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ATSB TRANSPORT SAFETY REPORT
Aviation Safety Research Grant – B2004/0237

Regional Airline Line Operations Safety Audit

Captain Clinton Eames-Brown
Safety Manager, Regional Express

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Abstract

Regional airline operations globally have expanded over the past decade for various reasons, including filling gaps left by legacy carriers who have reduced services on unprofitable routes, opportunities provided through other cost based market rationalisations, and the introduction of new and more capable regional type aircraft. Very little formal research has been done in Australia or overseas to assist with the development of safety models and tools for regional airline operations. Regional Express (REX) is a relatively new airline that was created by merging two separate and culturally different airline entities. After a post start-up initial settling in period, REX needed a new tool to further develop safety-based auditing for its newly combined flight operations department. The Line Operations Safety Audit (LOSA) offered through the University of Texas LOSA Collaborative, provided an effective tool for this purpose. Around the time REX was reviewing its need in this area, the LOSA Collaborative was confirming an interest in conducting research with regional airlines. The LOSA Collaborative wished to obtain data from regional airlines to add to its LOSA Archive database in order to move toward making the database more representative and the LOSA tools more relevant for use in the regional airline environment. The LOSA Collaborative set out to attract three regional airline participants to add their data through the LOSA process. Regional Express was successful in attracting funding under the Australian Transport Safety Bureau's Aviation Safety Research Grants Program to undertake the LOSA process. Completion of this project has added to the expansion of the LOSA database to include regional airline data. This report describes the LOSA process as it applies within the regional airline context of REX and the reported outcome types specific to the LOSA methodology, process, and tools. Regional Express is one of the first regional airlines globally to participate in a LOSA program.

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EXECUTIVE SUMMARY

This report authored by Regional Express, is an overview of the process involved in the conduct of a Line Operations Safety Audit (LOSA), which is a safety based auditing tool being perfected by the University of Texas Human Factors LOSA Collaborative group.

This LOSA was conducted in Australia within Regional Express, which, at the time of the study, was a relatively new airline formed from the merger and operational blending of two separate and culturally different regional airline carriers – Hazelton Airlines and Kendell Airlines.

This report discusses the recent history of the study 'target' in terms of the realities of organisational change as it may affect the individual employee and the objective that applied to the creation of Regional Express.

Specific points of interest in the methodology include a discussion on the work of Dr Robert Helmreich and the creation of the Threat and Error Management (TEM) model, which is at the heart of the LOSA process.

The analysis and conclusions describe and discuss the specific outputs from a LOSA study. Until now, largely due to cost, LOSA studies with these types of outputs have only been available to larger airlines operating above the regional airline profitability threshold.

The LOSA conducted at Regional Express has provided new and valuable research data from the regional context, which, along with future regional airline contributors, will assist in making the LOSA Archive database more representative and possibly pave the way for greater regional airline participation in the use of these types of tools.

The Civil Aviation Safety Authority (CASA) is also considering a number of safety focused regulatory changes including:

- Civil Aviation Safety Regulation Part 119E – Safety Management Systems
- Civil Aviation Safety Regulation Part 121.943 – CRM/HF Training.

Once these regulatory reforms are introduced, tools such as LOSA will be of even greater importance to regional airline carriers.

A widening of opportunities for LOSA participation by the regional industry will ultimately assist in driving safer operational outcomes for all industry participants including passengers, other customers, employees, shareholders and insurers.

ABBREVIATIONS

ATC	Air traffic control
ATSB	Australian Transport Safety Bureau
CASA	Civil Aviation Safety Authority
CRM	Crew resources management
HF	Human factors
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LOSA	Line operations safety audit
MEL	Minimum equipment list
REX	Regional Express
SME	Subject matter expert (an aircraft type specialist)
SOP	Standard operating procedure
TEM	Threat and error management
TLC	The LOSA Collaborative
UAS	Undesired aircraft state

GLOSSARY

Error: An observed flight crew deviation from organisational expectations or crew intentions. There are aircraft handling errors, procedural errors, and communication errors.

Flight Operational Quality Assurance (FOQA): Involves collecting and analysing flight data to determine if flight crews, aircraft systems, or the aircraft itself deviated from normal operating limits; identifying trends; and taking action to correct potential problems. Airlines typically use a quick access recorder to capture flight data onto a removable optical disk. The data is then analysed using a computer system that evaluates deviations from specified tolerance thresholds (GAO, 1997).

Line Operations Safety Audit (LOSA): A formal process that requires expert and highly trained observers to ride the jump-seat during regularly scheduled flights in order to collect safety-related data on environmental conditions, operational complexities, and flight crew performance (The University of Texas, 2005).

Threat: An event or error that occurs outside the influence of the flight crew, but which requires crew attention and management if safety margins are to be maintained. There are environmental and airline threats.

Undesired aircraft state (UAS): A flight-crew-induced aircraft state that clearly reduces safety margins (ie, a safety-compromised situation resulting from ineffective threat and error management).

1 INTRODUCTION

1.1 Change and change management

Resistance to change is widely acknowledged as a human trait. It is observed in all aspects of human activity and it is particularly evident when change is introduced into the work environment.

Business growth within an industry generally takes place organically or by mergers and acquisition. With an acquisition, a new owner may realise the considerable resources spent directly through the process of acquiring the target and as a result, impose one culture on another in order to quickly become productive.

In contrast to the above, airline companies are not often blended and there are notable alternatives to the strategy described above. For example, it is now understood by industry insiders and observers, that when Qantas acquired Australian Airlines (formerly Trans Australia Airlines), it allowed Australian Airlines to operate largely as a separate (although re-branded) domestically focussed entity for many years, while it continued to focus on core international business. Later, when Qantas acquired Impulse Airlines, it too was maintained as a separate entity, until it was morphed into the still separate and emerging Jetstar business model and brand.

