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Perceived threats, errors and safety in aerial work and low capacity air transport operations

Although several studies have reported the common threats and errors identified in line operations safety audits (LOSAs) of high capacity[1] regular public transport (RPT) operations (Klinect, Wilhelm & Helmreich, 1999; Veilette, 2005; Thomas, 2004), there is little information on the types of threats and errors faced by pilots in other parts of the aviation industry.

This report catalogues the most common threats to operations, and errors made by pilots, in aerial work and low capacity[1] air transport operations[2], as perceived by flight instructors, check-and-training pilots, chief pilots and line pilots. The aim of this report is to provide a snapshot of these perceived threats and errors, along with ratings of safety deficiencies, and to offer some suggestions in how to deal with threats and errors.

WHAT IS THREAT AND ERROR MANAGEMENT?

Threat and error management (TEM) is a method that can be used by flight crew to identify and mitigate hazards (known as threats) and crew errors which may have an impact on safe flight operations. The concept of TEM was derived from the LOSA program by researchers involved in the University of Texas Human Factors Research Project.

There are three basic components in the TEM model: threats, errors and undesired aircraft states.

1 A high capacity aircraft provides more than 38 passenger seats and a maximum payload greater than 4,200 kg. Low capacity refers to aircraft other than high capacity.

2 Air transport operations refer to both low capacity regular public transport and charter operations.

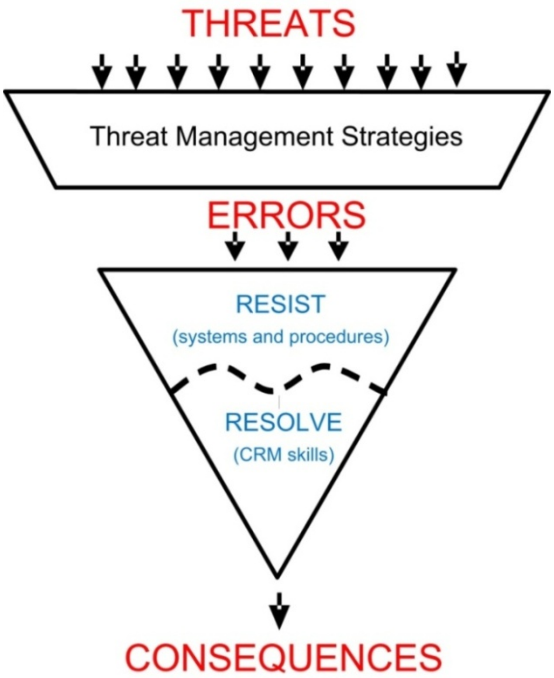
Threats are events or conditions, or errors made by people other than the pilots, which increase operational complexity. Although threats are often external to pilots, they can also include states and limitations that the pilot brings into the flight deck. Threats need to be managed to maintain the margins of safety. When undetected, unmanaged or mismanaged, threats may lead to errors or even to an undesired aircraft state.

Errors are 'actions or inactions by the flight crew that lead to deviations from organisational or flight crew intentions or expectations' (Maurino, 2005). When undetected, unmanaged or mismanaged, errors may lead to other errors and/or to undesired aircraft states.

Undesired aircraft states are defined as 'an aircraft deviation or incorrect configuration associated with a clear reduction in safety margins' (Maurino, 2005). Undesired aircraft states are considered to be the last stage before an incident or accident (ICAO, 2005). Thus, the management of undesired aircraft states represents the last opportunity for flight crews to avoid an unsafe outcome, and hence maintain safety margins in flight operations (Maurino, 2005).

Threats and errors are part of everyday flight operations that must be managed by flight crews, as they both carry the potential to generate undesired aircraft states. Cheng, Inglis and Godley (ATSB, 2009) outline how, from a theoretical view point, threats, errors, undesired aircraft states and consequences (accidents and incidents) are related. Figure 1 depicts a simplified relationship between threats, errors and consequences.

Figure 1: Relationship between threats, errors and undesired aircraft states (consequences)



Source: Adapted from Continental Airlines

DATA SOURCES

Participants who attended a threat and error management (TEM) course conducted by the Guild of Air Pilots and Air Navigators (GAPAN)[3] recorded what they considered were the five most common threats to operations and errors made by pilots in their industry in the preceding 12 months. They were also queried about their perceptions of safety within their industry using questions replicated from a 2003 Australian Transport Safety Bureau (ATSB) industry survey (see ATSB, 2005).

Three researchers at the ATSB independently coded the threats and errors identified and resolved discrepancies through discussion.

The 167 course participants who gave responses were grouped into two parts of the industry: 112 from aerial work (who were mostly from flying training, making up 80 per cent of aerial work respondents, but also including emergency services, agriculture, surveying or spotting), and 55 from low capacity air transport operations (RPT and charter).[4]

Three-quarters of respondents flew in single-pilot operations. The primary role of 66 per cent of respondents was that of a training or instructor pilot (e.g. check and training or instructor), while about 20 per cent of respondents were chief pilots. Fifteen per cent were line pilots.

Please refer to the ATSB (2009) report for a detailed description of the method of analyses.

