

# INVESTIGATING LINKAGES BETWEEN AN OCCURRENCE AND AN ORGANISATION'S SAFETY SYSTEM PERFORMANCE

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## Introduction

It has been established that aviation organisations with a well-designed safety management system (SMS) can reduce safety-related risk in their operations if the system is performing well (Thomas, 2012). Analysing the effectiveness of system performance as part of a safety investigation is now more prevalent, including how that performance may be linked to a specific occurrence.

The ATSB investigation analysis methodology categorises safety factors as individual factors, local conditions, risk controls and organisational influences (ATSB, 2008). In matters of system-related organisational influences, how can investigators clearly establish a linkage to the occurrence?

One example of how this linkage can plausibly be established is in the application of the ATSB's 'fatigue and fatigue risk management system (FRMS) investigation framework'. Based on the work of Dawson and McCulloch (2005), as well as other research and methodologies employed by international investigation agencies, the framework consists of five areas of fatigue risk. Evidence is required to support an assessment of that fatigue risk, for example:

- fatigue-related errors
- ability to maintain adequate alertness while on duty
- sleep obtained
- provision of adequate sleep opportunity
- organisational support for managing risks of fatigue impairment.

The last of these evidence sources may inform one or more organisational influences in an investigation. The ATSB investigation framework also provides guidance as to how this evidence will be used in fatigue analysis to satisfy firstly the test for existence, and secondly the test for influence, for the particular occurrence under investigation.

This paper details the utility of the ATSB's fatigue and fatigue risk management system framework in establishing a tangible link between the performance of an organisation's systems and an occurrence event. The applicability of a similar framework to the examination of an organisation's SMS more broadly is also discussed. This has been done within the context of two investigations.

## Context

### *The introduction of safety management systems to industry*

The trend for aviation organisations to implement formal SMSs has increased since around the 1990's, buoyed by the development of the International Aviation Safety Organisation's (ICAO) Global Aviation Safety Plan in 1997, and culminating in the release of Annex 19 and what is now the third edition of the ICAO Safety Management Manual in 2013. Additionally, the requirement that each ICAO signatory State develop a State Safety Program has furthered the incorporation of SMS requirements into national legislation, including in Australia.

In this context, Australia's State Aviation Safety Program (2012) defined an SMS as follows:

...a systematic approach to managing safety risks, an SMS encompasses organisational structures, policies and procedures. It is based on the idea that safety is best achieved through strong interwoven systems, rather than individual processes or practices. It is also underpinned by a philosophy of mutual responsibility and accountability, rather than relying solely on regulatory compliance.

The concept of achieving safety through 'strong interwoven systems' is an important influence on the consideration of how to review the effectiveness of an organisation's SMS. A key component of this concept is that the performance of an organisation's SMS relies on coordination between its policies, processes and practices.

### *Reviewing the effectiveness of safety management systems*

In 2011, in response to the move by Australia's transport industries toward incorporating SMS into their operations, the ATSB commissioned a study titled *A systematic review of the effectiveness of safety management systems*. The study examined the published research literature on the efficacy of SMSs, safety programs and related management processes, and identified the characteristics of these systems most related to the quality of an organisation's safety management. Noting that organisations that provide an appropriate investment and commitment to an SMS should receive a positive return on safety, the study also stated 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.'

This statement seemingly complicates the review of a safety system's effectiveness as, for example, it is not simply a case of comparing discreet activities against the related prescriptive regulation. However, in the context of an investigation, it is possible to focus on an organisation's practices in achieving specific outcomes. This can include how the organisation:

- identifies operational risks
- provides appropriate guidance through safe practices
- monitors their key areas of business.

Any examination of an organisation's SMS needs to be done in the context of a comprehensive analysis methodology. The following discussion describes such an investigation in the context of the ATSB's analysis methodology.

## Investigating organisational influences in the context of the ATSB analysis methodology

It has been widely accepted by investigators that most accidents are due to a combination of factors originating at all levels of the organisation. The quality of a safety investigation's analysis activities is critical in determining the contributing and other safety factors and issues in the development of an occurrence and, by implication, the potential for safety enhancement as a result of the investigation. However, safety investigations require analysis of complex sets of data and situations where the available data can be vague, incomplete and misleading. To address this situation, in 2008 the ATSB introduced a comprehensive investigation analysis framework (Walker and Bills, 2008).