Achieving a blend of compatible businesses requires expending more resources post acquisition, to firstly identify, then analyse, adapt as needed, and finally adopt differing business practices in order to produce a new and blended organisational culture, which then must be re-focussed on delivering synergies. All this must occur under the pressure of expectation and the need to deliver a positive result. Often, there is much upset and emotion with this process. This is particularly the case if wholesale redundancies are involved.

1.2 Regional Express – a blended airline

Regional Express (REX) was formed from the integration of two different and long established Australian regional air service providers (Hazelton Airlines and Kendell Airlines). These companies were wholly owned subsidiaries of Ansett Transport Industries and operated as separate entities.

Kendell Airlines had been owned by Ansett for many years and had recently upgraded services from turboprop aircraft to include jet operations using Bombardier CRJ-200 Regional Jets. Hazelton Airlines was acquired in April of 2001 and largely remained a turboprop operation, separate from the main Ansett Group. When the Ansett Group collapsed on 13 September 2001, these businesses were placed into administration and operated separately at a much reduced capacity while a buyer was sought.

After almost a year in administration, Hazelton and Kendell were acquired by Australiawide Airlines with a view to creating a new entity (REX) to operate Saab 340 and Fairchild Metro 23 type aircraft.

The new owners wished to completely integrate and blend the former Hazelton and Kendell businesses into REX as quickly as possible. Although the former companies operated the same aircraft types, their respective operating methods, and policies and procedures were significantly different for a variety of cultural, historical, developmental, and funding reasons.

In recognising these pre-existing corporate and operational cultural differences, the Australian aviation regulator, the Civil Aviation Safety Authority (CASA), required both flight departments to operate separately until a blended hybrid policy and procedural model was developed and implemented for use by all flight crew. Developing and testing a new hybrid operating model was a lengthy process.

The former Hazelton and Kendell crew members (pilots and cabin crew) first worked together as a mixed group under a common and evolving set of policies and operational procedures from mid November 2003. This was then followed by a year of cultural re-alignment between the former work groups to achieve the blended REX organisation. In creating REX, the combined workforce was reduced from 1,200 to 550 employees.

After the integration period, REX was interested in a means to obtain a fresh baseline view of the newly blended flight operations and using tools separate from the normal training and checking quality process. The objective was to identify and understand the subtle and on-going residual and culturally based cockpit work practice differences, which are usually not evident in formal flight checks, in order to target further post integration refinement of pilot training and checking programs to improve operational safety.

1.3 Line Operations Safety Audit

For many years airlines have relied on accident and incident investigation reports to further their understanding of safety and performance. While effective, the more extensive of these reports often only capture rare and/or drastic events.

It is now possible through a Line Operations Safety Audit (LOSA) to monitor and diagnose normal operations and develop proactive safety interventions. LOSA is based on the premise that traditional methods of ‘auditing’ flight crew, such as check rides and simulator checks, do not necessarily reflect everyday crew performance on normal line flights.

A LOSA is a formal process that requires expert and highly trained observers to ride the jump-seat during regularly scheduled flights in order to collect safety-related data on environmental conditions, operational complexities, and flight crew performance. Confidential data collection and non-jeopardy assurance for pilots are fundamental to the process (The University of Texas, 2005).

The LOSA process utilises a family of methodologies, including the Threat and Error Management model developed by Dr Robert Helmreich (ICAO, 2002). The premise for LOSA stems from the recognition that even the most competent and skilful crew will make errors, either in response to threats in the operating environment, or ‘unprompted’ errors.

LOSA samples all activities in normal operations. In these regularly scheduled flights, there may be some reportable events, but there will also be some near-events, and importantly, a majority of well-managed, successful flights. Line Operations Safety Audits provide a unique opportunity to study the flight management process, both successful and unsuccessful, by noting the problems crews encounter on the line and how they manage them (The University of Texas, 2005).

A LOSA can help an airline discover the safety margins associated with its operations. Backed by years of research by the University of Texas Human Factors Research Project and The LOSA Collaborative (TLC), the LOSA methodology is recognised worldwide and is formally endorsed by the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA), the International Federation of Airline Pilots Association (IFALPA) and the Airline Pilots Association.

A LOSA provides unique data about an airline's defences and vulnerabilities. Additionally, the data collected during a LOSA will assist an airline to:

- Identify threats in the airline's operating environment;
- Identify threats from within the airline's operations;
- Assess the degree of transference of training to the line;
- Check the quality and usability of procedures;
- Identify design problems in the human-machine interface;
- Understand pilots' shortcuts and workarounds;
- Assess safety margins;
- Provide a baseline for organisational change; and
- Provide a rationale for the allocation of resources (The University of Texas, 2005).

The high demand for LOSAs led to the formation of TLC in April 2001. In partnership with The University of Texas, TLC maintains a user-group of airline safety professionals, researchers, pilots and manufacturing representatives, who oversee the integrity of the LOSA process. Members of TLC have been producing LOSAs since 1996.

Although LOSA is currently being widely implemented in major jet carriers worldwide, there has been little research involving the use of LOSA at a regional airline level.

Conducting a LOSA at REX would achieve the objective of taking a new and different operational ‘snap-shot’ to document a specific profile of the newly blended REX flight operations processes. It would also generate new data that is specific to turboprop aircraft and the regional airline context, and which, over time, and through the inputs of other regional airlines, will assist to further develop the comparative dataset of the LOSA Archive[1].

1 The LOSA Archive database contains de-identified airline data for those airlines that participate in a LOSA with TLC. The database is maintained and updated by the University of Texas (Merritt, 2005).

1.4 LOSA and the regional airline environment

The development of LOSA has been regarded as a major step toward addressing the persistent problem of aircrew error. Success in introducing the LOSA process may be partly due to the operating characteristics of LOSA, which include:

- Jump seat observations during normal operations;
- Anonymous, confidential, and non-punitive data collection;
- Voluntary crew participation;
- Trusted and trained observers;
- Joint management/union sponsorship;
- Systematic observation instrument;
- Secure data collection repository;
- Data verification roundtables;
- Data derived targets for enhancement; and
- Feedback of results to line pilots (Klinect & Murray, 2005).