3 For more information about the GAPAN TEM course, presented in November 2007, refer to the ATSB Research and Analysis report AR-2006-156(1), *Threat and Error Management. Attitudes towards training and applicability of TEM to general aviation and low capacity air transport operations.*

4 Reponses from the private / business flying category were not included as the number of responses was not sufficient for meaningful analyses.

THREATS

Threats had been traditionally regarded as events or errors that occur 'outside the influence of the flight crew' (Maurino, 2005). However, this was based on the definition of threats used for LOSA, which only included threats that were observable during cockpit-based audits. In contrast, respondents identified threats both internal and external to the pilot as they were asked to list the most common threats in their flying operation.

Since both internal and external threats were reported, this study supports the idea that threats can also include states and limitations that the pilot may bring along with them into the flight deck. Internal threats, such as fatigue and pre-occupations, may lead to increased errors and degraded situational awareness due to physiological and psychological impairment (CASA, 2008).

This is consistent with the approach that the Civil Aviation Safety Authority (CASA) has taken by broadening the original concept of threats in their Civil Aviation Advisory Publications (CAAP 5.59-1(0)) to include internal threats.

The LOSA taxonomy (as reported by ICAO, 2002) identified 29 specific threats, categorised into seven higher level threat categories. This taxonomy was designed for observations made on high capacity RPT LOSAs. Table 1 presents examples of threats derived from LOSA (unless otherwise stated) for each threat category. Since some threats (20 per cent) identified by respondents did not fit into any LOSA threat category, researchers at the ATSB expanded some of those categories and created two new categories – *individual conditions* and *organisational threats*.

Individual condition threats reported included fatigue, a lack of experience (including students), crew health and stress, unsafe crew attitudes, training, knowledge and skills, and recency or currency of operating different aircraft types. On average, individual threats were the second most common threat category reported. Additionally, organisational threats identified included unstable operations due to changes in management and staff turnover etc.

Table 1: Examples of threats for each threat category

*Non-LOSA threat identified by respondents

Threat category	Threat example
Departure/ arrival	Adverse weather; terrain; airport; TCAS; birds*; CTAF*
Aircraft	Aircraft malfunction; automation event or anomaly; communications event (radios, ATIS, ACARS); fuel related*
Operational	Time pressure; missed approach; flight diversion; unfamiliar airport; operating environment*
Cabin	Cabin event/distraction; flight attendant error; passenger related threat*
ATC/ Communication-	ATC command/error; ATC language difficulty; ATC non-standard phraseology; radio congestion; similar call signs; pilot-to-pilot communications*; pilot language difficulty*
Crew support	Maintenance event/errors; ground handling event/error; dispatch paperwork event/error; crew scheduling event; manual/charts incomplete/incorrect
Individual conditions*	Recency/currency; experience; fatigue; knowledge/skills; training (initial); crew health; crew attitudes; technology/ automation
Organisational*	Unstable operations (e.g. from change in management etc); change of staff/ high rate of staff turnover
Other threats	Workload; distraction

Figure 2 illustrates the composition of threat categories for each flying category. Respondents from aerial work (who were mostly from flying training) identified a total of 488 threats, while those from low capacity air transport identified 245 threats. For all flying categories, departure / arrival threats were the most commonly encountered, while organisational threats, cabin threats, and other threats were the least common.