### *ATSB investigation analysis model*

The ATSB investigation analysis model is based on the widely used Reason model of organisational accidents. It consists of five levels of safety factors, including the occurrence events, individual actions, local conditions, risk controls and organisational influences. Working through from the occurrence events through to organisational influences demonstrates the 'link-by-link' approach. See annex A for a diagrammatical representation of the model.

Organisational influences are those conditions that establish, maintain or otherwise influence the effectiveness of an organisation's risk controls. This includes an organisation's SMS, inclusive of the framework developed and their safety philosophies, policies, processes and practices.

Before any findings are made, they need to be tested or verified. In the ATSB analysis framework, this involves using a structured process to examine the available evidence and conduct tests for existence, influence and, if required, importance.

The testing process determines whether a potential safety factor is a 'contributing factor' (it passes the tests of existence and influence), an 'other factor that increased risk' (passing the tests of existence and importance but failing the test of influence), or of no consequence to the investigation ('not a safety factor'). The ATSB adopted a 'link-by-link' approach, where the judgement about whether a safety factor contributed to the development of an occurrence is made in terms of its relationship to another contributing factor.

The ATSB guidelines for testing existence, influence and importance have three main components:

- background information on critical reasoning
- a process for developing and evaluating arguments
- criteria for evaluating each test.

When testing an aspect of an organisation's SMS, the most challenging step seems to be that of 'influence'; does it have any linkage to an occurrence event? The answer may be, 'well, it depends on the nature of the finding'.

### *Types of findings relating to organisational influences*

Organisational influences will be reflected in one of two types of findings:

- A contributing factor indicates that had the condition not existed at the relevant time, then either the occurrence would probably not have occurred, the consequences would not have been as grave, or another contributing factor would probably not have occurred

or existed (ATSB, 2008). With respect to an organisation's SMS, investigators need to explore the extent to which any underperforming/absent elements contributed to the occurrence. This can be a significant challenge.

- Other safety factors, which are considered not to have contributed to the occurrence, but often indicate the presence of safety issues in a system.

A 'safety issue', which can include either contributing or other safety factors that increased risk, is a finding with the potential to adversely affect the safety of future operations, and is a characteristic of an organisation or a system, rather than a characteristic of a specific individual.

The identification of a safety issue suggests that it is reasonable or practicable for the relevant organisation(s) to address the issue. It is important for safety enhancement purposes to further analyse those issues and the reasons why they occurred. When analysing aspects of an organisation's SMS, findings have more commonly been classified as an 'other safety factor', rather than being contributory.

One tangible means of demonstrating how organisational influences may link to an occurrence event is to consider fatigue, and fatigue management.

### **The ATSB's fatigue and FRMS investigation framework**

Due to the fatigue risk associated with transport operations, investigators should consider the possibility of fatigue as a safety factor for virtually all investigations where human performance issues are apparent. This could be expected to include an examination of the involved organisation's management of its fatigue risk.

Based on the work of Dawson & McCulloch (2005) as well as other research, and methodologies employed by a number of international investigation agencies, the ATSB has determined a framework to assist its investigators with the collection of fatigue-related evidence. The framework supports a rigorous assessment of fatigue risk and its involvement in the development of an incident or accident.

#### ***Components of the ATSB fatigue and fatigue risk management investigation framework***

The framework consists of five areas of fatigue risk with corresponding fatigue risk controls/indicators. Evidence standards are defined in support of the assessment of that fatigue risk that broadly categorise the risk as organisational- or individual/group-focussed. Guidance is provided as to how the evidence will be used to test for existence, influence and importance for the particular occurrence under investigation. The five areas include:

- fatigue-related errors
- ability to maintain adequate alertness while on duty
- sleep obtained (quality and quantity)
- provision of adequate sleep opportunity
- organisational support for managing risks of fatigue impairment.

The last of these is the most relevant in the context of this paper. An organisation's FRMS policy, procedures and practices are reviewed, as are the rostering practices, the provision of training in fatigue and its management, reporting trends, and the systems for analysing workforce occurrences and risks.

