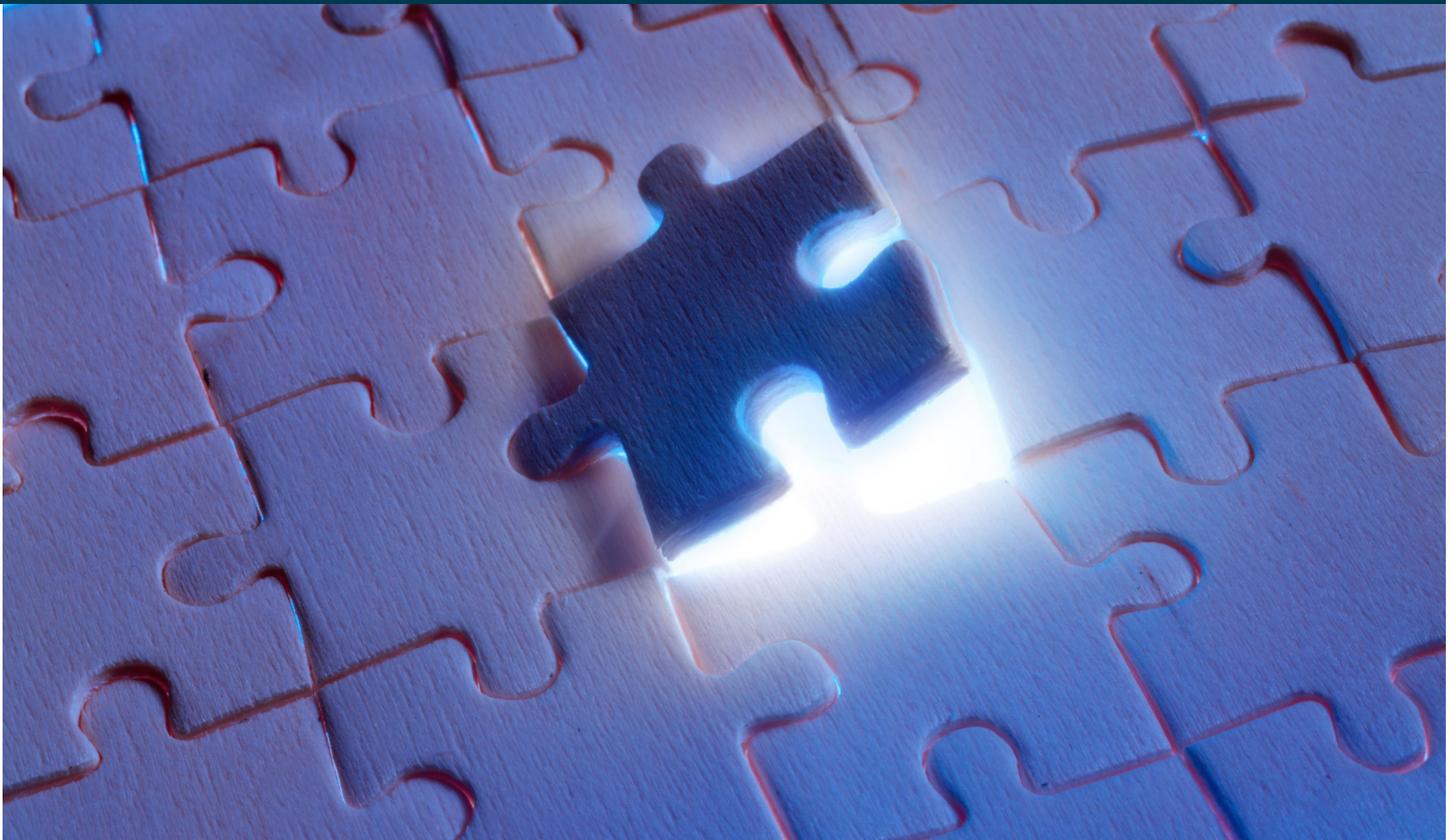




Australian Government
Australian Transport Safety Bureau

A systematic review of the effectiveness of safety management systems

Dr Matthew J W Thomas | Westwood-Thomas Associates



Research

ATSB Transport Safety Report
Cross-modal Research Investigation
XR-2011-002
Final



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ATSB TRANSPORT SAFETY REPORT

Cross-modal Research Investigation

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**A Systematic Review of the Effectiveness of
Safety Management Systems**

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Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

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SAFETY SUMMARY

Why have we done this report?

Australian aviation, marine and rail industries have all recently incorporated safety management systems into regulations and operations as a required way of managing safety. Safety management systems (SMS) refer to organisations having a systematic approach to managing safety, including organisational structures, accountabilities, policies and procedures. They generally include several common elements such as explicit management commitment to safety, appointment of key safety personnel, hazard identification and risk mitigation, safety investigations and audit, and safety performance monitoring.

Although Australia's transport industries' SMS approach is following world's-best practice, little empirical research evidence has been presented to determine the impact on safety of a structured SMS. The objective of this research investigation was to examine the published research literature into the efficacy of safety management systems, safety programs and related management processes that is applicable to high-reliability transport operations. The examination also aimed to identify which characteristics of these systems, and/or other organisational characteristics or external influences, are most related to the quality of an organisation's safety management. The outcome of this review may help organisations and regulators prioritise their efforts on those areas most likely to improve safety performance, and provide guidance for reviewing, auditing or investigating an organisation's safety management processes.

What was found

A comprehensive search of the literature found 2,009 articles, with 37 directly relevant to the objectives of this investigation, and a significant amount of literature published in the past 5 years. However, only 14 involved a SMS designed to avoid low-probability/high-consequence (LP-HC) accidents, with the remaining 23 studies relating to work health and safety. In addition, very few of these studies were undertaken in transport domains, and many studies only measured subjective perceptions of safety rather than objective measures. The limited quality empirical evidence available relate to the difficulty of measuring objective safety improvements in industries where the SMS is aimed at avoiding LP-HC accidents and the relative recency of the application of SMS.

Nineteen studies analysed objective metrics such as safety performance, employee behaviours, and accidents. Several of these found that organisations with a certified SMS had significantly lower accident rates. However, across these studies, there was a lack of agreement about which components of a safety management system individually contributed the most to safety performance.

A further 18 studies used self-report metrics about perceptions of safety within the organisation to examine the effectiveness of a SMS. Although there was also a general lack of consistency across which elements of a SMS affected safety the most, it was commonly found that both management commitment and safety communication were important.

Safety message

Incorporating safety management systems into normal business operations does appear to reduce accidents and improve safety in high-risk industries. At present, there have only been a small number of quality empirical evaluations of SMSs and it is unclear as to whether any individual elements of a SMS have a stronger influence on safety over other elements, although management commitment and appropriate safety communications do affect attitudes to safety. Transport organisations that provide an appropriate investment and commitment to a safety management system should receive a positive return on safety.

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Author

Matthew J W Thomas

Organisation that prepared this document

Westwood-Thomas Associates. ABN 25 990 655 971
12 John Street Goodwood SA 5034

Prepared By

Australian Transport Safety Bureau
PO Box 967, Civic Square ACT 2608 Australia
www.atsb.gov.au

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

DEFINITIONS

Safety management system – A safety management system (SMS) can be defined simply as a planned, documented and verifiable method of managing hazards and associated risks.

High risk industries – Industries in which safety incidents and accident pose the risk of harm to the general public. For example, nuclear reactors, oil and gas, chemical manufacture, aviation, shipping, rail.