Figure 2: Threat categories by flying categories

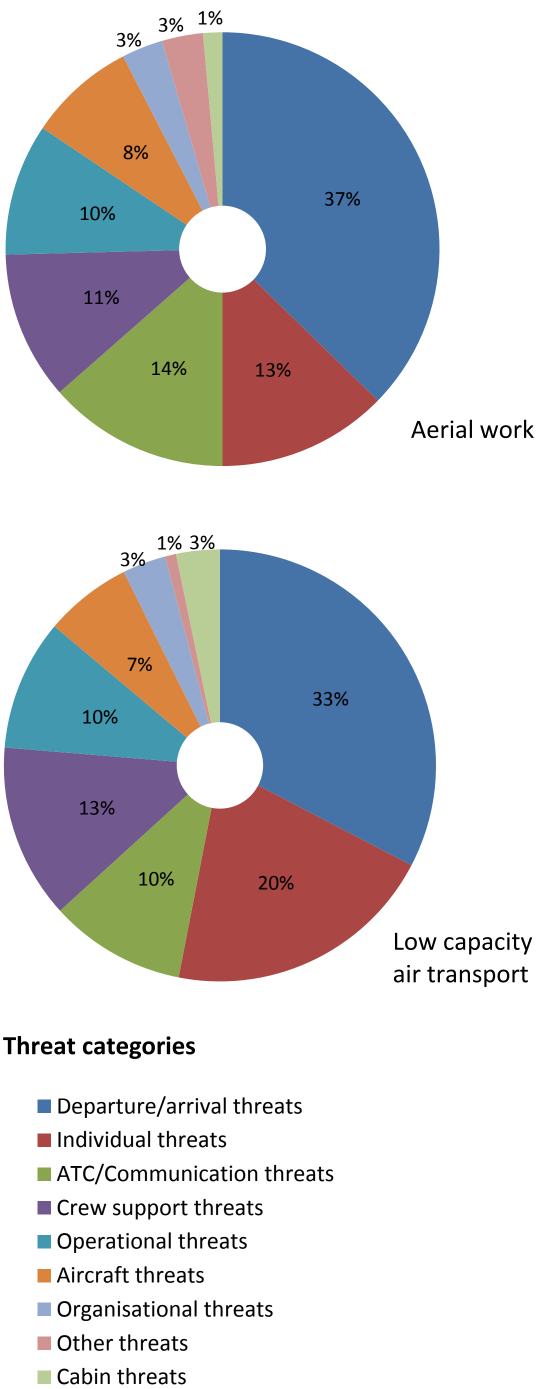


Table 2 shows that adverse weather, such as turbulence, fog, crosswind, and high temperatures, was the most common specific threat encountered by pilots in both flying categories in this study. This is also the case in high capacity regular public transport (RPT) (e.g. Thomas, 2004). Adverse weather represented a quarter of the total threats in the LOSA database for high capacity RPT (Veillette, 2005) and, similarly, represented about 20 per cent of all threats faced by pilots in aerial work and low capacity air transport operations who responded to the survey.

The US Federal Aviation Administration (FAA) published a guide to help general aviation pilots develop skills in obtaining appropriate weather information, interpreting the data, and applying the information and analysis to make safe weather flying decisions (FAA, 2006). Beard and Geven (2005) recommend that pilots learn how to recognise typical weather patterns and therefore anomalies; mentally stimulate a course of action when they find themselves in adverse weather; prioritise weather cues; and develop expectancies. The authors also discuss how to implement those recommendations.

Communication issues from ATC and pilots in other aircraft were also one of the top five threats identified by the respondents (Table 2). Examples included pilot language difficulties, ATC command (e.g. difficult clearance, late changes), and ATC instructions. Research by Grayson and Billings (1981) has found that inaccuracies in content and ambiguous phraseology are two of the common problems faced by pilots during communication exchange. Pilots should not assume that a routine read-back of an unclear or questionable clearance or instruction, is enough for confirmation. Instead, pilots are advised to call attention to their uncertainty by prefacing their read-back with the word "Verify…" (Monan, 1983).

Table 2 also shows that traffic congestion and operational pressure (such as on-time-performance) were also common threats encountered by pilots of all flying categories in this study. The top four threats faced by low capacity air transport operations were also a part of the top five threats found in the Thomas (2004) study of threats faced by a Southeast Asian high capacity airline operating both domestic and international routes.

Maintenance events, such as poor maintenance procedures or maintenance of a fault not rectified, made up one of the top five threats identified by respondents in aerial work. Fatigue was also one of the top five threats of threats faced by respondents in low capacity air transport.

Table 2: Top five threats by flying category

Flying category	Threats	Per cent
Aerial work	Adverse weather/ turbulence/ IMC	19.9
	Traffic – air or ground/ water congestion	10.2
	ATC command/ error/ communication	8.2
	Operational pressure	7.4
	Maintenance event	5.9
Low capacity air transport	Adverse weather/ turbulence/ IMC	19.2
	Operational pressure	8.6
	Traffic – air or ground/ water congestion	7.3
	ATC command/ error/ communication	6.9
	Fatigue	5.3

An Australian regional airline LOSA (Eames-Brown, 2007) report grouped the threats encountered as either environmental or organisational in nature. Environmental threats were outside the organisation's direct control, while organisational threats were those that originated within flight operations. Eames-Brown (2007) found that environmental threats made up 59 per cent and organisational threats made up 41 per cent of all threats encountered by pilots in the regional airline. This is in stark contrast to the results in the current survey, where, excluding individual and organisational threats (as they were not part of the LOSA taxonomy) and other threats, pilots identified more organisational (60 per cent) than environmental (40 per cent) threats.

The threats reported in this survey should be seen as a starting point for aerial work and low capacity air transport pilots to anticipate the type of threats they may encounter during flight. Pilots are not only encouraged to anticipate such threats, but also to plan countermeasures for them as a pre-flight routine. This pre-flight assessment and planning may then reduce workload during flight when threats materialise. To manage threats and errors, pilots may call on many tools, including checklists, training, briefings, and human factors principles (CASA, 2008). A list of all threats identified by at least five respondents in the current survey appears in Appendix A.

Ratings of internal and external threats

Respondents rated how often they personally saw the five individual internal threats, shown in Figure 3, negatively affect flight safety in Australia in the last 12 months (that is, during 2007).

On average, the internal threat identified by respondents as being the most commonly seen, was a lack of pilot skill, knowledge or experience, followed by fatigue and personal stress (Figure 3). There was minimal reporting of medical conditions, alcohol, drugs or prescribed medication use. The second most identified internal threat was fatigue.

The symptoms of fatigue and its effects on performance have been well documented. For example, Batelle (1998) notes that a large amount of literature on fatigue has established that fatigue degrades short term memory, error management, decision making, motivation and attitudes, and communication. Fatigued pilots may find their attention waning, attitude and mood deteriorating and pilots may find that even simple tasks become more difficult to perform (Caldwell, 2008). It is easier to recognise that others are fatigued than to recognise that you are fatigued yourself. Thus, it is important that solo pilots assess whether they are fit to fly before taking off and be aware of the signs of fatigue whilst in flight as part of their threat management strategy. It is said that 'takeoffs are optional, landings are not' (Reinhart, 1996).