A detailed diagram of the framework is at annex B. The framework is designed to be read from the bottom up, consistent with the chronological order in which an investigation progresses.

***A recent example of the application of the ATSB framework: investigation AO-2014-189***

On the evening of 4 December 2014, a Saab Aircraft Co. 340B aircraft was on a scheduled passenger service from Sydney to Narrandera, New South Wales. After take-off from runway 34 Left, the crew inadvertently did not retract the landing gear. The crew later identified this and instinctively retracted the gear whilst the aircraft was above the maximum landing gear retraction speed. A review of the application of the ATSB’s fatigue investigation framework to this investigation, and other aspects of the investigation follows.

**a) Evidence collection**

Figure 1 is an example of the fatigue investigation framework ‘in action’. It outlines the evidence collected during investigation AO-2014-189 in support of each of the five areas in the fatigue investigation framework.

**Figure 1: Fatigue-related evidence collected as part of AO-2014-189**

<b>Framework components</b>	<b>Sources of evidence in support of an investigation</b>	<b>Examples of evidence from AO-2014-189</b>
<b><i>Fatigue-related errors</i></b>	<ul style="list-style-type: none"> <li>• Account of events via interview.</li> <li>• Performance – actions, communications, decisions – leading up to and during the occurrence.</li> </ul>	<ul style="list-style-type: none"> <li>• Crew errors were consistent with the effects of fatigue on performance (attention, decision making and reaction time).</li> </ul>
<b><i>Ability to maintain adequate alertness whilst on duty</i></b>	<ul style="list-style-type: none"> <li>• Self/other reported observations of alertness.</li> <li>• Fatigue proofing strategies.</li> <li>• Subjective alertness scale responses.</li> <li>• Workload dimensions (physical, cognitive, pace of work).</li> </ul>	<ul style="list-style-type: none"> <li>• The first officer recalled feeling ‘drowsy’ earlier in the day and ‘pretty tired’ prior to sign-on.</li> <li>• The first officer recalled that they were tired before the flight.</li> <li>• Elevated workload of the departure due to the first officer’s reduced familiarity and adverse weather in the region.</li> </ul>
<b><i>Sleep obtained</i></b>	<ul style="list-style-type: none"> <li>• Sleep quantity and quality over the last 72 hours.</li> <li>• Estimation of individual need for sleep.</li> <li>• Description of the sleeping environment.</li> <li>• Other factors – that is sleep disorders, alcohol or drug use, use of stimulants and so on.</li> <li>• Recorded data – that is, actigraphy.</li> </ul>	<ul style="list-style-type: none"> <li>• The first officer obtained about 4 hours of sleep in the preceding 48 hours.</li> <li>• First officers’ usual sleep was 8 hours each night.</li> <li>• First officers’ sleeping environment was affected by storms in the region the night before the occurrence.</li> <li>• Stress associated with a check flight the day before significantly affected the first officer’s sleep two nights before the occurrence.</li> </ul>
<b><i>Provision of adequate sleep opportunity</i></b>	<ul style="list-style-type: none"> <li>• Planned and actual duty rosters.</li> <li>• Fatigue risk assessment of rosters.</li> <li>• Suitability of sleeping environment.</li> </ul>	<ul style="list-style-type: none"> <li>• Duty rosters recorded a time away from duty for the first officer of between about 2200 the evening before and 0800 on the day, providing a minimal sleep opportunity.</li> </ul>

Framework components	Sources of evidence in support of an investigation	Examples of evidence from AO-2014-189
	<ul style="list-style-type: none"> <li>• Commute method and duration.</li> </ul>	<ul style="list-style-type: none"> <li>• The first officer's commute was 1 hour each way from the airport, reducing the available sleep opportunity.</li> </ul>
<b>Organisational support for managing risks of fatigue impairment</b>	<ul style="list-style-type: none"> <li>• Documented FRMS or fatigue management policies and procedures.</li> <li>• Use of fatigue-modelling tools.</li> <li>• Fatigue reporting and action management.</li> <li>• Fatigue awareness training content, attendance.</li> <li>• Individual knowledge/attitudes about fatigue management</li> </ul>	<ul style="list-style-type: none"> <li>• Individual fatigue assessment tools to assist in determining fitness for duty not in use at the time.</li> <li>• At the time of the occurrence the operator was not required to undertake biomathematical modelling on roster patterns.</li> <li>• Fatigue training limited to an overview of fatigue, sleep and fatigue countermeasures.</li> <li>• The first officer did not perceive the risk of fatigue from their limited sleep.</li> </ul>