Low-probability / high-consequence events – Catastrophic failures which have a low likelihood of occurrence, but if they do occur have extremely significant consequences.

Work health and safety – Safety measures for the prevention of workplace injuries and management of workplace hazards, including control measures to limit the consequences of major incidents, to ensure the health and safety of all workers (including employees, contractors, volunteers, trainees) and third parties (formally known as occupational health and safety or OHS). Work health and safety laws and requirements apply to all workplaces, including high risk industries.

INTRODUCTION

A safety management system (SMS) can be defined simply as a planned, documented and verifiable method of managing hazards and associated risks (Bottomley, 1999).

Further, as the International Civil Aviation Organization (ICAO) defines in a little more detail, a safety management system involves a systematic approach to managing safety, including the necessary organisational structures, accountabilities, policies and procedures (ICAO, 2009).

While there are many subtly different opinions on the essential components of an SMS, across all regulatory domains, the basic common attributes of an SMS include:

1. identification of safety hazards
2. remedial action to maintain safety performance
3. continuous monitoring and regular assessment of safety performance
4. continuous improvement of the overall performance of the SMS (ICAO, 2009).

These definitions imply some form of rigor in the actual development and specification of SMS, and further imply that such an approach to safety management is built upon a strong foundation of scientific evidence.

This report seeks to review the science that underpins the regulatory structures imposed on organisations involved in air, marine and rail modes of transport. In particular, this review has been undertaken to identify the evidence that exists to support the effectiveness of components of safety management systems.

The history of safety management systems

While the regulatory specification of safety management systems implies a strong theoretical foundation, the historic evolution of safety management systems tells a rather different story. The history of SMS is in many respects ‘organic’, having evolved from a haphazard collection of ‘best practice’ activities to promote safety across a wide variety of industrial contexts. Only when the primary mechanism for safety management moved from prescriptive regulation to organisational responsibility were specific practices for organisational safety management collectively grouped together under the banner of ‘safety management systems’. This collection of practices was grouped together to form the strategies by which an organisation could demonstrate that they were taking all reasonably practical steps to ensure the safety and welfare of employees and others.

Prior to the requirement for individual organisations to adopt a systematic approach to the management of safety, the welfare of employees, and the general public, was generally managed through adherence to prescriptive regulation as set out by government bodies. This so called ‘boots, belts and buckles’ approach to safety management suggested that as long as organisations followed government regulation with respect to technical protection of the workforce, the health and safety of employees was being managed effectively. Health and safety was

therefore managed through the powers of the governmental inspectorate ensuring that organisations were adhering to the relevant legislation and regulations.

While this approach was deemed sufficient in the early industrial age, by the later part of the 20th century, a number of catastrophic accidents resulting from the complexity of the post-industrial era led to significant regulatory reform that shifted the responsibility from the inspectorate to individual organisation's management of their unique industrial risk.

An organisation's own responsibility for safety management (beyond adherence to regulatory requirements) was perhaps only first realised after the watershed report of the Robens Committee in the 1970s in the UK (A.R. Hale & Hovden, 1998). The Robens Committee recommended that an organisation's management must assume responsibility for the organisational management of risk. This recommendation, and its embodiment in 1974 within the UK *Health and Safety at Work Act*, set out a philosophy of 'self-regulation'. Although the terminology of self-regulation remains problematic, this act was innovative in the fact that it included the first requirement for a common law 'duty of care' for an employer to ensure, as far as reasonably practical, the health and safety of its employees.

Robens saw three important pillars to improved safety performance through self-regulation. These were:

1. better systems of safety organisation
2. more management initiatives
3. more participation from employees (Reason, 1997).

Safety management shifted in the late 1970s from an approach that focused on adherence to prescriptive legislation, to an approach that focused on an organisation taking responsibility for its own management of its unique risk profile. To this end, 'self regulation' was defined as the requirement for an organisation to ensure that they took all reasonably practical steps to ensure the health and safety of their workforce (Feyer & Williamson, 1998).

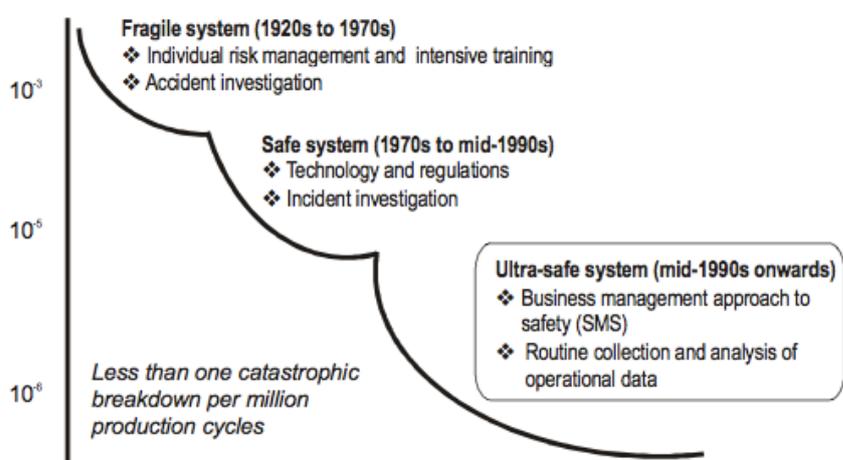
This shift in regulatory orientation was driven by a spate of catastrophic events in a diverse set of industry domains. For instance, the 1976 Seveso disaster, which involved a large-scale release of highly toxic dioxins from a small chemical processing plant in Italy, gave rise to the Seveso II directive, which mandated systematic management systems across facilities in Europe that handled dangerous substances (Anvari, Zulkifli, & Yusuff, 2011). A decade later, the Piper Alpha accident in the North Sea saw similar directives put in place for offshore oil and gas facilities as a result of the Cullen inquiry (Reason, 1997).

In this environment, SMS emerged as a conglomerate of safety-related activities that enabled an organisation to discharge their responsibilities under the spectre of self-regulation. Instead of completely walking away from regulation, the role of the regulator has in turn evolved to one that attempts to support and evaluate the strengths and weaknesses of a safety management system. This change has not only presented challenges to an organisation that now must effectively self-regulate, but also to the regulator who must now evaluate the effectiveness of a system, rather than compliance with a prescriptive regulation.

Development of guidance

Modern SMS could be defined as an arbitrary collection of activities that were deemed necessary actions to discharge responsibilities under the new age of the delegated responsibility of self-regulation. As regulatory bodies shifted from the production of prescriptive regulation to the requirement for systematic safety management, organisations demanded guidance as to how they could meet these new regulatory requirements. This occurred somewhat independently within various industries, with some industries being several years ahead of others. As demonstrated in Figure 1, safety management systems can be defined as the ‘third age of safety’.

Figure 1: The evolution of ultra-safe systems - after Amalberti, as cited in ICAO (2009).



The transition between the pure prescriptive approach and the modern SMS involved a gradual evolution in the way in which regulation sought to ensure safe systems of work. Certainly the period between the 1970s and the 1990s was very much the domain of ‘safety programs’ that had many elements, and to some extent many of these were elements of what we now call safety management systems.

In the stark light of self-regulation, the initial formulation of safety management systems were a collection of largely common-sense activities which would provide comfort and security to organisations in the new age of regulatory demands.

Prior to this, and as is largely still the case, there was certainly neither agreed definition nor specification for what a safety management system entailed. Rather, regulatory bodies aggregated safety management activities that appeared to be ‘best-practice’ in order to respond to the operators’ calls for ‘just tell me what I have to do to be compliant’.