Assessment of fitness to fly begins with an understanding of the causes of fatigue. For pilots, these include: lack of restful sleep (both short-term and long-term); disrupted sleep; operating at night, especially between midnight and 6am; extended time since last sleep until the end of duty time; illness, dehydration, sleep disorders; alcohol and drugs; noise and vibration; and flicker (the sensation resulting from sunlight shining though spinning helicopter rotor blades).

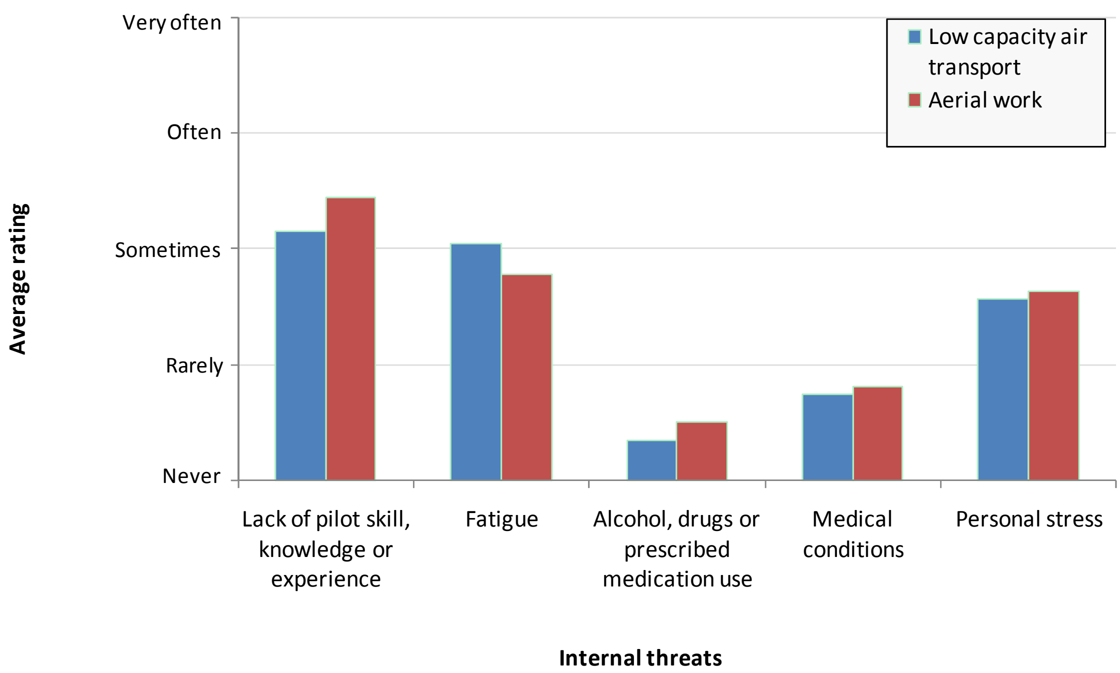
The following are ways to prevent and manage fatigue (Caldwell & Caldwell, 2003):

- avoid building a sleep debt and try to have 8 hours sleep each night
- minimise time since you have last slept by sleeping or napping before operating at night and in between split shifts
- create a comfortable sleeping environment (for example, ensure the room is cool, dark and quiet)
- have a balanced diet and keep physically fit.

Obviously, preventing fatigue in the first place is the key to fatigue management. However, if you find that you are getting tired in the flight deck, below are some strategies, which were created in consultation with ATSB investigators, to stay alert:

- drink a caffeinated beverage
- if possible, stretch and flex limbs to improve blood circulation
- keep your mind active - look for emergency landing spots, start a conversation with your copilot or a passenger
- in extreme cases, consider a precautionary diversion and landing.

Figure 3: Average frequency of influences negatively affecting flight safety in the last 12 months