### **b) Analysis**

It is difficult to definitively state that a crew member was experiencing the effects of fatigue such that their performance was negatively impacted and that this contributed to the occurrence. However, in this case, the evidence indicated a high likelihood that the first officer was experiencing acute fatigue. This was reported in the final investigation report as follows:

- The first officer reported obtaining a total of between 4 and 6 hours sleep in the 48 hours prior to the occurrence. Accordingly, it is reasonable to conclude that the first officer was experiencing a level of acute fatigue known to have at least a moderate effect on performance.
- While it is difficult to conclude that fatigue alone led to the first officer's errors on this occasion, it was considered contributory to the occurrence.
- The ATSB found that at the time of the occurrence the first officer was experiencing a level of fatigue that affected performance. However, the first officer's ability to self-assess their level of fatigue was impeded by a lack of training and objective tools to determine their suitability to operate.

Organisational fatigue management policies, processes and practices were also analysed, with the following reported in the final investigation report:

- At the time of the occurrence the content of the operator's fatigue training was limited to a general overview of fatigue, sleep and fatigue countermeasures which may not provide crew with an adequate opportunity to develop the skills or utilise tools that could best help them identify signs of fatigue in themselves or others.
- The operator managed its flight crews' flight and duty times to comply with Australian Civil Aviation Order 48 at the time of the occurrence. Although compliant with those requirements, the operator's rostering processes did not wholly account for the potential for the conduct of the flight check to have impacted on the first officer's sleep preceding the check, or unforeseen extension of the officer's previous duty period and the associated time between sign-off and being able to leave the airport.



The investigation also examined the operator's fatigue management processes and practices to determine if they were reasonable. This included consideration of, and reference to, the regulatory requirements at the time of the occurrence.

### **c) Developing the report**

Recognising the operator's compliance with relevant fatigue management regulations at the time, while emphasising the benefits of further improvements to address key issues identified as part of the investigation, presented a challenge when developing the investigation report. The second point is important in developing the investigation report, as it represents the safety educational message that would ideally be adopted by other operators not directly involved in the occurrence, thereby reducing safety risk. In this respect, the investigation report addressed the two points as follows:

- **Operator compliance with the existing regulations.** To reinforce the operator's compliance with the existing regulations, and show their efforts to progress to the new set of fatigue management rules, the report stated that:

In March 2013, the Australian Civil Aviation Safety Authority released new rules on fatigue management for flight crew. At the time of the occurrence, air operators that already held, or had applied for an air operator's certificate after April 2013, had until April 2016 to transition to the new fatigue management rules. Consistent with this timeline, the operator was planning for their transition to meet those requirements at the time of the occurrence.

- **Emphasising the opportunity for operators to adopt fatigue management improvements.** In an effort to increase the likelihood that operators would be receptive to the safety educational message, the report reiterated that the operator was not required to have implemented an FRMS at the time. For example, when discussing the operator's fatigue training in the context of the new rule set, the investigation report stated:

Noting that [the operator] was not required to comply with the new fatigue rules on training at the time of the occurrence, it could be expected that, as they work towards implementing those requirements by May 2017, the training content will be revised.

The ensuing safety education message included that:

...while this occurrence highlights the difficulties associated with assessing fatigue, operators...can reduce fatigue risk by providing crew with adequate rest opportunity, comprehensive training in fatigue management, and tools designed to support objective self-assessment of their alertness.

## **Investigating an organisation's SMS performance**

The ATSB intends to develop a specific framework for the investigation of SMS. A number of recent ATSB investigations have demonstrated the value of approaching this task in a similar manner to that of the investigation of fatigue. That is, by:

- reviewing any errors in individual actions,
- ascertaining possible local conditions and risk controls relating to the safety processes and practices of the organisation, and then:
- considering how one or more components of the SMS may not be performing as it could reasonably be expected to.

