that describe the purpose of what an individual is required to do with regard to the operation of the SMS.

[14] The term "senior management" as used in this Discussion Paper includes executive leadership (other than the Accountable Executive) as well as senior departmental management.

International Transport Forum

International Transport Forum
2 rue André Pascal
F-75775 Paris Cedex 16
contact@itf-oecd.org
www.itf-oecd.org