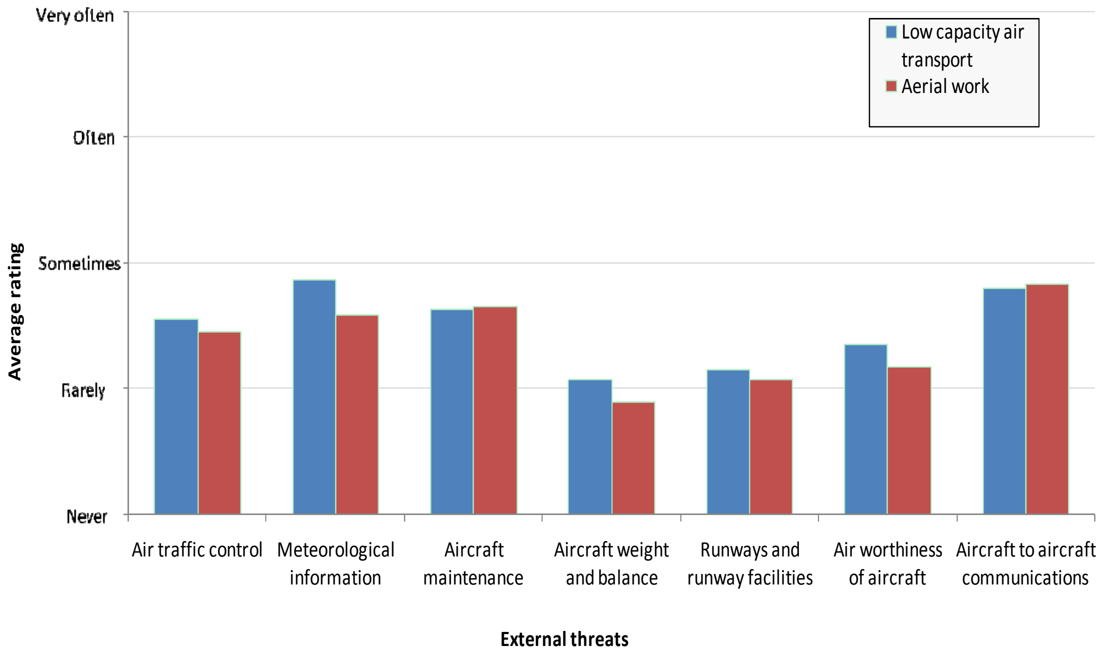
Source: Brindabella Airlines

Respondents were also asked to rate how often they encountered a number of external threats in the preceding 12 months. These safety deficiencies can be considered as external threats as they occur outside the flight deck.

There were no statistical differences between the two flying categories for the perceived frequency of external threats. Moreover, the pattern of results were similar to those in the 2003 ATSB pilot safety survey, such that in both surveys, aircraft to aircraft communications was the most frequently encountered safety deficiency (albeit only sometimes encountered) and aircraft weight and balance was encountered least frequently.

It can be seen in Figure 4 that the average rating for all of the external threats explored lay between rarely and sometimes. Compared with this, the frequencies for all safety deficiencies in the 2003 ATSB survey were lower, lying between never and rarely.

Figure 4: How often did you personally encounter significant safety deficiencies in the following areas in Australia in the last 12 months?



ERRORS

Helmreich, Klinect and Wilhelm (2001) described five categories of observed error used for coding errors identified during LOSAs. These were:

- procedural errors where crews are trying to follow procedures but execute them incorrectly
- communication errors in which information is improperly or incompletely communicated, withheld, or misunderstood between crew or between crew and outside agencies
- proficiency errors where tasks are improperly executed because of a lack of skill or knowledge
- decision errors involving situations not covered by procedure or regulation in which crews take actions that unnecessarily increase risk
- intentional non-compliance where crews knowingly violate company policy or regulations.

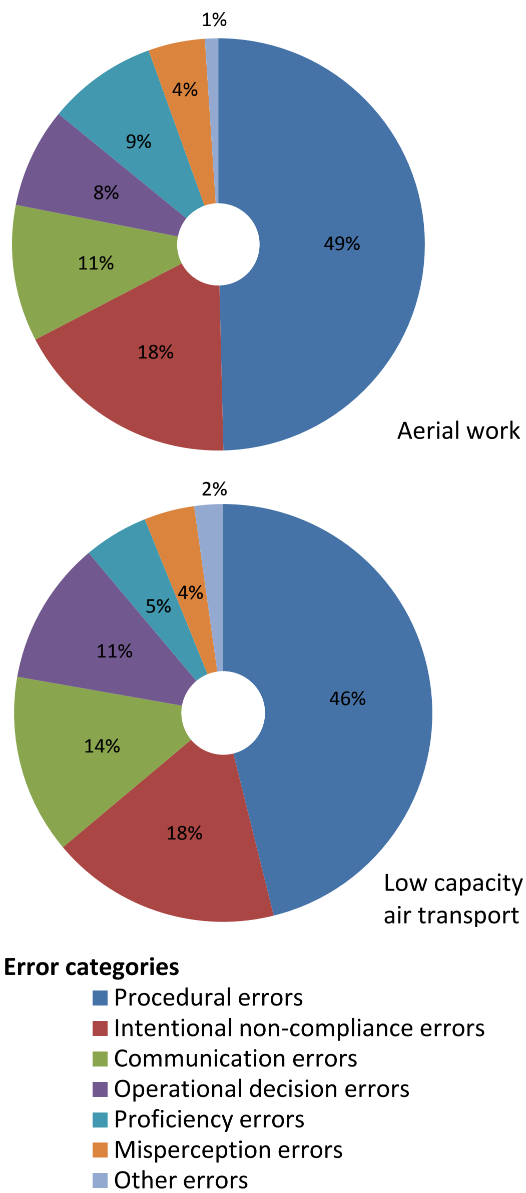
Those five error types formed the basis of error coding in the current survey, along with a sixth error category, misperception errors, which was created in light of the responses given. Misperception errors involve the crew misreading information or failing to perceive information, such as misreading the altimeter or fuel levels.

Figure 5 shows the frequency of reported errors for the six error categories for both flying categories. Respondents from aerial work identified a total of 383 errors, while those from low capacity air transport identified 180 errors. Similar to the results in the earlier ATSB pilot survey assessing common flying errors reported in ATSB (2004), procedural errors were the most commonly identified error by respondents from both low capacity air transport and aerial work, followed by intentional non-compliance errors.