In addition to other models and approaches, the Transportation Safety Board of Canada's (TSB) *Guide to Investigating for Organizational and Management Factors - 2<sup>nd</sup> Edition*

(2014) is a useful reference for investigators addressing organisational influences. Incorporating the Degani and Weiner (1994) hierarchy of influences (Philosophies, Policies, Processes and Practices) into this approach facilitates the identification of 'mismatches between procedures and actual practices'.

### **Key challenges so far**

The TSB (2014) outlined a series of challenges that continue to arise when investigating organisational and management issues, including the investigation of an SMS. These challenges included:

- the identification of investigation scope
- weak and missing links in evidence and analysis
- the potential for hindsight bias
- investigators' experience with investigating management issues.

Recent ATSB investigations have similarly encountered a number of challenges in these areas, as well as some additional challenges that may be valuable for investigators to consider:

#### **a) *Articulating the linkage between an organisation's SMS and the occurrence event (where relevant)***

If a contributing factor involving the performance of an organisation's SMS has been identified, demonstrating that linkage often requires a significant amount of contextual and analytical explanation (particularly due to the 'strong interwoven' nature of an SMS). This can, in turn, inadvertently lead to a perception by the reader that the volume automatically indicates that the SMS-related finding is the most important part of the investigation. The challenge can be addressed by ensuring that the 'link-by-link' analysis is articulated, specifically the risk controls that indicated the presence of organisational influences. Using a link-by-link approach, safety management problems can be linked through various risk controls and local conditions with the crew actions involved in the occurrence.

#### **b) *The inclusion of third-party organisations within the scope of the investigation***

An ongoing and high profile ATSB investigation includes the review of four different organisations' SMSs and their relationship to each other. The resulting challenge is to pinpoint the precise points of linkage between these organisations. However, one approach that the TSB (2014) has documented is to overtly focus on the hierarchy of influences in any safety system (that is, what is documented/espoused versus what actually happens). This has been of great assistance to the ATSB in reviewing these organisational and SMS linkages.

#### **c) *Acceptance of safety messaging within the organisation and wider industry***

The requirement to implement safety and fatigue risk management systems remains relatively new and unfamiliar for many sectors of the aviation industry. Comprehension of the various requirements and their implementation can prove difficult. As a consequence, some operators have been highly sensitive to an investigation focusing on something which, it is often perceived, they 'didn't even have to do.' This is understandable, and is an important consideration for any investigator as a safety message can be lost if perceived as unjust. The ATSB has recently addressed this risk by balancing acknowledgements against regulatory compliance with descriptions of additional improvements in the organisation's safety systems.



***A recent investigation highlighting an operator's SMS performance: ATSB investigation AO-2014-192***

At 1748 Australian Eastern Daylight-saving Time on 29 December 2014, a Cessna 172S aircraft departed Cambridge Airport, Tasmania to photograph yachts participating in the 2014 Sydney Hobart race. On board the aircraft were the pilot and a photographer. After completing a run on one yacht at a height of about 50 ft, the aircraft entered a steep climbing turn. The aircraft had almost completed a 180° turn when the upper (right) wing dropped sharply while the aircraft's nose pitched down to almost vertical. The aircraft impacted the water's surface in an almost vertical, nose-down attitude with wings about level. Both aircraft occupants were fatally injured and the aircraft was seriously damaged.

In addition to focusing on various operational topics, the ATSB examined the role of the operator's SMS in the accident. This was prompted after consideration of the operator's operational risk management practices with respect to low-level operations. A review of the ATSB's examination of the operator's SMS and other aspects of the investigation follows.

***a) Evidence collection***

The collection of evidence for the SMS aspects of this investigation is outlined below in the context of the hierarchy of influences. This is not how the evidence was presented in the final report, but demonstrates the use of certain evidence sources.