The rapid worldwide acceptance of LOSA and its endorsement by both industry and regulatory bodies led to its growth being described as 'exponential' by ICAO in 2001.

As with many air safety innovations, LOSA has been primarily developed for, and adopted by, major jet air carriers. Prior to this study, Qantas had been the only Australian airline to implement a University of Texas LOSA program.

Regional carriers generally operate with less stringent regulatory requirements, fewer company resources, less sophisticated aircraft, and in a more hazardous operating environment than their mainline jet counterparts. Furthermore, unlike jet operators, regional airlines rarely have the resources to implement flight data recorder based Flight Operational Quality Assurance programs. Despite this, it appears the Bureau of Air Safety Investigation (now the ATSB) study of 1999 titled 'Regional Airline Safety Study: Project Report', remains the only significant study of this vital sector of the Australian air transport industry.

The LOSA Collaborative recognised that LOSA would be an invaluable tool for regional airlines to focus and redirect training, as well as giving flight operations and safety staff detailed information about what is really occurring on normal everyday scheduled operations. However, to date, such a tool has financially been beyond the reach of regional airlines.

The LOSA Collaborative is currently working towards making LOSA more accessible to regional carriers, and as such, wished to work with up to three regional airlines to develop a program more suited to the unique regional airline operating environment. One New Zealand based operator had already committed to the project. This project resulted in REX being one of the first regional operators worldwide to conduct a LOSA program.

2 METHODOLOGY

2.1 Project outline

This project consisted of several overlapping phases and sub elements. In a general sense, the project phases comprised project analysis definition and research planning, set up, observer training and data collection.

The objective of the project was to provide TLC with a representative dataset of REX regional airline operations. This dataset was then analysed by TLC and the results compared with the LOSA Archive.

Outcomes were two-fold:

- Firstly, to document the LOSA into a final confidential report of the data findings and the LOSA Archival comparisons. This material was then provided to REX to conduct further in-house analysis, with a view to a gradual integration of the findings into programs within the operational environment to further improve safety outcomes.
- Secondly, to provide a dataset to TLC, derived from, and representative of the turboprop aircraft regional airline environment for inclusion in the LOSA Archive.

2.2 LOSA quality assurance process

To ensure successful implementation, REX was required to participate in a multi-part LOSA quality assurance process:

1. An agreement was reached between REX airline management and the REX pilots' association. This agreement ensured that all data was de-identified, kept confidential, and sent directly to TLC for final analysis. The agreement also confirmed that both parties had an obligation to use the final results to improve safety.
2. Regional Express was assisted in selecting a diverse and motivated group of observers. This team comprised external observers as well as line flight-operation members.
3. The observers received five days of training in the Threat and Error Management model, the observation methodology, and the LOSA software tool, which organises data input. The LOSA Collaborative software also provided data security through automatic encryption.
4. After the initial observer training, observers conducted at least two sample observations and then reconvened for re-calibration sessions.
5. During this time, the observers were given one-on-one feedback on the quality of their observations and certified to act as observers on the project. The observer training and re-calibrations were considered essential for a standardised LOSA dataset. Subsequent observations were then conducted during a two month period.

6. Encrypted observations were sent to TLC, where analysts read the observers' flight narratives and checked that the data had been coded accurately. This data integrity check ensured the REX data was of the same standard and quality as other airlines in the LOSA Archive.

7. Once the data integrity check was completed, REX fleet subject matter experts (SMEs) attended a data cleaning roundtable with TLC analysts. Together, they reviewed the data against a suite of REX technical manuals to ensure that events and errors were correctly coded. After the roundtable was completed the fleet experts signed-off on the dataset as being an accurate rendering of threats and errors and suitable for the process completion.

2.2.1 Methodology discussion

As mentioned above, the LOSA program consisted of jump seat observations of normal scheduled line flight operations, conducted by a combination of external (TLC) and internal (REX) observers trained in the LOSA methodology. By capturing data from these flights, a picture of what really occurs during everyday normal operations can be obtained.

The data obtained from the LOSA consisted of two main sets:

- Firstly, the prevalence of 'threats' to flight safety and their management by crew was documented. Errors made by crew, either in response to threats or 'unprompted', and their management by aircrew were also documented.
- Secondly, crew were rated using a series of Crew Resource Management (CRM) Behavioural Markers, resulting in a picture of crew CRM skills (or threat and error management skills) being obtained.

The observations were not part of the normal airline checking regime and are non-jeopardy, with no data identifying individual crews or flights being recorded. One of the strengths of LOSA is that the data obtained is de-identified and the results remain confidential between TLC and the airline.

From the raw data, TLC builds an airline specific database, tracking all threats and errors and their management. Errors resulting in 'undesired aircraft states' (UASs) were also extracted and highlighted.

To assist in data accuracy, a two stage cleaning process was conducted, one by TLC and the second in consultation with airline fleet SMEs. Full data analysis can be done either by TLC, or via a data report supplied to the operator, who then conducts the analysis.

In either case, the data was also supplied to The University of Texas Human Factors Research Project, for addition to, and comparison with, the global LOSA database (currently consisting of over 4,000 observations from approximately 20 jet carriers). The data from this project will provide valuable information to begin building a database of threat and error management in the regional airline environment.

While this project specifically sampled Saab 340 turboprop operations, in addition, TLC also conducted a number of observations on the Fairchild Metro 23 turboprop fleet as a case study, to examine how LOSA might be further developed for smaller aircraft applications that do not have a dedicated cockpit third pilot/observer jump seat station.