Safety management systems in the Australian context

The development of formal standards and regulations with respect to SMS commenced in Australia during the 1990s, in parallel with a number of similar initiatives worldwide.

While the drivers for the development of safety management systems internationally had been catastrophic industrial accidents with widespread social impacts, in Australia, regulatory activity focussed on generic workplace health and safety management.

Two Australian standards relating to the design, implementation and on-going maintenance of generic occupational health and safety management systems were developed in the late 1990s and published in the year 2000. First, Australian Standard *AS4801 Occupational Health and Safety Management Systems – Specification with Guidance for Use* provides the detailed specification, and *AS4804 Occupational Health and Safety Management Systems - General Guidelines on Principles, Systems and Supporting Techniques* provides more general guidance. These standards were heavily influenced by previous directives in the UK and Europe and explicitly aligned with the International Organization for Standardization standard ISO 9000 *Quality Management* suite of management systems standards.

The standards for safety management systems are designed such that they mirror many components of the ISO 9000 series of standards pertaining to quality management systems and the ISO 14000 series of standards pertaining to environmental management systems. Indeed, for some time organisations have sought integration of their management systems in order to gain efficiencies and avoid duplication of processes across an organisation.

Even given the very different demands of managing the risks of workplace injury compared to the risks associated with low-probability high-consequence (LP/HC) transportation accidents, the overarching structures, individual components, and major functionality of safety management systems have remained very similar, regardless of industrial context.

Commercial aviation domain

In the context of Australian civil aviation, the Civil Aviation Safety Authority (CASA) mandated under Civil Aviation Orders CAO 82.3 and 82.5 that all regular public transport operators must have in place a functioning and effective SMS since 2009. Responding to the broad guidance provided by ICAO with respect to SMS, CASA has developed a detailed framework that stipulates the minimum components of an SMS (ICAO, 2009).

This regulation is the result of a long process of regulatory development, and industry-specific training beginning over a decade earlier. In the early 2000s, CASA produced a range of guidance manuals and training materials pertaining to safety management systems. In many respects, Australia was seen as an international leader in SMS development in aviation, even if it took some ten years to produce a formal regulatory requirement for all regular public transport operators.

Figure 2 highlights the 15 core components of an SMS as defined by CASA, grouped under the four key areas of:

- safety policy, objectives and planning
- safety risk management
- safety training and promotion
- safety assurance.

Figure 2: CASA Safety Management System Framework (CASA, 2009)



Operators are provided solid guidance with respect to operationalising the required components on an SMS through the proliferation of support materials in the form of Civil Aviation advisory publications (CAAPs) and other training and promotional materials produced by CASA, including a purpose-built aviation SMS Resource Kit¹.



¹ See http://casa.gov.au/scripts/nc.dll?WCMS:STANDARD::pc=PC_91430.

The CAAPs are:

- SMS-1(0) *Safety Management Systems for Regular Public Transport Operations* (January 2009)
- SMS-2(0) *Integration of Human Factors (HF) into Safety Management Systems (SMS)* (January 2009)
- SMS-3(1) *Non-Technical Skills Training and Assessment for Regular Public Transport Operations* (April 2011).

Maritime domain

The Australian Maritime Safety Authority (AMSA), under Marine Orders Part 58, requires operators, owners and managers of all passenger vessels, cargo vessels of 500 tonnage or more, and mobile offshore drilling units propelled by mechanical means of 500 tonnage or more, to be certified under the International Maritime Organisation's (IMO) International Safety Management (ISM) Code.

While AMSA is responsible for the audit, verification and certification of Australian vessels, it is also responsible for exercising 'control' over foreign flag vessels in Australian ports. By applying the international code across the world, as AMSA does in Australia, ship owners only need to be compliant with the requirements of one safety management system code to be compliant with local regulations in all countries that the ship visits.

The ISM code came into effect in 1998, having been first developed in the early 1990s in response to rising concerns over organisational safety management in the maritime industry in the late 1980s (Sahatjian, 1998). Under the ISM Code, ship owners and operators must:

- follow safe practices in ship operation
- provide a safe working environment
- establish safeguards against all identified risks
- continuously improve safety management skills of personnel ashore and aboard ships, including preparing for emergencies (IMO, 1998; Sahatjian, 1998).

Like other regulated forms of safety management systems, the ISM Code mandates an assortment of safety management practices which are broadly in line with other industries. The following elements are required under the ISM Code for inclusion in a maritime SMS:

- safety and environmental policies
- procedures to ensure safe operation of ships and protection of the environment
- defined level of authority and lines of communication
- procedures for reporting accidents and non-conformities
- procedures to prepare for and respond to emergency situations
- procedures for internal audit and management reviews.

As the maritime SMS standard for larger vessels in Australia is an international standard, AMSA directs operators to international publications for guidance for complying with the ISM code. The *Guidelines on the Application of the IMO International Safety Management (ISM) Code*² is a key recommended publication on the basis that it provides comprehensive instruction on the implementation of ISM as well as additional guidance on risk management, safety culture and environmental management.



Smaller vessels used for public passenger services, such as ferries used in city harbours and rivers, are regulated under state jurisdictions but are also required to be operated under an SMS. In New South Wales, for example, ferries are required under the *Public Transport Act (1990)* Part 6 to have a SMS that:

- identifies any significant risks that may arise from providing the service
- specifies controls (including audits, expertise, resources and staff) to manage risks and monitor safety outcomes in relation to the provision of the service.

Most other smaller commercial vessels are also required to be operated under an SMS under state laws and regulations. For example, in New South Wales, the Marine Safety (Commercial Vessels) Regulation 2012 Part 10 requires all commercial vessel owners to have a written SMS that includes identifying risks and specifying controls as per above. Some states require some commercial vessels to have a SMS in place, such as in Queensland where it only applies to commercial ships over 8 m in length and most fishing vessels.

Rail domain

Historically, the regulatory environment in the context of the Australian rail industry has been administered through independent state and territory based government authorities. Originally, the Australian Standard suite of Railway Safety Management Standards, AS4292, published from 1995 to 1997, were referenced under the respective state and territory rail safety legislation as guidance for rail transport operators and regulators with respect to the minimum content of a SMS.

With the adoption of the Rail Safety Bill 2006, state and territory rail safety regulators required rail transport operators to comply with the national Model Rail Safety Act and Regulations, as implemented in each jurisdiction. The mandated regulations (National Transport Commission (Model Rail Safety Regulations) Regulations 2007) detailed the minimum requirement that rail operators needed to develop for a compliant SMS.³

From 2013, state-based regulation in rail will be replaced by a single national regulator. In November 2012, Australia's transport ministers approved a new set of

² *Guidelines on the Application of the IMO International Safety Management (ISM) Code*, 2010, Fourth edition. This publication is a guide developed by maritime stakeholders (International Chamber of Shipping and International Shipping Federation).

³ Although the regulations drew significantly from the AS4292 standards, they no longer specifically reference the Australian standard, although the standard still remains an acceptable guidance document for developing systems complying with the regulations.

Laws and Regulations which will provide the regulatory framework for the new national regulator.