In comparison, intentional non-compliance has been the most commonly observed error category followed by procedural errors for LOSA-observed errors in high capacity RPT (Klinect et al, 1999; Helmreich et al, 2001). Pilots operate under many standard operating procedures (SOPs), and airline pilots work under many more SOPs than pilots in general aviation. In addition, the nature of error identification between independent LOSA observations and subjective perception of common errors in the current study, may have also contributed to this difference. Non-compliance and procedural errors were found to occur more often than proficiency errors, communication errors, and decision errors for both flying categories, and this pattern was also observed in high capacity RPT (Klinect et al, 1999; Helmreich et al, 2001).

Despite being the most cited error category in high capacity RPT, Klinect et al (1999) found that intentional non-compliance errors were the least likely to result in an undesired aircraft state. On the other hand, proficiency and operational decision errors, being the least often observed, were the most difficult for pilots to manage.

Figure 5: Error categories by flying categories



Source: Brindabella Airlines

Table 3 shows the most common specific error types for each flying category. Procedural checklist errors, such as performing the wrong checklist or missing a checklist item, was the most commonly encountered error type for pilots in aerial work and was the second most common error for Low capacity air transport respondents. The National Aeronautics and Space Administration (NASA) Ames Research Center (Degani & Wiener, 1990) provides advice on checklist design issues, such as the order of the items, the types of items that should be included in the checklist, as well as implications on the use of checklists for long and short haul operations.

Radio errors, such as selecting the wrong frequency, were the second most common error type described by aerial work pilots. Radio errors were particularly common from respondents within flying training.

For low capacity air transport pilots, communication errors between crew and ATC or other aircraft, such as omitting calls signs to ATC, were the most cited error type, and was the third most cited error for aerial work pilots. Non-compliance to standard operating procedures (SOPs) was also the most encountered error for low capacity air transport pilots. In fact, non-compliance with SOPs also featured in the top five errors for aerial work. Planning errors, such as fuel mismanagement and poor weather planning, were also common to both flying categories.

Other communication errors were also included in the top five errors for low capacity air transport pilots.

A list of all errors identified by at least five respondents appears in Appendix B.

Table 3: Top five errors by flying category

Flying category	Errors	Per cent
Aerial work	Checklist errors (procedural)	12.3
	Radio errors	8.4
	Crew to ATC/ other aircraft errors	7.0
	Non-compliance to SOPs	6.0
	Planning errors	5.5
Low capacity air transport	Non-compliance to SOPs	7.8
	Crew to ATC/ other aircraft errors	7.8
	Planning errors	6.7
	Checklist errors (procedural)	6.7
	Other communication errors	5.6

ERROR REDUCTION AND MANAGEMENT

Managing error

There are three aspects to managing error which pilots should be aware of: error avoidance, error detection, and error recovery.

Error avoidance

Error avoidance requires pilots to be proactive in detecting errors and in employing error reduction strategies. In general, error avoidance strategies include pre-flight briefings (even if there is only a single pilot) where typical errors and how they will be handled are reviewed. This will then reduce pilot workload if and when these errors present themselves during flight.

Following SOPs and having clear and unambiguous communications also reduce the likelihood of errors occurring. Standard operating procedures provide safe and effective guidelines for operations and reflect tried and proven solutions to the main problems operators may meet, both in normal and unexpected situations. Pilots are also encouraged to be aware of and brief others about internal threats, such as fatigue, lack of experience, or preoccupations, that may promote errors, and to put in place countermeasures.

Error detection

In the event that error occurs, it is imperative that they are detected before they lead to further errors or to an undesired aircraft state. Having situational awareness and employing the following strategies should make early detection more likely.

- Seeking feedback about the actual and expected state of the aircraft may afford pilots the chance to detect an anomaly early.
- It is important that checklists are adhered to as they can draw attention to errors that may have been made.
- Cross-checking requires explicit responses and promotes a common understanding of the state of the aircraft.
- Gross error checking also affords the pilot the opportunity to trap errors before they lead to more errors or to an undesired aircraft state.
- Read-backs provide a confirmation of understanding between the pilot and ATC as well as between pilots in the flight deck. For example, as one pilot reads back the clearance, the other pilot (who usually has also heard the clearance) may be able to detect an error in the read-back.

Error recovery

Early detection of error is important for early recovery. Typically, early error recovery involves correcting the error. This includes continually monitoring the effectiveness of the error recovery strategy and enquiring about the state of the aircraft to determine whether it is as expected.

Late error detection, however, may require pilots to apply emergency procedures or avoidance action. Discussing typical errors during pre-flight briefings and deciding on how they will be managed, may reduce workload and aid early error recovery.

Error reduction strategies

Respondents revealed that checklist errors, communication errors, non-compliance with SOPs, and planning errors were the most common across flying categories. The following describes some strategies that pilots can use to reduce and manage these errors. These strategies were created using various external references and in consultation with ATSB investigators and CASA human factors staff.

Checklist errors

- If possible, wait until you don't have any distractions or expected interruptions before conducting a checklist.
- If you are interrupted, restart the checklist to eliminate the chance of missing a checklist item.
- Read each item (don't conduct them from memory).
- Perform the checklist at an appropriate speed – faster performance leads to more error.
- Confirm each item - visually and by touch/pointing, and verbally announce switch positions etc.
- If there are two pilots, ensure both are involved (challenge and response).
- Watch out for confirmation bias (i.e. you may see something as you expect it to be). The pilot who did not do the action is in a more unbiased position to check that the action has been carried out correctly.