2.2.2 Steering committee and set-up

As part of the project set-up, a REX steering committee was formed and a LOSA co-ordinator was appointed. To ensure the maximum benefit from the project, 'buy in' from relevant areas of the company, including flight operations, training and checking, and operations safety was essential.

The steering committee worked with TLC to define the precise focus of the LOSA. Considerations included Saab 340 and Fairchild Metro 23 fleet specific issues, selection of airports and safety issues.

This phase element also included planning and scheduling the logistics of the observations, recruitment and selection of observers, and carrying out observer training.

To ensure the highest degree of acceptance by the airline pilot group (and therefore success of the project), an education campaign was also developed to inform aircrew about the nature and purpose of LOSA. A copy of the REX Administration Memorandum introducing LOSA is provided in Appendix 6.2.

2.2.3 Data collection objectives

Data collection consisted of two objectives:

1. Obtaining data to develop a new baseline perspective on the recently blended REX flight operations department.

2. Assisting TLC to broaden its research by developing a baseline of data about the normal everyday operations of regional airlines.

The standard LOSA information collection parameters defined a dataset suitable for effectively sampling all the necessary aspects, which included:

- Crew performance;
- Threat and error management;
- Proficiency;
- Decision making;
- CRM skills;
- Procedural compliance;
- System performance;
- Airspace system – airports and navaids;
- Automation;
- Standards/training/safety/maintenance; and
- Crew support – air traffic control (ATC)/cabin/ground crew.

2.2.4 Data collection, round table ‘cleaning’ and analysis

This phase element consisted of actual cockpit jump seat observations of normal scheduled flights by the observers. An outline schedule of 60 to 70 flight sectors over a two month period was proposed (57 observations were actually conducted).

Included in this phase element was the downloading, decoding and initial data collation, independent data cleaning, and data cleaning ‘round table’ with airline SMEs. Completing this task also included the extraction and amplification of any high risk events that may have been observed (UAS).

The final phase element included a month long process of initial database construction and analysis for input to TLC.

3 RESULTS

3.1 Introduction

The benchmarking data for determining the final results for REX were created by averaging the scores for the last 10 airlines that completed a LOSA. Data based on quartiles were drawn from 20 airlines in the LOSA Archive.

Significantly, all prior LOSA participants were operators of swept wing jet aircraft types larger than, and with performance characteristics different to, the straight wing Saab 340 and Fairchild Metro 23 turboprop aircraft types operated by REX.

The aviation environment applicable to operating larger aircraft varies significantly to that typically experienced by REX and other similar regional airline operators.

3.2 Presentation of results

The REX LOSA results were presented in three forms:

1. The first, and shortest, was an Executive Summary, which presented REX threats, errors, any UASs and countermeasure profiles.
2. The report body expanded upon Executive Summary information by providing tables, figures and extensive details about the prevalence and management of threats, errors, and any UASs at REX.
3. The LOSA raw data reports were presented on a compact disc, which included a listing of all recorded threats and errors and the crews' management of those events, observed through the LOSA. Also included was full-text, phase of flight narratives for every observed flight. The LOSA raw data reports, in conjunction with the summary text, provided data for further analysis by REX.

3.3 Threat and Error Management model

Threats are everywhere in flight operations (adverse weather, airport conditions, ATC, aircraft malfunctions, cabin interruptions, etc.) and flight crews have to divert their attention from normal flight duties to manage them. The more complex, or challenging, and/or distracting the operating environment becomes, the greater the flight crew's workload.

Flight crew errors can vary from minor deviations, such as entering the wrong altitude but quickly identifying the mistake, to something more severe, such as failing to set the flaps before takeoff.

The Threat and Error Management (TEM) model views operational activity as a series of ongoing threats and errors that flight crews must manage to maintain adequate safety margins. Threats are external events or errors outside the influence of the flight crew that increase the operational complexity of the flight.

The TEM model is a conceptual framework for understanding operational performance in complex environments. Originally created to capture the flight crew's task in commercial aviation, the model is generic and can be applied to numerous situations. The added value that TEM brings to alternative performance models is that it focuses simultaneously on the operating environment and the humans working in that environment. Because the model captures ongoing performance in its 'natural' or normal operating context, the resulting description is realistic, dynamic, and holistic. The model can also quantify the specifics of the environment and the effectiveness of performance in that environment; it is also highly diagnostic (Klinect & Murray, 2005).

Flight crew error is defined as action or inaction that leads to a deviation from crew or organisational intentions or expectations. Errors in the operational context tend to reduce the margin of safety and increase the probability of adverse events.

Broadly speaking, there are handling errors (flight controls, automation), procedural errors (checklists, briefings, callouts) and communication errors (with air traffic control, ground, or pilot-to-pilot). Understanding how the error was managed is as important, if not more important, than understanding the prevalence of different types of error. It is of interest to know if and when the error was detected and by whom, as well as the response(s) upon detecting the error, and the outcome or consequence of the error. As with threats, some errors are quickly detected and resolved, leading to inconsequential outcomes, while others go undetected or are mismanaged. A mismanaged error is defined as an error that is linked to or induces additional error or UASs (The University of Texas, 2005).

Regardless of cause or severity, the outcome of an error depends on whether the flight crew detects and manages the error before it leads to an unsafe outcome. This is why the foundation of TEM lies in understanding error management rather than solely focussing on error commission.

Examples of countermeasures that were used to assess the effectiveness of TEM are listed in Appendix 6.1.

An undesired aircraft state (UAS) is defined as a position, condition or attitude of an aircraft that clearly reduces safety margins and is a result of actions by the flight crew. It is a safety compromising state that results from ineffective error management.

Examples of UASs include unstable approaches, lateral deviations, firm landings, and proceeding towards the wrong taxiway/runway. Events such as equipment malfunctions or ATC command errors can also place the aircraft in a compromised position, but these would be considered threats. As with errors, UASs can be managed effectively, returning the aircraft to safe flight; or the flight crew action or inaction can induce an additional error, incident, or accident (The University of Texas, 2005).