Within the new regulations, as per the 2007 Model Rail Safety Regulations, all rail operators must have a functioning and effective SMS. These elements are identical to those provided by the National Transport Commission in the 2008 guideline on preparation of a rail safety management system (National Transport Commission, 2008). A total of 29 components of a SMS are provided in the regulations and are as follows:

- Safety policy
- Safety culture
- Governance and internal control arrangements
- Management responsibilities, accountabilities and authorities
- Regulatory compliance
- Document control arrangements and information management
- Review of the SMS
- Safety performance measures
- Safety audit arrangements
- Corrective action
- Management of change
- Consultation
- Internal communication
- Human factors
- Training and Instruction
- Risk management
- Procurement and contract management
- General engineering and operational systems safety requirements
- Process control
- Asset management
- Safety interface coordination
- Management of notifiable occurrences
- Security management
- Emergency management
- Rail safety worker competence
- Fatigue
- Drugs and alcohol
- Health and fitness
- Resource availability

The regulations provide a high degree of specificity for operators charged with implementing an SMS.

Purported benefits of safety management systems in Australian transport Industries

While safety management systems may be conceived quite differently in each of the Australian transport domains, the regulatory framework for each mode is based on the premise that an SMS will lead to enhanced safety performance.

The actual benefits of a safety management system have been purported as wide-ranging across the scope of a whole organisation. These are most boldly purported in the aviation domain where the CAAP SMS(1) dedicates a whole appendix to 'selling' the benefits of an SMS. As this appendix, entitled *Benefits of a Safety Management System* states (CASA, 2009):

An SMS is as important to business survival of the organisation as financial management. The implementation of an SMS should lead to achievement of one of civil aviation's key goals; enhanced safety performance through the identification of hazards and reducing these hazards until they are ALARP. An effective SMS may produce the following benefits:

- Reduction in incidents and accidents (occurrences);
- Reduced direct and indirect costs;
- Safety recognition by the travelling public;
- Reduced insurance premiums; and
- Proof of diligence in the event of legal or regulatory safety investigations.

Unfortunately, this appendix makes no reference to any scientific evidence to support these claims, nor legal evidence with respect to due diligence. Indeed, much of the regulatory effort with respect to the adoption of SMS as the primary regulatory platform has been characterised on uncritical acceptance, and based on expert opinion and face validity, rather than subjected to formal scientific validation.

Previous published reviews of SMS research do not appear to provide strong empirical evidence to support the specific benefits of adopting an SMS. For instance, the summary of a 2006 review of evidence for the effectiveness of SMS across a wide cross-section of industries suggests that there has been a 'less than expected' reduction in accident occurrence since the implementation of SMS (Rosenthal, Kleindorfer, & Elliott, 2006). Moreover, the review continues by demonstrating that despite the less than expected decrease in accident incidence:

most practitioners continue to believe that an 'effective' management system is the key to prevention and that the less than expected decrease in accident incidence has occurred because the newly adopted regulations have not resulted in the hoped for adoption of 'effective' process safety management systems by industry (Rosenthal et al., 2006).

This sentiment has been shared across other industry sectors, where in Singapore even after a decade of SMS implementation in the construction industry, little benefit has been identified:

In Singapore, the construction industry had implemented safety management system (SMS) and SMS auditing for about 10 years now, but the

improvement in safety standard is not significant (Ai Lin Teo & Yean Yng Ling, 2006).

In short, the empirical evidence reviewed by various authors to date has not yet provided a significant demonstrable safety improvement that can be directly attributable to SMS. To some degree, this lack of evidence can be attributed to the difficulties associated with undertaking such forms of research, as is discussed towards the end of this report.

However, over the last 5 years, a large number of new studies have been published that may well yield the empirical evidence to support the effectiveness of SMS, and provide guidance with respect to effective SMS investment and implementation. The present report will examine this evidence in detail.

Research objectives

The objective of this research investigation is to produce a detailed, rigorous examination of the published research into the efficacy of safety management systems, safety programs and related management processes that are applicable to high-reliability transport operations. The review of the literature seeks to identify what characteristics of these systems are most related to the quality of an organisation's safety management. That is, what evidence exists that various aspects of safety management systems enhance safety.

The potential contribution to safety for this review is that findings could help organisations prioritise on those areas most likely to improve safety performance when establishing a SMS. It could also help the development of future guidance and standards in safety management systems, as well as guidance for reviewing, auditing or investigating an organisation's safety management processes.

METHOD

This report presents a detailed systematic review of the research evidence with respect to the primary research question of ‘the efficacy of safety management systems, safety programs and related management processes that are applicable to high-reliability transport operations’. More specifically, the review seeks to examine the specific components of safety management systems that have been demonstrated within the literature to result in improved safety performance. A *systematic review methodology* has been chosen from the range of literature review methodologies as it affords the most scientific rigor and is specifically oriented towards providing an unbiased, highly structured, and comprehensive review of evidence.

A traditional ‘narrative’ literature review focuses on a topic of interest, and brings to the review a wide range of theoretical positions to create new understandings in the form of a synthesis of findings from previous literature. In contrast, a systematic review focuses on the analysis of the results from *interventional* studies in a narrow topic area in order to answer a pre-determined research question about the effectiveness of the intervention of interest.

Literature search

A total of seven electronic databases indexing peer reviewed research articles were searched for this study. These databases included:

1. Scopus
2. Academic Search Premier
3. Business Source Complete
4. Ergonomics Abstracts
5. Health Business Elite
6. PsycARTICLES and
7. PsycINFO.

Search strategy

The search strategy involved a Boolean keyword search for the term ‘safety management systems’ and its derivatives. All fields of the database were searched to ensure that a comprehensive set of literature was retrieved. The searches utilised a ‘search limit’ in the form of only retrieving articles that were published in a peer-reviewed scholarly journal.

Inclusion and exclusion criteria

According to guidelines for the conduct of systematic reviews, a standardised set of criteria for inclusion or exclusion of studies in the systematic review was defined prior to the commencement of the literature search (Higgins & Green, 2011). The following criteria for inclusion and exclusion were used for this review.

- *Publication type:* Only peer reviewed articles published in peer-reviewed journals in the last 33 years were included in this study (1980-2012).
- *Research question:* For inclusion within the review, studies must have had clearly defined a research question that related to the effectiveness of safety management systems, or specific components of a safety management system. Effectiveness was defined for the purposes of this review specifically in terms of safety-related outcomes. To this end, studies of a qualitative nature were excluded, as were studies that assessed the effects of a safety management system with respect to production or economic metrics.
- *Population of interest:* The study could have been undertaken in any organisational context worldwide.
- *Nature of intervention:* Any type of intervention undertaken within the context of a safety management system was included.
- *Types of evidence:* To be included, the studies must have reported quantitative measures of safety-related outcome such as changes in incident or injury statistics.
- *Language:* Due to study constraints, any non-English language studies were excluded.

Quality appraisal

The next stage in the selection of articles for inclusion in the systematic review involved an appraisal of the studies' inherent quality. For the purposes of this review, each potential study was subjected to analysis and classification under the National Health and Medical Research Council (NHMRC) 'Levels of Evidence' criteria (NHMRC, 2009). These criteria are used to evaluate the methodological approach and scientific rigor applied to research studies. Accordingly, these criteria indicate the levels of confidence a professional may have in a certain intervention. This approach to the assessment of scientific evidence can easily be applied to other domains, and is suitable for the review of evidence relating to the effectiveness of safety-related interventions within the organisational context. As an SMS is effectively a safety-related intervention, the NHMRC criteria pertaining specifically to interventional studies were applied to the papers identified for analysis in this study.

Data Extraction

The next stage in the selection of articles for inclusion in the systematic review involved the extraction of key data fields for analysis. For each study, data relating to the following fields were extracted:

- year published
- study design
- industry
- country
- specific interventions (e.g. initial implementation on an SMS)
- comparison groups (e.g. companies with SMS compared to those without)
- independent variables (input measures)
- dependent variables (outcome measures such as accident rate)
- summary of results.