Crew to ATC/other aircraft communication errors

To increase the likelihood that your message is accurately transmitted:

- use correct terminology
- communicate when there are no cockpit distractions
- speak slowly and clearly
- seek feedback if it is not apparent the message has been understood.

To increase the likelihood a message will be received clearly and accurately:

- actively listen to the sender
- seek clarification if you are unsure of the message
- provide feedback to confirm that the message has been heard correctly (complete the read-back – hear-back loop).

Non-compliance with SOPs

- Ensure SOPs are available and understood for all frequently performed or critical safety-related tasks.
- If you are a trainer, manager, supervisor, or senior pilot, ensure you lead by example when it comes to using SOPs. If you don't respect them, others won't either.
- If you find that you are violating a SOP, ask yourself if there is a problem with the SOP.
- If you identify problems with the design of a SOP, make sure the relevant people are aware of the problem.

Planning errors

- Always provide a pre-flight briefing. If you are the only pilot, go through each briefing item as you would with another pilot.
- Involve all pilots in the planning process to ensure everyone has the same knowledge and expectations.
- Don't rush flight preparation – it's better to be late than unprepared.
- The more prepared you are for the flight, the more likely you are to avoid situations that can promote error.
- During the pre-flight briefing, identify what threats may occur during the flight and discuss how these threats will be mitigated – this often involves making decisions now.

PERCEIVED SAFETY OF THE AVIATION INDUSTRY

Respondents were asked to rate the safety level of their flying category and to rate how the overall level of safety in their category has changed in the preceding 12 months (that is, in 2007).

The pattern of responses in Figure 6 suggests that respondents from both flying categories had similar perceptions of safety levels. Over half of the respondents from each flying category rated their category as safe. Only six respondents from the aerial work category rated it as unsafe, and no-one rated their category as very unsafe.

A comparison with the 2003 ATSB pilot safety survey (ATSB, 2005) shows a very similar pattern of results for each of the flying categories. The one notable change between the two surveys was that respondents in the current survey were less likely to rate their sector of the industry as 'very safe' than those from the 2003 survey.

Respondents to the current survey also rated how the level of safety had changed in their sector of the industry in the preceding 12 months.

Figure 7 shows that 60 per cent of aerial work respondents (who were mainly from flying training) and half of low capacity air transport respondents indicated that safety had remained unchanged in their operational category. Twenty per cent of pilots from aerial work and a third from the low capacity air transport category rated their sector had improved. Sixteen per cent of respondents from low capacity air transport operations rated safety had deteriorated.

In general, more respondents in the current survey rated that safety had improved in the 12 months preceding the survey compared with respondents in the 2003 ATSB survey.

Figure 6: Ratings of safety over the previous 12 months

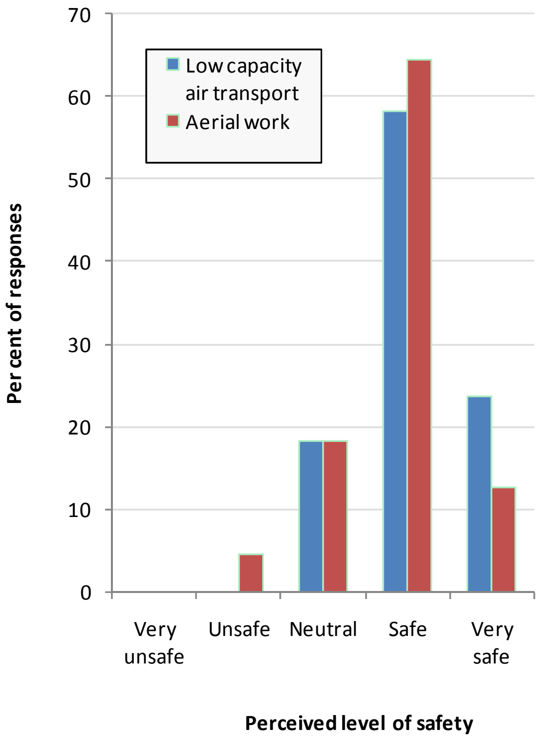
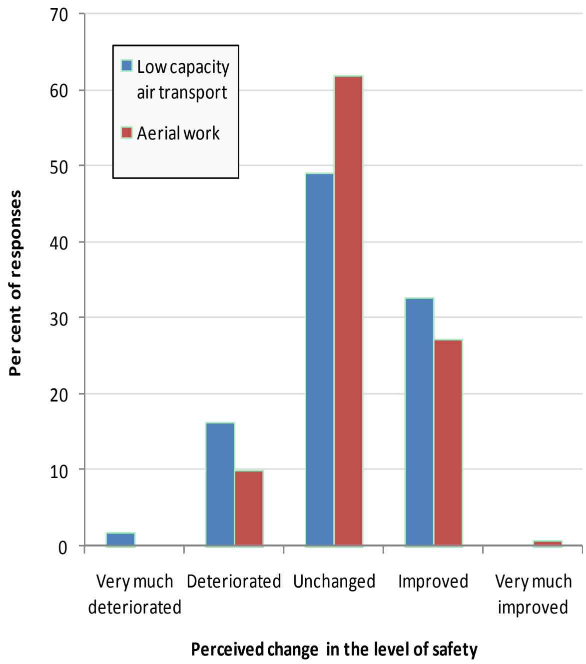


Figure 7: Ratings of change in the level of safety over the previous 12 months



CONCLUSION

Threat and error management (TEM) provides a formal process to identify and mitigate possible threats and errors, starting in the pre-flight planning and briefing stages.