The TEM model has been adopted by several organisations:

- Threat and error management was a central focus in the ICAO Human Factors Training Manual (ICAO Document 9683), which was produced in 2002 to help airlines design human factors curricula.
- Threat and error management is the foundation of human factors training programs at several airlines, including Air New Zealand, Cathay Pacific, Continental, Delta, EVA Air, Frontier Airlines, Singapore Airlines and US Airways.

- Threat and error management has been adopted as the framework for the classification and analysis of worldwide accidents and incidents by the IATA Classification Working Group.
- Threat and error management has been integrated into confidential incident reporting systems at several United States airlines. The TEM framework directs pilots to self-report errors they may have made, factors that contributed to an event, and how well the event was managed or mismanaged.

3.4 The LOSA Archive

The LOSA Archive is a database containing results from all the airlines that have conducted a LOSA with TLC. Because of its stringent quality assurance process, TLC can accurately benchmark an airline's performance against other airlines that have conducted a LOSA.

The LOSA Archive currently contains data from the following airlines:

- Aero Mexico
- Air New Zealand
- Alaska Airlines
- Braathens ASA
- Cathay Pacific Airways
- China Airlines
- Continental Airlines (2000, 2004)
- Continental Express
- Continental Micronesia
- Delta Airlines (2000, 2004)
- EVA Air
- Frontier Airlines (2002, 2004)
- Malaysia Airlines
- Qantas Airways
- Silk Air
- Singapore Airlines
- UNI Air
- US Airways

3.5 Diagnostic snapshot

The REX LOSA report provided a diagnostic snapshot of normal flying operations, based on 57 actual observations by six observers of 30 REX flight crews flying in and out of 26 airports.

3.5.1 Threat prevalence

Regional Express crews encountered one or more threats on all observed flights (100 per cent of flights, with an average of 4.9 threats per flight).

- Environmental threats accounted for 59 per cent of all threats, while airline threats accounted for the remaining 41 per cent.
- The most frequent environmental threats were ATC and adverse weather (both observed on 54 per cent of flights).
- The most frequent airline threat was ground/ramp operations (observed on 46 per cent of flights).
- Approximately half of the environmental threats occurred during the descent/approach/land phases of flight, whereas 75 percent (three quarters) of airline threats occurred during pre-departure/taxi-out.

3.6 Demographics

During April and May 2005, LOSA observers collected 57 observations from 30 flight crews flying in and out of 26 airports. All observations were conducted on regularly scheduled line flights (none were line checks or training flights).

There were two LOSA Collaborative observers, who made six observations, and four observers from REX (three First Officers and one Captain), who made the remaining 51 observations (table 1).

Table 1: Observer demographics

Observer position	Observer numbers	Observations conducted (%)
Captain	1	12 (21%)
First Officer	3	39 (68%)
LOSA Collaborative	2	6 (11%)
Total	***6***	***57 (100%)***

Other demographic details

- The Captain was the pilot flying for 50 per cent of the observations.
- The Captains observed during LOSA averaged 14 years of airline experience and 8 years in position.
- First Officers observed during LOSA had an average of 6 years airline experience and 3 years in position.
- Fourteen per cent of the observed flights involved a late departure, defined as more than 10 minutes past the scheduled departure time.

3.7 Threat results

A threat is defined as an event or error that occurs outside the influence of the flight crew, but which requires their attention and management if adequate safety margins are to be maintained.

Threats can be divided into environmental threats, which are outside the airline's direct control, such as weather and ATC; and airline threats, which originate within the flight operations, such as aircraft malfunctions and ground problems.

Understanding the prevalence and management of different threats is the first step toward developing interventions that reduce those threats. The LOSA threat categories are listed in table 2.

Table 2: LOSA threat categories

Environmental threats	Examples
Adverse weather	Thunderstorms, turbulence, poor visibility, windshear, icing, etc.
ATC	Difficult to comply with clearances/restrictions, re-routes, controller errors, etc.
Airport conditions	Poor signage, faint markings, runway/taxiway closures, inoperative navigational aids, poor braking action, contaminated runways/taxiways.
Other environmental	Terrain, traffic, TCAS TA/RA[2], radio congestion.

Airline threats	Examples
Airline operational	Time pressure, missed approach, diversions, non-normal operations.
Cabin	Cabin event, flight attendant errors, distractions and interruptions.
Aircraft malfunctions	Systems, engines, flight controls, automation anomalies detected by crew, minimum equipment list (MEL) items with operational implications.
Ground maintenance	Repairs, maintenance log problems, errors.
Ground/ramp	Aircraft loading events, fuelling errors, agent interruptions, improper ground support, de-icing.
Dispatch/paperwork	Load sheet errors, crew scheduling events, late paperwork changes or errors.
Manuals/charts	Incorrect/unclear Jeppesen pages or operating manuals.

2 A traffic alert and collision avoidance system (TCAS) provides flight crews with traffic advisory (TA) and resolution advisory (RA) alerts. A TA informs flight crews of other traffic within the area, while an RA provides recommended manoeuvres in the vertical plane (climb or descend) to avoid conflicting traffic (Kumar, DeRemer & Marshall, 2005).

3.8 Organisational threat profile: prevalence and management

Line operations safety audit observers recorded threats that occurred across the different phases of flight and how those threats were handled by the flight crew. This information formed the basis of the organisational threat profile.

The profile is composed of the Threat Prevalence and Threat Mismanagement Indices and provides three key pieces of information:

1. **The frequency and location of environmental threats**. For example, understanding the extent to which certain airports or ATC pose a consistent problem for the flight crews can lead an airline to develop special procedures or advisories regarding those areas to help its pilots manage the known threat. Or, a high incidence of adverse weather threats may lead an airline to install new weather aids or add a specific module on weather management to its pilots training program.
2. **Problem areas within the airline's operations (airline threats)**. For example, a high number of threats arising from dispatch or cabin might signal that these departments require attention, that inter-group co-operations with the pilots' needs to be improved or procedures are inconsistent across departments.
3. **More problematic threats**. Threats with higher mismanagement rates can be prioritised for intervention as targets for enhancement.