This data extraction enabled comparative analysis of research findings to take place as the primary component of the systematic review.

RESULTS

Results of the literature search

A total of 2,009 articles were initially selected for review against the inclusion and exclusion criteria after conducting the search of the seven databases. The abstracts of each of these articles was then read as a ‘first cut’ to identify any articles that clearly did not meet the inclusion criteria, or were to be excluded as per the exclusion criteria. This preliminary analysis left only approximately one tenth of the initial articles for further analysis of the full text.

At the completion of screening, a total of 37 articles remained that were in line with the inclusion criteria. Of these, only one article was a previous systematic review, performed in 2007, which identified only 13 research papers from a field of over 4,000 that met the inclusion criteria for their study into SMS effectiveness, of which only three included analysis of comparison groups and only one of these actually involved a randomised control trial (Robson et al., 2007). This finding indicates that a significant amount of new literature has been added to our body of knowledge in the past five years.

Although the body of knowledge is expanding with respect to SMS, there were very few studies undertaken in the transport domain. Table 1 shows the distribution of published literature according to industry for the effectiveness of SMS aimed at reducing either work health and safety (WHS) related accidents (those leading to occupational injuries to workers) or low-probability / high-consequence (LP-HC) accidents (see definitions on page viii).

Table 1: Distribution of published literature according to industry

Industry Sector	WHS	LP-HC	Total	%
Aviation	1	2	3	8.1
Rail	0	0	0	0.0
Maritime	0	2	2	5.4
Construction	3	0	3	8.1
Major hazard facilities	1	9	10	27.0
Cross industry	8	1	9	24.3
Manufacturing	9	0	9	24.3
Other	1	0	1	2.7
Total	23	17	37	100

Quality of evidence

Each of the final 37 papers was initially subjected to analysis using the NHMRC Evidence Hierarchy. In short, studies at Level I and II of the hierarchy demonstrate appropriate rigour, and the findings can be taken to be accurate and relatively free of bias. However, at the lower levels of the hierarchy, trust in the research findings should not be so freely given.

Table 2 provides the results of this analysis:

Table 2: Evaluation of Levels of Evidence

Level	Description	N	%
I	Systematic Review of Level II studies	1	2.7
II	A randomised control trial	1	2.7
III-1	A pseudo-randomised control trial	0	0
III-2	Comparative cohort study with concurrent controls	17	45.9
III-3	Comparative cohort study with no controls	2	5.4
IV	Case-series with post-test outcomes	16	43.2

As evident in Table 2, the vast majority of studies fell within Levels III and IV, demonstrating that overall, the scientific literature provides relatively low quality of evidence supporting SMS interventions.

The most frequently observed type of research involved comparative cohort studies, whereby organisations were grouped and compared according to a range of criteria relating to SMS effectiveness. In general, these studies identified one or more aspects of the safety management system as independent variables (describing the *intervention*), and safety outcome metrics such as accident rate or lost time injury frequency rate as dependant variables (*outcome* measures).

The second most frequently observed type of research involved case-series analyses. This grouping of studies pertain to a trend towards developing structural equation models⁴ to demonstrate what components of safety management are associated with changes in safety performance. Often, these studies derived measures of SMS interventions from safety climate questionnaires, and self-reported safety performance.

The majority of the studies analysed in these two categories were methodologically compromised by utilising self-assessment of SMS implementation or safety-related effort, such as a safety manger's assessment of the organisation's resource expenditure with respect to safety. While some studies compared this self-assessment to objective metrics of safety performance, many also relied on self-reported safety metrics. To this end, the majority of comparative cohort studies suffered from potential bias in terms of circulatory of measurement. Methodologically, this problem is termed *common method variance*, and is a common problem facing self-report measures, where relationships between a range of variables are detected in data collected using the same instrument. In these

⁴ Structural equation modelling is a multivariate statistical technique used to explore the relationship between a number of different factors, and their relationship to a particular outcome.

situations, the relationships which emerge might be the result of a common relationship with a third spurious and unmeasured variable, rather than an independent relationship between the two or more variables as measured (Kline, Sulsky, & Rever-Moriyama, 2000).

With respect to high-quality evidence for the effectiveness of safety management systems, there was only one study that met the methodological requirements for a randomised control trial (LaMontagne et al., 2004). This study clearly demonstrated that it is possible to undertake such a rigorous approach to measuring the effectiveness of safety management system interventions. However, as will be discussed below, the study unfortunately stopped short of measuring program effectiveness in terms of safety performance outcomes.

The following pages summarises the main findings from these studies. A full list of the 37 publications, along with each study's design, NHMRC Evidence Hierarchy class, industry, measures, country and the main findings are presented in the Appendix in Table 3.

Findings in relation to SMS effectiveness – Objective safety performance

Of the 37 articles subjected to analysis within this systematic review, 19 utilised objective metrics of safety performance. These objective metrics spanned the spectrum of safety performance, from observations of employee behaviour and unsafe acts, to lost time injury rates, and through to low-probability / high-consequence industrial accidents.

Work health and safety performance

Of these 19 studies that presented objective performance data, the majority (15) related to work health and safety (WHS) performance, primarily focusing on reducing occupational injuries to workers (mostly in manufacturing, construction and chemical industries). Of these studies, the majority demonstrated significant positive effects with respect to dimensions of SMS. A number of studies found general relationships between SMS implementation and safety performance. Of these, two studies (in manufacturing and chemical industries) found that those companies who had a certified SMS had significantly lower accident rates (Chang & Liang, 2009; Vinodkumar & Bhasi, 2011).

However, across multiple studies there was considerable lack of agreement with respect to which components of a safety management system were individually related to safety performance. First, Askorn & Hadikusumo (2008b) demonstrated that of the suite of SMS interventions, in the context of the construction industry, 1. incident investigation; 2. audit; 3. subcontractor management; and 4. safety incentives were associated with a reduction in accident rate. Another study examining generic WHS performance in the US manufacturing sector found that 1. hazard identification; 2. tracking hazard control efforts; and 3. health promotion programs were the three most critical components (Wurzelbacher & Jin, 2011).

In another study examining WHS performance, a Spanish team found that emphasis on 1. 'the innovative dimensions of prevention activities'; 2. the 'intensive use of quality management tools'; and 3. the 'empowerment of workers' were the primary factors that contributed to reduce the number of injuries (Arocena, Nunez, & Villanueva, 2008). This participatory focus was echoed in a Dutch study, which found that 'interventions bringing about constructive dialogue between shop-floor and line management, providing motivation to line managers and strengthening the monitoring and learning loops in the safety management system appeared more successful' (A. R. Hale, Guldenmund, van Loenhout, & Oh, 2010). Similarly, firms that combined both technical and people-oriented measures in their SMS were shown to have the highest safety performance (Arocena & Nunez, 2010).

While most studies analysed demonstrated positive effects of components of a safety management system, there were a number of studies that failed to identify positive effects. For instance, Glendon & Litherland (2001) found no relationship in the Australian road maintenance industry between individuals' perception of safety management practices and observed safe behaviour. The findings of this study suggest quite appropriately that the effectiveness of the SMS might only be seen at the organisational level, rather than influencing the rate of unsafe acts. In an Iranian study, there was no relationship seen between the implementation of an SMS and productivity metrics within an organisation, providing evidence to contradict conventional wisdom (Hamidi, Omidvari, & Meftahi, 2012).