<b>Influence (text extracted from TSB, 2014)</b>	<b>Sources(s) of evidence to facilitate the analysis of the SMS</b>	<b>Nature of evidence collected in this investigation</b>
<p><b><i>Philosophy</i></b>                      'An organization's philosophy provides a broad specification for how it wants to operate and communicates values throughout the organization'.</p>	<ul style="list-style-type: none"> <li>• Interviews with the Chief Executive Officer and safety manager.</li> <li>• SMS Manual.</li> </ul>	<ul style="list-style-type: none"> <li>• Planning for future implementation/improvements, including plans for a full-time safety manager.</li> <li>• Safety commitment statement versus senior level perceptions on a formal approach to safety, particularly with respect to SMS implementation outside of compliance requirements.</li> <li>• Past and future resourcing (that is, safety-specific staffing and investments).</li> <li>• Perceptions on key safety risks.</li> </ul>
<p><b><i>Policy</i></b>                      'An organization's policies represent broad specifications of the manner in which management expects tasks to be carried out'.</p>	<ul style="list-style-type: none"> <li>• SMS Manual.</li> <li>• Operations Manual.</li> </ul>	<ul style="list-style-type: none"> <li>• Scope of SMS implementation across different business functions (including flight training, maintenance and so on).</li> <li>• Documented risk-based approach advocated for key operational tasking (including low-level flying in this case).</li> </ul>
<p><b><i>Processes</i></b>                      'An organization's procedures dictate the specific steps an individual should take to accomplish a task. They operationalize the</p>	<ul style="list-style-type: none"> <li>• Risk and hazard registers.</li> <li>• Risk assessments of specific operational activities.</li> </ul>	<ul style="list-style-type: none"> <li>• Documented methods of safety information communication and decision making amongst managers.</li> <li>• Safety reporting processes for the pilots.</li> </ul>

Influence (text extracted from TSB, 2014)	Sources(s) of evidence to facilitate the analysis of the SMS	Nature of evidence collected in this investigation
philosophy and policies by indicating how work will be carried out’.	<ul style="list-style-type: none"> <li>• Interviews with the chief pilot, safety manager, chief flying instructor.</li> <li>• Interviews with the regulator (operational and safety system oversight).</li> </ul>	<ul style="list-style-type: none"> <li>• Methods and triggers for developing risk assessments (designed as change- and task-based).</li> </ul>
<p><b>Practices</b></p> <p>‘An organization’s practices represent what actually happens in day-to-day operations...[because] in reality, practices may differ from procedures for any one of a number of reasons’.</p>	<ul style="list-style-type: none"> <li>• Interviews with the chief pilot, safety manager, chief flying instructor.</li> <li>• Regulator’s surveillance report on the operator.</li> <li>• Safety reports from the previous 2 years.</li> <li>• Minutes of safety committee meetings.</li> </ul>	<ul style="list-style-type: none"> <li>• The distribution of safety-related roles and responsibilities, and the capabilities of those conducting them.</li> <li>• Past challenges in developing a positive safety reporting culture.</li> <li>• Ways the operator managed any non-compliances identified by the regulator.</li> <li>• Scope of the application of risk management processes (that is, change-based rather than all operational tasking).</li> <li>• Content of risk assessments and the extent of their implementation.</li> </ul>

The most important aspect of this review was not only collecting documented policies and processes and then the associated practices, but also considering actions that may have met a safety intent but were not necessarily presented in a formalised, documented way. An example could be the conduct of regular, informal discussions between key managers that may also be considered a safety-related decision making method.

All policies, processes and practices could then be benchmarked with reference to relevant and credible references, with consideration that a rigid ‘best practice’ might not be the most realistic standard to advocate if the intent of the system was being achieved in a different way. That is, instead of ‘auditing’ an operator to see if they are complying with their SMS, this approach is centred on establishing what happens in practice and if that achieves the same outcome.

**b) Analysis**

In this case, the most relevant aspect on which to focus was the operator’s capability to identify operational safety risks. Without adequate identification methods, the prioritisation and treatment of risks is also affected. In investigation report AO-2014-192, the operator’s ability to identify operational risks was affected as follows:

The main source of safety risk information was the safety reports submitted by crew, in an environment where the reporting culture had only recently improved amongst the small flight crew workforce.

The risk management process was only utilised for managing operational or organisational changes, which precluded the proactive identification of risks in existing operational activities such as low-level flying.