The common threats and errors described in this report can be used as a guide for pilots when adopting TEM in their pre-flight planning and briefing. The most common threats reported included external threats such as weather, operational pressure, and traffic congestion, and internal threats, such as fatigue. The threats posed by errors and commands from ATC and communications with ATC and other aircraft were also common. The common errors reported were: procedural errors in using checklists; non-compliance with SOPs, planning errors; and communication with ATC or other aircraft.

Post-flight debriefings are highly recommended, even if the flight was uneventful, to assess the effectiveness of the management of the threats and errors that were identified, as well as assessing what could be done differently next time. Don't forget, every flight is different and post-flight briefings may help you with your next pre-flight planning and briefing.

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APPENDIX A: THREATS

Table 4: Threats for low-capacity air transport

Threats (as identified by five or more respondents)	**Frequency**	**Per cent**
Adverse weather/ turbulence/ IMC	47	19.2
Operational pressure	21	8.6
Traffic - air or ground/ water congestion	18	7.3
ATC command/ error/ communication	17	6.9
Fatigue	13	5.3
Aircraft malfunction/ serviceability/ age	12	4.9
Maintenance events	12	4.9
Crew attitudes - complacency, flight discipline etc	12	4.9
Experience (incl. Students)	11	4.5
Crew scheduling event	10	4.1
Passenger related	7	2.9
Knowledge/ skills	7	2.9
Organisational threats	7	2.9
Other ATC/ Communication threats	6	2.4
Dispatch/ paper work event	6	2.4
Airport - construction, signage, ground conditions, water conditions	5	2.0
Birds & animals	5	2.0

Table 5: Threats for aerial work

Threats (as identified by five or more respondents)	**Frequency**	**Per cent**
Adverse weather/turbulence/IMC	97	19.9
Traffic - air or ground/water congestion	50	10.2
ATC command/error/communication	40	8.2
Operational pressure - delays, OTP, late arriving pilot or aircraft, flight completion	36	7.4
Maintenance events	29	5.9
Aircraft malfunction/serviceability/age	23	4.7
Airport - construction, signage, ground conditions, water conditions	15	3.1
Experience (incl. Students)	15	3.1
Crew scheduling event	14	2.9
Other aircraft threat	13	2.7
Other ATC/Communication threats	12	2.5
Recency/currency/operating different aircraft types	12	2.5
Fatigue	10	2.0
Organisational threats	10	2.0
Other Threats	9	1.8
Terrain	8	1.6
Knowledge/skills	7	1.4
Pilot language difficulties	6	1.2
Birds & animals	6	1.2
Unfamiliar airport/aerodrome	6	1.2
Distractions	6	1.2
Radio congestion	5	1.0
Passenger related	5	1.0
Other (including situational awareness, aging pilots)	5	1.0
Training	5	1.0
Employee turn-over	5	1.0

APPENDIX B: ERRORS

Table 6: Errors for low-capacity air transport

Errors (as identified by five or more respondents)	**Frequency**	**Per cent**
Crew to ATC / other aircraft errors	14	7.8
Noncompliance to SOPs	14	7.8
Checklist errors (procedural)	12	6.7
Planning errors	12	6.7
Handling errors	10	5.6
Other communication errors	10	5.6
Navigation errors	9	5.0
Briefing errors (procedural)	8	4.5
Checklist errors (intentional noncompliance)	7	3.9
Documentation errors	7	3.9
Lever and switch errors	6	3.4
Radio errors	6	3.4
Flight management computer/ Control display unit errors	5	2.8
Other knowledge or proficiency based errors	5	2.8
Other procedural errors	5	2.8

Table 7: Errors for aerial work

Errors (as identified by five or more respondents)	**Frequency**	**Per cent**
Checklist errors (procedural)	47	12.3
Radio errors	32	8.4
Crew to ATC / other aircraft errors	27	7.0
Noncompliance to SOPs	23	6.0
Planning errors	21	5.5
Checklist errors (intentional noncompliance)	17	4.4
Documentation errors	16	4.2
Lack of stick and rudder proficiency	15	3.9
Other procedural errors	15	3.9
Mode control panel errors	13	3.4
Other intentional noncompliance	13	3.4
Crew to ATC errors	12	3.1
Handling errors	10	2.6
Other communication errors	9	2.3
Flight management computer/ Control display unit errors	8	2.1
Fuel management errors	8	2.1
Navigation errors	7	1.8
Crew interaction / Workload errors	6	1.6
Descent and approach errors	6	1.6
Lever and switch errors	6	1.6
Lack of knowledge of radio telephony	5	1.3
Other misperception errors	5	1.3
Paperwork errors	5	1.3
Situational awareness (lack of)	5	1.3