Low-Probability / High-Consequence Industries

As was the case with respect to work health and safety performance, no consistent findings were demonstrated with respect to performance on various dimensions of an SMS and poor safety outcomes from the perspective of low-probability but high-consequence events in the major hazard process industries.

In the first of only four studies exploring this relationship, the use of a standardised audit tool to assess the functioning of safety management system components in Europe could not predict either lost time injury or loss of containment rates (Hurst, Young, Donald, Gibson, & Muyselaar, 1996). This suggests that in high risk industries, there may well be little relationship between the factors influencing occupational health and safety outcomes, and performance in process safety.

Indeed, in perhaps one of the most important studies in terms of relevance to high-risk transport industries (using a cross section of industries), there was no real relationship established between everyday safety performance and low-probability / high-consequence events (Elliott, Kleindorfer, DuBois, Wang, & Rosenthal, 2008). This finding from the US highlights the lack of clarity in what might actually be driving ultra-safe performance, and in many respects the question as to SMS effectiveness is unable to be adequately answered by even the most recent research.

In a study from the UK offshore oil and gas industry which utilised objective safety performance data, 1. management commitment; and 2. health promotion and surveillance were found to be associated with decreased accident rates (Mearns, Whitaker, & Flin, 2003).

To some degree, the lack of clear relationships between the performance of components of an SMS and objective safety data in high risk industries is likely to be influenced by the inherent lack of frequency of high consequence failures, and may well be reflective of issues in measurement, rather than the lack of any underlying relationship.

Findings in relation to SMS effectiveness – Subjective self-report

Of the 37 articles subjected to analysis within this systematic review, 18 utilised only subjective self-report metrics of safety performance. Most of these studies adopted a survey-based approach to examine inter-relationships between individual perceptions on the functioning of components of safety management systems and self-reported safety performance metrics.

Work health and safety performance

As was found with respect to objective safety outcomes, there was a distinct lack of consistency in the findings of the critical components of safety management system effectiveness.

Several studies highlighted variables that mediated the influence of safety management activities on safety outcomes. For instance, one study found that individual attitudes mediate the relationship between management and accident occurrence, and specifically that individual responsibility and personal involvement were the most proximate factors which influenced accident involvement (Tomás, Cheyne, & Oliver, 2011). However, the findings of these studies are potentially biased as they are drawn from individual survey responses which by definition would highlight these factors. Some consistency was found with respect to the factors of 1. management commitment; and 2. safety communication (Fernandez-Muniz, Montes-Peon, & Vazquez-Ordas, 2012).

Low-Probability / High-Consequence Industries

Several studies explored the relationships between components of SMS and safety performance in the context of major hazard facilities. The first of these studies from an oil refinery environment established a relationship between self-reported safety performance and the two components of 1. management commitment; and 2. safety communication. A second study, undertaken by the same authors found no direct effect of management commitment, but rather 1. supervision; 2. safety reporting; and 3. team collaboration as the immediate drivers of safe work practices (S. H. Hsu, Lee, Wu, & Takano, 2010). Slightly different findings were obtained in another study, whereby 1. management commitment; and 2. safety rules and procedures were found to be directly associated with safe work practices in major hazard facilities in India (Vinodkumar & Bhasi, 2010).

One study was clearly notable as an exception to the general findings in support of safety management systems. This study, within the maritime domain, found that safety behaviour was influenced by safety policy and perceived supervisor behaviour rather than other components of safety management systems. The authors quite eloquently conclude that:

Shipping companies should therefore invest large amounts of money in developing and implementing safety rules, procedures, and training (Lu & Tsai, 2010).

In short, as with the previous components of the review, a lack of consistency was the only systematic finding with respect to relationships between SMS and safety performance. Moreover, the current methodological trend towards the use of

survey-based studies and structural equation modelling to tease out the inter-relationships between components of safety management systems, safety climate factors, and safety performance might not assist in clarifying the complex set of factors influencing safety performance, and do not really assist in enhancing our understanding with respect to establishing the effectiveness of safety management systems.

DISCUSSION

Summary of findings from the systematic review

Overall, the review found a lack of clarity in what might actually be driving safety performance, especially in low-probability / high-consequence industries and in many respects the questions posed by this review as to SMS effectiveness is unable to be adequately answered by even the most recent research.

Only a few of the studies could speak directly to high-risk transport industries, rather than generic WHS performance. Evaluating the effectiveness of SMS in managing low-probability but high consequence events such as a major transport accident is extremely difficult. This is primarily due to the infrequent occurrence of compromised safety, and the problems associated with ‘the fine art of measuring nothing’ (Lofquist, 2010). As Amalberti (2001) argues, the low-probability / high-consequence transport system faces a paradox, in as much as when safety improves, increased safety performance is achieved through implementing new interventions, rather than attempting to optimise existing interventions.

Beyond the limitations of establishing effectiveness in the absence of catastrophe, the current methodological trend towards the use of self-report survey-based studies and structural equation modelling to tease out the inter-relationships between components of safety management systems, safety climate factors, and safety performance only serve to muddy the water with respect to establishing the effectiveness of safety management systems. First, these studies fail to utilise a standard set of instruments, thus leaving the industry unsure of exactly what is being measured. Furthermore, there is a tendency to infer causality from the findings of these models, in as much as increased management commitment *leads* to reduced rates of safety occurrence. No such directional causality can be inferred through these study designs, and as discussed previously, each of these studies is limited from the perspective of common method variance.

A reflection on excluded studies

Traditionally, western science has adopted methodological rigor as a core value, and utilises a strict set of criteria for evaluating the appropriateness of research design such that the results of research can be interpreted in with respect to their validity and reliability. This study has adopted this paradigm and tested the empirical strength of research examining the effectiveness of safety management systems.

A proliferation of ‘models’

Of the studies excluded from the analysis, there were a proliferation of ‘frameworks’, ‘models’ and ‘strategies’ that were argued for with respect to their potential contribution to safety performance through inclusion within an organisation’s safety management system. These frameworks often lacked theoretical strength and it could be argued that most simply reflected an author’s common sense rather than any scientific rationale.

Nonetheless, it is apparent from this review that this indeed reflects the typical developmental trajectory of safety management systems across many industry contexts.

The parachute analogy...

There is a well-known axiom that states ‘there was never a randomised control trial for the effectiveness of the parachute’. This is to say that there has never been a study in which one group jumps from an aeroplane with a parachute, and their survival is compared with a group that jumps in exactly the same conditions, but without a parachute.

The argument here is simple, some interventions just do not require large-scale experiments to establish their effectiveness. Many interventions are based on first principles, that are things that we already know to be true, and logic. Safety management systems contain many of these elements. For instance, logic simply dictates that if you are to prevent the reoccurrence of an event, you need to understand what caused the event, and put in place strategies such that those causes are prevented from occurring again. Hence, the need for accident investigation is a simple logical necessity that requires no empirical evidence to support its use within safety management processes.

This review of the scientific literature suggests that this logical necessity, which many might call ‘common-sense’, has driven much of the development of safety management systems.

The legacy of accumulated safety management practice...

Another driver of components of a safety management system involves the legacy of previous intervention. This review has highlighted that in many respects, safety management systems represent just an accumulation of a wide range of common-sense interventions. Moreover, these accumulations have a tendency to continually grow, rather than seasonally bloom then wither.

Given the overall lack of genuine scientific evidence for the composition of safety management systems, it would be a very brave manager to suggest that safety

performance might improve if the organisation ceases to invest in one of the components of a safety management system.