Data from the LOSA provided REX with specific detail on threat prevalence for further analysis. Environmental threats included those from adverse weather, ATC, airport conditions, and terrain and traffic threats.

Airline threats included those from aircraft malfunctions/MEL items, dispatch/paperwork, ground maintenance, ground/ramp, cabin, operational, and manuals/charts.

Tables were presented for each threat category, showing the prevalence of the different threats. An extract is shown below.

Table 3: Extract of LOSA threat categories and prevalence

Threat group	Total
Environmental	59% (167)
Airline threats	41% (114)
Total	***100% (281)***

Environmental threats: phase of flight	Total
Pre-departure/taxi	23% (38)
Takeoff/climb	15% (25)
Cruise	9% (15)
Descent/app/land	47% (78)
Taxi-in/park	6% (11)
Total	***100% (167)***

Table 3: Continued

Airline threats: phase of flight	Total
Pre-departure/taxi	72% (82)
Takeoff/climb	10% (11)
Cruise	3% (3)
Descent/approach/land	8% (9)
Taxi-in/park	8% (9)
Total	***100% (114)***

Note: Components may not sum to totals due to rounding.

3.9 Error results

The previous section demonstrated that a REX flight typically encountered four or five threats. Errors are also ubiquitous in normal flight operations for a variety of reasons. Error management is a key to successful flight performance. Table 4 lists the LOSA error categories and examples.

Table 4: LOSA error categories

Error types with examples	
Aircraft handling errors	**Examples**
Manual handling/flight controls	Hand flying, vertical, lateral or speed deviations. Approach deviations by choice (eg flying below the ground speed). Missed runway/taxiway, failure to hold short, taxi above speed limits. Incorrect flaps, speed brake, auto-brake, thrust reverser or power setting.
Ground navigation	Attempts to turn down wrong taxiway/runway, missed taxiway/runway/gate.
Automation	Incorrect altitude, speed, heading, auto-throttle settings, mode executed or entries.
Systems/radio/instruments	Incorrect packs, altimeter, fuel switch settings, or radio frequency dialled.
Procedural errors	**Examples**
Standard operating procedure (SOP) cross-verification	Intentional or unintentional failure to cross-verify automation inputs.
Checklist	Checklist performed from memory or omitted, wrong challenge and response checklist performed late or at wrong time, items missed.
Callouts	Omitted takeoff, descent or approach callouts.
Briefings	Omitted departure, takeoff, approach, or handing over briefing, items missed.
Documentation	Wrong weight and balance, fuel information, automatic terminal information service, or clearance recorded. Misinterpreted items on paperwork, incorrect log book entries.

Table 4: Continued

Procedural errors	Examples
Other procedural	Administrative duties performed after top of descent or before leaving active runway. The pilot flying makes own automation changes. Incorrect application of MEL procedures.

Communication Errors	Examples
Crew to external communication	Crew to ATC – missed calls, misinterpretations of instructions, or incorrect read backs. Wrong clearance, taxiway, gate or runway communicated.
Pilot-to-pilot communication	Within crew miscommunication, or misinterpretation, sterile cockpit violation.

3.10 Organisational error profile: prevalence and management

The LOSA observations note several parameters about flight crew errors. Categorisation of parameters included logging the following:

- Type of error;
- Who caused it;
- Who detected it;
- Whether it involved a lack of handling (such as ‘stick and rudder’) skills;
- Proficiency based;
- Whether it involved a violation of regulations;
- Policies, procedures or SOP’s (otherwise known as intentional non-compliance);
- Crew response; and
- Result (inconsequential, additional error, or a UAS).

This information forms the basis of the organisational error profile of an airline. Because not all errors are observable—some are internal to the individual—and because an observer is not infallible and may miss some errors, the rate of observed error is considered a conservative estimate of flight crew errors in normal flight operations.

The Organisational Error Profile synthesises the Error Prevalence and Error Management Indices and provides three key pieces of information:

- **Patterns of error within the airline**. For example, if a significant number of pilots make the same automation error, it may be an indication of a flawed user-interface design. Similarly, a poorly written or ambiguous procedure may foster the same error in multiple crews. When analysed at the airline level, it becomes clearer that it is not one pilot who is more error prone than another, rather, pilots in similar environments will tend to make the same errors.

- **Patterns of error across the industry**. The systemic nature of error is even more apparent when benchmarking data from other airlines is used. If pilots from different airlines make the same types of error, it provides further evidence that the situation (aircraft, airports, manuals, schedules, terrain, etc) may be more at fault than any one individual.
- **Prioritisation of the most consequential errors**. Mismanagement rates for error are generally more variable than for threats – they may range from less than 1 per cent to more than 70 per cent. Not only high impact errors (those with high mismanagement rates), but also low impact errors can be significant if they happen with high frequency.

This aspect of the LOSA provided useful feedback in identifying areas to further develop the airline pilot training processes and procedures after the recent business amalgamation settling in period that created REX.

3.11 Threat and error countermeasure results

The initial focus of LOSA was on CRM performance, however, the introduction of the TEM model has provided a broader base for understanding these skills, which are now described as threat and error countermeasures.

Ten years of research by the University of Texas Human Factors Research Project has led to the development of 12 crew countermeasures grouped into four higher-level activities:

1. Team climate
2. Planning, execution
3. Review
4. Modification

Appendix 6.1 provides examples of threat and error countermeasures observed in a LOSA.

3.11.1 Threat and error countermeasure ratings

Observers were instructed to rate a countermeasure if they observed it, or if its absence was significant (such as a flight crew failing to re-evaluate their plan in light of new information). A one-time rating was given for overall crew effectiveness, leadership, and communication environment.