The ability for managers to be aware of existing operational risks was reduced due to the narrow application of documented risk management processes and tools (including the risk register).

The resources to facilitate the implementation and improvement of the SMS were limited to the time that the CFI [chief flying instructor] could spend in the role of safety manager. This reduced the opportunity to implement the operator's risk management processes and tools more extensively.

There was some discussion as to appropriate references against which to compare the operator's SMS, as a prescriptive approach was too punitive. In the end, the International Standards Organisation ISO31000:2009 Risk Management standard was used to demonstrate the overall intention of risk management practices.

### **c) *Considerations in drafting the report***

As discussed earlier in the paper, in order to increase the likelihood of a receptive response from the affected organisation and wider industry, striking a balance between a thorough account, and being perceived as too focused on weaknesses, needs to be achieved. In this endeavour, the ATSB settled on the following text in the investigation report:

At the time of the occurrence, the evidence gathered as part of the investigation indicated that the operator's SMS complied with the applicable regulatory requirements.

and:

While it was not established that the safety risk management processes and practices directly contributed to the occurrence, there were aspects that the operator could consider working towards to more effectively identify all key operational risks.

Overall, the SMS content in the final investigation report was relatively detailed. The intent was to provide sufficient explanation for the SMS-related finding in the context of a topic that has not commonly appeared in investigation reports until recently. The report also stands as an example of the applicability of SMS implementation in the context of small organisations.

## **Conclusion**

As safety can best be achieved through 'strong interwoven systems', the responsibility of the investigator is to explore these systems when considering organisational influences. The ability to demonstrate either a tangible linkage between the performance of an organisation's systems to an occurrence event, or its importance in future operations, is likely better facilitated through a framework that utilises the 'link-by-link' approach and takes into account the hierarchy of influences and a range of evidence sources.

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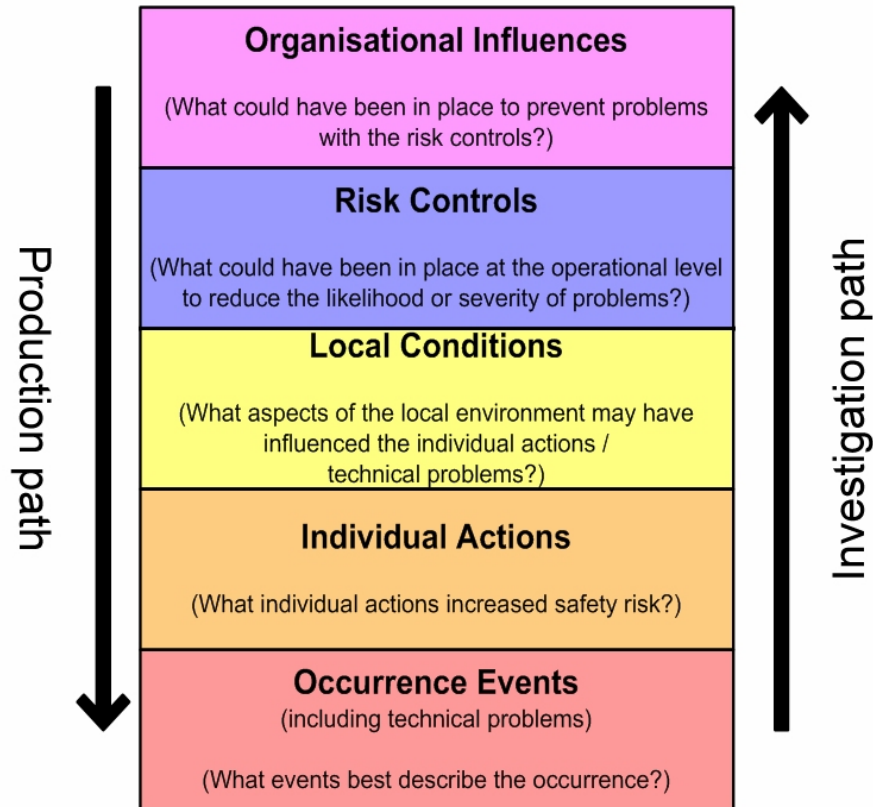
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## Annex A: The ATSB analysis model