However, given the unquestionable reality of a focus on profit in a capitalist society, organisations will always limit their investment on safety management activities. To this end, it just might be the case that the ever growing list of components of a safety management system may well result in dilution of effort across the spectrum of safety management activities. This dilution of effort may well result in poorer safety performance as the critical components receive less time and effort at the expense of yet another ‘good idea’ dressed up as a legitimate safety program. Given that, at present, there is no clear objective empirical evidence as to whether there are any critical elements, this is a real possibility.

Limitations due to a quantitative lens

This review focused solely on studies in which the effectiveness of a safety management system (or one or more of its sub-components) was assessed through quantitative measurement of a safety-related outcome metric. To this end, studies of a qualitative nature were excluded, as were studies that assessed the effects of a safety management system with respect to production or economic metrics.

While the reliance on purely quantitative evidence has been criticised for adopting an overtly reductionist approach, in which ‘the big picture’ might be lost by attempting to explain phenomena by relationships between their constituent parts, for the purposes of this study it was critical to establish what empirical evidence does in fact exist with respect to the effectiveness of safety management systems.

Only recently has the scientific community seen a strong debate from several position-papers within the leading journal *Safety Science* with respect to the tools we are currently using to evaluate the effectiveness of safety management systems (c.f. Pedersen, Nielsen, & Kines, 2012). This debate has focussed on whether it is appropriate to use the existing hierarchies of evidence in order to evaluate the effectiveness of safety management systems, and what new approaches might be more appropriate. It is perhaps only when some resolution has been achieved within this debate that we may move a step closer to actually being able to demonstrate with confidence just which components of a safety management system contributed to enhanced safety, and the mechanisms by which they do so.

The precautionary principle...

Even within a vacuum of evidence, the precautionary principle states that we must not fail to take precautionary action. To this end, it is likely that the current regime of an aggregate set of components assembled into something, which we call a ‘safety management system’, remains an important tool in the management of safety.

CONCLUSIONS

While the findings of this systematic review perhaps shed little more light on the specific elements critical to SMS effectiveness, Australian industry can rest assured that the regulatory frameworks of an SMS adopted in Australia are in line with international best-practice.

The majority of studies reviewed have attempted to answer questions relating to system effectiveness by deconstructing the system and looking closely at each of its components.

A synthesis of the findings of this systematic review would suggest that the effectiveness of Safety Management Systems may well not lie in specific components of the system, but rather in the level of sophistication and effort applied across the system as a whole. To this end, the lack of evidence for SMS effectiveness may well reflect the simplistic approach adopted within the scientific research, and the lack of scientific rigour applied to answering this critical question.

The systematic review did, however, highlight that recent studies have demonstrated that well-implemented SMS, especially those where the organisation invests effort into the SMS, are associated with enhanced safety performance.

The review highlighted a deficit of studies in high-risk transport domains, and also very few studies originating from Australia. To this end, Australian transport industries should consider participating in wide-spread sophisticated evaluation of their SMS, such that we can come to better understand the most important systemic structures critical for enhanced safety performance.

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APPENDIX

Table 3: Summary of the 37 studies subjected to systematic review

DETAILS	METHODS		CONTEXT			INTERVENTIONS		FINDINGS
	Citation	Study design	Class	Industry	Measures	Country	Specifics	
Fernandez-Muniz et al. (2012)	Case Series Post-Test (Survey)	IV	Generic WHS	WHS	Spain	N/A	N/A	Management commitment and communication positively related to safety behaviour. Safety behaviour related to safety performance, employee satisfaction, and firm competitiveness.
S. H. Hsu, Lee, Wu, & Takano (2008)	Case Series Post-Test (Survey)	IV	Oil Refinery	LP-HC	Japan Taiwan	N/A	N/A	The casual relationships between organisational factors and workers' safety performance were investigated using structural equation modelling (SEM). Results indicate that the influence mechanisms of organisational factors in Taiwan and Japan are different.
Jiang, Yu, Li, & Li (2010)	Case Series Post-Test (Survey)	IV	Petro-Chemical	WHS	China	N/A	N/A	Perceived colleague's safety knowledge and behaviour predicted individual's safety behaviour, with a mediating effect of climate. Safety behaviour predicted injury.
Lu & Tsai (2010)	Case Series Post-Test (Survey)	IV	Maritime	LP-HC	Taiwan	N/A	N/A	Safety policy predicted safety management activities, perceived supervisor safety behaviour, and individual safety behaviour. Safety management activities predicted perceived supervisor safety behaviour but not individual safety behaviour.
Lu & Yang (2011)	Case Series Post-Test (Survey)	IV	Maritime	LP-HC	Taiwan	N/A	N/A	Safety training and emergency preparedness were found to positively affect self-reported safety behaviours with respect to safety compliance and safety participation.

DETAILS	METHODS		CONTEXT			INTERVENTIONS		FINDINGS
	Citation	Study design	Class	Industry	Measures	Country	Specifics	
Vinodkumar & Bhasi (2010)	Case Series Post-Test (Survey)	IV	Major Hazard	LP-HC	India	N/A	N/A	Some safety management practices had direct and indirect relations with the safety performance components, namely, safety compliance and safety participation. Safety knowledge and safety motivation were found to be the key mediators in explaining these relationships. Safety training was identified as the most important safety management practice that predicts safety knowledge, safety motivation, safety compliance and safety participation.
Aksorn & Hadikusumo (2008b)	Comparative Cohort Study	III-2	Construction	WHS	Thailand	N/A	N/A	Safety programmes that positively influenced accident rates included accident investigations, jobsite inspections, control of subcontractors and safety incentives.
Tomás et al. (2011)	Case Series Post-Test (Survey)	IV	Generic WHS	WHS	Spain	N/A	N/A	Variables dealing with the work environment, in particular the presence of workplace hazards, and the individual's approach to working safely were directly related to accident outcomes, explaining 19% of the variability in accident history.
Hobbs & Williamson (2003)	Case Series Post-Test (Survey)	IV	Aviation (Maintenance)	LP-HC	Australia	N/A	N/A	Different error types error were associated with a particular set of contributing factors and with specific occurrence outcomes. Among the associations were links between memory lapses and fatigue and between rule violations and time pressure.
Elliott et al. (2008)	Comparative Cohort Study	III-2	Cross Section of Industries	LP-HC	USA	N/A	N/A	The study found only weak evidence that everyday safety performance in terms of occupational injury rates predicted process safety performance and low-probability / high-consequence events.
Arocena & Nunez (2010)	Comparative Cohort Study	III-2	Cross Section Spanish SMEs	WHS	Spain	N/A	N/A	Evidence suggested that the effort and type of WHS management system significantly affected the injury rate. More specifically, firms that complement traditional technical preventive activities with people and organisation-oriented procedures were the most effective in reducing occupational accidents.
Liou, Yen, & Tzeng (2008)	Case Series Post-Test (Survey)	IV	Aviation (Airline Operations)	LP-HC	Taiwan	N/A	N/A	The study suggests that safety strategy and policy play the most important role in an effective SMS in as much as they had the highest net influence on all the other factors relating to safety performance.