The planning countermeasures are considered an integral part of threat management and are rated during the pre-departure/taxi-out and descent/approach/land phases of flight. The execution countermeasures are considered crucial for error detection and error management and are rated during pre-departure/taxi-out, cruise and descent/approach/land.

If a flight proceeds as planned, there is little need to review or modify the flight plan. However, in the case of unexpected threats or UASs, the flight crew needs to openly evaluate the plan and modify it if required.

Evaluation of plans is therefore an important part of on-going threat management. Inquiry is needed so that both crewmembers know an error has been made – asking a question in a way that allows clarification, and where necessary, rectification of the situation.

LOSA observers' rated performance with the scale listed in table 5.

Table 5: Observers performance scale

1	2	3	4
Poor	**Marginal**	**Good**	**Outstanding**
Safety implications	Barely adequate	Effective	Truly noteworthy

Summary information is obtained by combining any 'poor' and 'marginal' ratings and comparing them with the 'good' and 'outstanding' ratings. For those countermeasures across different phases of flight, a low or high rating in any phase defined the flight for that countermeasure.

Observers were asked to explain their rating if it was anything other than 'good' and this information became part of a flight narrative.

Regional Express was presented with an organisational threat and error countermeasure profile, which included a consolidated dataset comparison from the LOSA Archive database of the past 10 airlines to complete the process.

3.12 Crew interviews

Supplementing the LOSA, crew interviews were conducted during the cruise phase of many observed flights. Pilots were asked to answer four generic questions about their perceptions of various safety and training issues.

The four questions were:-

1. In your opinion, what specific area of flight operations is likely to cause the next incident or accident in your airline?
2. Please state your concerns and suggestions to improve safety in any aspect of the airline (for example, flight operations, dispatch, airports, ATC, standard operating procedures?
3. What areas of confusion or automation 'traps' have you experienced with this aircraft?
4. What if any, are the differences between how you were trained and how things really go in normal line operations?

There were 30 crews observed on 57 flights. Twenty-three of the 30 crews were able to answer the interview questions during the cruise phase.

Verbatim responses to all the questions were provided to REX in a supplemental disc entitled 'LOSA Raw Data Report: Interview responses'.

3.13 LOSA raw data reports overview

The LOSA raw data reports were provided to REX as a series of documents presenting all data points collected during the LOSA. As previously stated, all raw data was verified by the REX fleet SME for integrity and coding consistency at the LOSA data cleaning round table phase.

This enhanced not only the credibility of the findings presented in the LOSA, but it also instilled confidence within the airline to use the data to implement meaningful safety changes. The LOSA raw data reports were categorised as listed in table 6.

Table 6: LOSA raw data reports categorisation

Report name	Description
Observation narratives	Overall and flight phase narratives for each observation.
Threat and error countermeasure narratives	Overall and flight phase crew performance marker.
Threat by LOSA flight number	Listing of observed threats by flight number.
Errors by LOSA flight number	Listing of observed errors by flight number.
Threats by threat type	Threats organised by type defined by LOSA.
Errors by error type	Errors organised by type defined by LOSA.
Secondary database	List of errors deleted by REX fleet specialists at the data cleaning roundtable but saved for later review.
Interview responses	Verbatim comments from the in-flight LOSA crew interviews.

4 CONCLUSIONS

Traditionally, the regional airline sector has experienced a higher accident rate than larger carriers, both in Australia and worldwide. Despite this, there appears to have been little research carried out in this segment of the industry, when compared with that conducted for and by major carriers.

At present, LOSA is largely beyond the reach of regional airlines, arguably the sector of the industry most in need of such programs. A lack of resources limits an airline's ability to undertake flight data recorder analysis. Accordingly, little data exists to provide baseline information for normal scheduled regional services.

The work conducted at REX, in conjunction with TLC and The University of Texas, had three primary effects.

Firstly, a baseline of data has been expanded about normal regional airline operations through the addition of the REX data.

Secondly, application of the LOSA tool in the regional context is enabling TLC and The University of Texas to refine LOSA further to be more regional specific, and improve its accessibility to regional airlines. Results from these aspects of this research will have wider implications for the whole Australian regional airline sector.

The third impact, which is internal to REX, has been the application of the new LOSA derived baseline dataset tool to better understand and aid in refining training and checking programs to further improve operational safety outcomes.

Since the initial LOSA work was completed, several new programs have been introduced within REX. Some examples include:

- An internal review of the REX training and checking organisation's policies and procedural business plan with a view to further improving safety through improved airline pilot training and checking quality assurance processes.
- The development and introduction of database tools to provide comparative analysis of pilot training and checking outcomes against measurable internal benchmarks.
- Liberalisation of the airline pilot training checking process through the introduction of specific and targeted remedial initiatives.

The objectives that are targeted by the internal programs mentioned above will be further aided through the introduction of safety focussed CASA regulatory changes. Some of these include:

- Civil Aviation Safety Regulation Part 119E – Safety Management Systems
- Civil Aviation Safety Regulation Part 121.943 – CRM/HF Training.

After these regulatory reforms are introduced, the development and refinement of aviation safety tools such as LOSA will be of even greater importance to regional airline carriers.

Regional Express will consider scheduling an internally run LOSA towards the end of 2007 or in early 2008, and after the current safety programs and initiatives become embedded in the REX flight operations culture.