## Annex B: The ATSB Fatigue and Fatigue Risk Management System investigation framework (adapted from Dawson and McCulloch (2006), Belenky (2007) and the Australian Maritime Safety Authority (2015))

Fatigue hazard	Fatigue risk controls / indicators	Evidence to support investigation	
Direction of systemic investigation	<b>Organisational support for managing risks of fatigue impairment</b> <ul style="list-style-type: none"> <li>FRMS policy, procedures, practices</li> <li>Roster design principles and practices</li> <li>Fatigue awareness training</li> <li>Safety culture – fatigue self reporting and consequences</li> <li>Systems for collection and analysis of aggregated workforce sleep data and fatigue incidents</li> </ul>	<ul style="list-style-type: none"> <li>Documented FRMS, or fatigue management policy, procedures, practices; rostering principles, practices</li> <li>Integration of fatigue modelling tools and nature of use</li> <li>Organisational analysis and treatment of fatigue reports and occurrence</li> <li>Organisational objective/ subjective sleep monitoring records, analyses</li> <li>Fatigue awareness training policy, content, attendance records</li> <li>Any organisational use of fatigue specialists / fatigue studies – reports</li> <li>Individual knowledge/attitudes re fatigue impact and management (interview)</li> </ul>	Organisational
	<b>Provision of adequate sleep opportunity (quality and quantity)</b> <ul style="list-style-type: none"> <li>Duty scheduling and planning</li> <li>Use of fatigue modelling tools</li> <li>Roster design principles and practices</li> <li>Provision / nature of sleeping facilities</li> </ul>	<ul style="list-style-type: none"> <li>Planned and actual duty/rest rosters (2 – 4 weeks previous to event)</li> <li>Fatigue risk assessment of rosters (via fatigue modelling or other methods)</li> <li>Suitability of sleeping environment</li> <li>Required commute method and duration</li> </ul>	
	<b>Sleep obtained (quality and quantity)</b> <ul style="list-style-type: none"> <li>Sleep monitoring and self reported sleep</li> <li>Sleep diaries, wearable technology</li> <li>Other factors influencing sleep quantity quality</li> </ul>	<ul style="list-style-type: none"> <li>Detailed self / other reported obtained sleep quantity in 24, 48 and 72 hours prior to the event</li> <li>Self / other reported sleep quality achieved in 24, 48, 72 hours</li> <li>Self/other reported broken sleep and time awake</li> <li>Estimation of individual need for sleep for adequate performance – what is “normal” for him/her</li> <li>Any deviations from “normal” sleep in the past week – what, when, why</li> <li>Description of sleeping environment – noise, light/darkness, motion, privacy, comfort</li> <li>Other factors affecting sleep quantity and quality, eg. health (physical/mental), sleep disorders, mood, nutrition, alcohol, other drugs - prescribed/over the counter/natural remedies/recreational, stimulants – caffeine, guarana, nicotine, amphetamines</li> <li>Recorded data: eg wearable tech, smart device applications, phone records (calls, SMS, social media, browsing), email records, log book entries, credit card transactions, CCTV footage.</li> </ul>	Individual / group
	<b>Ability to maintain adequate alertness while on duty</b> <ul style="list-style-type: none"> <li>Self / peer observations of fatigue related behaviours</li> <li>Use of symptoms checklists / subjective sleepiness scales</li> <li>Org / indiv fatigue proofing strategies/countermeasures</li> </ul>	<ul style="list-style-type: none"> <li>Self/other reported observations of alertness, other fatigue related behaviours, communications</li> <li>Self/other reported fatigue proofing strategies/countermeasures – napping, task redesign/reallocation/scheduling, breaks, caffeine</li> <li>Self/other assessed subjective alertness scale responses (eg. Samn-Perelli scale)</li> <li>Workload dimensions– cognitive demand, physical demand; pace of work required</li> </ul>	
<b>Fatigue related errors</b>	Errors associated with: <ul style="list-style-type: none"> <li>Problem solving      Decision making</li> <li>Memory                  Attention lapses</li> <li>Vigilance                Reaction time</li> </ul>	Detailed account of events via interviews / OBR / logs: Performance - actions, communications, decisions - leading up to, during, and following the event	