DETAILS	METHODS		CONTEXT			INTERVENTIONS		FINDINGS
Citation	Study design	Class	Industry	Measures	Country	Specifics	Groups	
Basso et al. (2004)	Comparative Cohort Study	III-2	Major Hazard	LP-HC	Italy	N/A	N/A	The study found that operational control, hazard identification, and organisational/personnel factors to be the most critical elements of SMS.
Chang & Liang (2009)	Comparative Cohort Study	III-2	Paint Manufacturing	WHS	Taiwan	N/A	N/A	Companies with certified SMS had significantly lower accident rates.
S. H. Hsu et al. (2010)	Case Series Post-Test (Survey)	IV	High risk industries	LP-HC	Taiwan	N/A	N/A	The study found that safety leadership style and organisational harmony in Taiwanese high-risk industries can exert significant influences on work-group processes, which in turn have greater effects on individual safety awareness and practice.
Hurst et al. (1996)	Comparative Cohort Study	III-2	Major hazard	LP-HC	Europe	N/A	N/A	The study demonstrated that an SMS performance audit tool PRIMA was not able to predict lost time injury of 'loss of containment' events, but demonstrated some success at predicting self-reported accident rates.
Wurzelbacher & Jin (2011)	Comparative Cohort Study	III-2	Generic WHS - manufacturing	WHS	USA	N/A	N/A	Higher levels of several self-reported WHS program elements (tracking progress in controlling workplace safety hazards, identifying ergonomic hazards, using health promotion programs) were associated with lower rates of workers compensation cases.
LaMontagne et al. (2004)	Randomised Control Trial	II	Generic WHS - manufacturing	WHS	USA	Wellworks-2 program	General Workplace Health program	The study demonstrated that the Wellworks 2 Intervention improved aspects of the WHS program, such as worker involvement. However, no outcome measures in terms of safety performance were reported.
Rosenthal et al. (2006)	Narrative Review	III-3	High risk industries	LP-HC	Europe	N/A	N/A	The review highlights that data to date does not support the general consensus that incident rates will significantly decrease as a result of SMS implementation.

DETAILS		METHODS		CONTEXT			INTERVENTIONS		FINDINGS
Citation	Study design	Class	Industry	Measures	Country	Specifics	Groups		
Conchie & Donald (2006)	Case Series Post-Test (Survey)	IV	Offshore Oil and Gas	LP-HC	UK	N/A	N/A	Results identified attitudes toward offshore management as the strongest predictor of safety performance at an industry level. At an installation level, safety performance was best predicted by attitudes toward contractors and workmates.	
Mearns, Whitaker, & Flin (2001)	Case Series Post-Test (Survey)	IV	Offshore Oil and Gas	LP-HC	UK	N/A	N/A	Results highlighted perceived management commitment to safety and willingness to report accidents as significant predictors of personal accident involvement. Changes in perceived management commitment to safety were closely associated with changes in safety behaviour.	
Aksorn & Hadikusumo (2008a)	Comparative Cohort Study	III-2	Construction	WHS	Thailand	N/A	N/A	The results suggested that in construction projects, where all SMS elements, and not just one or a few, are given proper attention, there is a higher standard of safety performance.	
Arocena et al. (2008)	Comparative Cohort Study	III-2	Generic WHS	WHS	Spain	N/A	N/A	The results demonstrated that emphasis on the innovative dimensions of prevention activities, the intensive use of quality management tools, and the empowerment of workers are all factors contributing to reduce the number of injuries.	
Bottani, Monica, & Vignali (2009)	Comparative Cohort Study	III-2	Manufacturing	WHS	Italy	N/A	SMS or no SMS	Results show that SMS adopters experience a substantially lower number of accidents per year (7.03) if compared with non-adopters (15.05).	
Cheng, Ryan, & Kelly (2012)	Comparative Cohort Study	III-2	Construction	WHS	Hong Kong	N/A	High or Low project performance (50th percentile cut)	An exploratory factor analysis was conducted, and three SMS categories – ‘information’, ‘process’, and ‘committees’ – were extracted. Of these three categories, ‘process’ was perceived by construction practitioners as being the most important. However, regression results indicated that the ‘information’ and ‘committees’ categories were associated with project performance positively and significantly.	

DETAILS		METHODS		CONTEXT			INTERVENTIONS		FINDINGS
Citation	Study design	Class	Industry	Measures	Country	Specifics	Groups		
Fernández-Muñiz, Montes-Peón, & Vázquez-Ordás (2009)	Case Series Post-Test (Survey)	IV	Construction, industrial and services sectors	WHS	Spain	N/A		Findings show that safety management has a positive influence on safety performance, competitiveness performance, and economic-financial performance.	
Glendon & Litherland (2001)	Case Series Post-Test (Survey)	IV	Road maintenance	WHS	Australia	N/A	N/A	No relationship was found between safety climate factors and behaviour observation data.	
Granerud & Rocha (2011)	Case Analysis	V	Manufacturing	WHS	Denmark	N/A	N/A	Certification was found to support lower levels of continuous improvement performance in handling health and safety issues. However, more advanced improvement practices were shown to be connected to the integration of health and safety in other managerial areas, as well as to the employment of similar advanced improvement processes within firms.	
A. R. Hale et al. (2010)	Comparative Cohort Study	III-2	Generic WHS	WHS	Netherlands	Various SMS interventions		Interventions bringing about constructive dialogue between shop-floor and line management, providing motivation to line managers and strengthening the monitoring and learning loops in the SMS appeared more successful. The amount of energy and creativity injected by top managers and, above all, by the coordinator (safety professional) appeared also to be a distinguishing factor.	
Hamidi et al. (2012)	Comparative Cohort Study (no control)	III-3	Generic WHS	WHS	Iran	Integration of management systems	N/A	The results showed a significant difference between various safety indices before and after the implementation of integrated management systems. However, the results showed that the safety system existence cannot ensure productivity increases.	
I. Y. Hsu et al. (2012)	Case Series Post-Test (Survey)	IV	Chemical	WHS	Taiwan	N/A	N/A	The study found a range of inter-related factors predicted safety performance.	
Mearns et al. (2003)	Comparative Cohort Study	III-2	Offshore Oil and Gas	LP-HC	UK	N/A	High and Low accident groups	Associations were found between certain safety climate scales and official accident statistics and also the proportion of respondents reporting an accident in the previous 12 months. Proficiency in some safety management practices was associated with lower official accident rates and fewer respondents reporting accidents.	

DETAILS	METHODS	CONTEXT				INTERVENTIONS		FINDINGS
		Citation	Study design	Class	Industry	Measures	Country	
Remawi, Bates, & Dix (2011)	Comparative Cohort Study	III-2	Aviation	WHS	UAE	SMS	SMS or no SMS	The study demonstrated that implementation of an SMS was associated with significant positive shift in safety attitudes of employees.
Robson et al. (2007)	Systematic Review	I	Generic WHS	WHS	International	N/A	N/A	The review concluded that the body of evidence was insufficient to make recommendations either in favour of or against SMS.
Saksvik, Torvatn, & Nytrø, (2003)	Comparative Cohort Study	III-2	Generic WHS	WHS	Norway	N/A	Fully implemented SMS or not	Businesses that had fully implemented SMS demonstrated significantly better safety performance.
Vinodkumar & Bhasi (2009)	Comparative Cohort Study	III-2	Chemical	WHS	India	N/A	Low or High Accident rate	Safety climate scores calculated were found to have significant negative correlation with self-reported accident rates revealing good predictive validity
Vinodkumar & Bhasi (2011)	Comparative Cohort Study	III-2	Chemical	WHS	India	N/A	Certified OHSMS or not.	Organisations certified with SMS performed better in terms of safety outcomes than organisations with certified management systems or no certified systems in place.

Research

ATSB Transport Safety Report

Cross-modal Research Investigation

A systematic review of the effectiveness of
safety management systems
by Dr Matthew J W Thomas Westwood-Thomas Associates

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Web www.atsb.gov.au

Twitter @ATSBinfo

Email atsbinfo@atsb.gov.au