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6 APPENDIXES

6.1 Threat and error countermeasures

Team Climate		
Countermeasure	**Definition**	**Example performance**
COMMUNICATION ENVIRONMENT	Environment for open communication was established and maintained	*- Good cross talk – flow of information was fluid, clear, and direct*
LEADERSHIP	Captain showed leadership and coordinated flight deck activities	*- In command, decisive, and encouraged crew participation*
OVERALL CREW PERFORMANCE	Overall assessment of crew performance for all phases of flight	*- Overall, crew performed well as risk managers*
Planning		
Countermeasure	**Definition**	**Example performance**
SOP BRIEFING	The required briefing was interactive and operationally thorough	*- Concise and not rushed* *- Bottom lines were established*
PLANS STATED	Operational plans and decisions were communicated and acknowledged	*- Shared understanding about plans: "Everybody on the same page"*
CONTINGENCY MANAGEMENT	Crew members developed effective strategies to manage threats to safety	*- Threats and their consequences were anticipated* *- Used all available resources to manage threats*
Execution		
Countermeasure	**Definition**	**Example performance**
MONITOR/CROSS-CHECK	Crew members actively monitored and cross-checked systems and other crew members	*- Aircraft position, settings, and crew actions were verified*
WORKLOAD MANAGEMENT	Operational tasks were prioritized and properly managed to handle primary flight duties	*- Avoid task fixation* *- Did not allow work overload*
AUTOMATION MANAGEMENT	Automation was properly managed to balance situational and/or workload requirements	*- Briefed automation setup* *- Effective recovery techniques from anomalies*
TAXIWAY/RUNWAY MANAGEMENT	Crew members used caution and kept watch outside when navigating taxiways and runways	*- Clearances were verbalized and understood* *- Airport taxiway charts were used when needed*
Review/Modification		
Countermeasure	**Definition**	**Example performance**
EVALUATION OF PLANS	Existing plans were reviewed and modified when necessary	*- Crew decisions and actions were openly analysed to make sure the existing plan was the best plan*
INQUIRY	Crew members were not afraid to ask questions to investigate and/or clarify current plans of action	*- 'Nothing taken for granted' attitude: Crew members spoke up without hesitation*

6.2 Regional Express Administration Memorandum and introduction to LOSA

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ADMINISTRATION MEMORANDUM NO: A13/05

DATE: **7th February 2005**
TO: **All Crew**
FROM: **General Manager Flight Operations**
SUBJECT: **Line Operations Safety Audit – (LOSA)**

Commencing in February 2005, the Flight Safety Department of REX plans to conduct a Line Operations Safety Audit (LOSA) of flying operations on the SAAB fleet.

LOSA is an ICAO-endorsed safety program that has been successfully implemented by carriers such as Singapore, Cathay, Qantas, Air NZ and Continental. Devised by the University of Texas Human Factors Research Project, LOSA consists of non-jeopardy, de-identified cockpit observations of airline crews conducting normal line flight operations. Through analysis of such observations a "snapshot" or safety "health check" of an airline's operations can be obtained.

Results from the LOSA will enable us to gain data on our safety strengths and weakness, enabling problem areas to be identified and resolved to make our operation safer and more efficient.

Whilst some of the audit will be conducted by observers from the UT LOSA Collaborative (TLC), the majority will be carried out by Rex pilots. Expressions of interest from line crews in becoming LOSA observers are invited, and should be directed to the Chris Hine, Chief Pilot (see below). The LOSA model gives best results if company Check and Training staff are not used as observers and therefore recommends that line pilots are employed as much as possible.

Both the Rex PC and the AFAP are familiar with the LOSA concept, and have agreed to the collection and use of data in accordance with LOSA protocols. As part of the protocols, Flight Crew have the right to refuse a LOSA observation at all times.

An introduction to LOSA is attached to this memo and queries on both the LOSA concept and its implementation at Rex are welcome, and should be directed to Terry Horsam (Human Factors Coordinator).

LOSA OBSERVERS

Volunteers are requested from Captains and First Officers to undertake the duties of LOSA observers (auditors) during the period of the audit.

Volunteers must have strong computer skills and must be able to maintain strict confidentiality during the audit.

Full training will be provided by the LOSA contractor.

LOSA activities will commence 28th February 2005 and flying observation duties will be completed by the end of March. LOSA observation duties will be rostered and are not additional to your current work load.

Volunteers are requested to submit expressions of interest to Chris Hine by email (chris.hine@rex.com.au) or fax (02 9023 3557) by the close of business **Friday 11th February**.

An information sheet on LOSA observer duties and requirements may be obtained from Sandy Reilly at Flight Operations Lord Street (ph 02 9023 3577).

INTRODUCTION TO LOSA

Recently REX was awarded a grant from the Australian Transport Safety Board [ATSB] to conduct a Line Operations Safety Audit [LOSA]. The grant is given to assist organisations seeking to improve their safety performance.
The following information is provided to advise flight crew participating in the LOSA program of the aims and objectives and also their rights in relation to the information gathered. LOSA is an initiative of the University of Texas and as the name suggests is a safety audit of an organisations systems and procedures. REX is the first regional airline in Australia to introduce LOSA which further enhances our commitment to aviation excellence.

Frequently Asked Questions.

Who will run the LOSA program?
The REX LOSA program will be administered by an external service provider however trained REX employees will be utilised as observers.

Who will the observers be?
The LOSA observers will be REX flight crew volunteers interested in safety promotion within the airline.

Is LOSA a check on me personally?
NO, LOSA is an audit of systems and procedures and not individuals. The volunteers are not part of the check & training department.

What if my name appears on a bad report?
No names are ever entered onto a LOSA observers report form. All flight information is de identified and once entered into a database the forms are destroyed. As a final assurance of confidentiality the external service provider supplies REX with statistical information only.

What if I don't want a LOSA observer on my flight?
If any crew member does not want to participate in the LOSA program they will not be compelled to do so with no negative connotation placed on their decision. Participation is on a voluntary basis however crews are reminded that the program is non jeopardy for individuals taking part.

What will REX do with the LOSA statistics?
Airlines around the world have found LOSA useful in identifying problems with systems and procedures and have applied solutions to fix these problems before they resulted in accidents or incidents. LOSA will provide REX with a "snapshot" of our operation, this will enable us to identify our risk areas and implement reduction strategies appropriately.

Further information.