Final Report

Advancing Aviation Safety: Threats, Errors, and their Management in
Normal Operations

The University of Texas at Austin

Final Report (Grant# 04-G-041)

Project: The University of Texas Human Factors Research Project
Project Director: Robert Helmreich, Ph.D.
Senior Researchers: James Klinect, Ph.D. and Ashleigh Merritt, Ph.D.
Staff Administrator: Lou Montgomery

---

Introduction

Grant 04-G-041, titled Advancing Aviation Safety: Threats, Errors, and their Management in Normal Operations, was proposed on the premise of providing a capstone to FAA funded research development of the *Line Operations Safety Audit* (LOSA) and *Threat and Error Management* (TEM) framework. The previous University of Texas FAA grant, titled Human Factors, Human Error, and System Safety (99-G-004), established the groundwork for LOSA and TEM. The research produced in both grants has led to LOSA becoming an ICAO Standards and Recommended Practice (SARP) for normal operations monitoring. A few years later LOSA was officially endorsed as an FAA Voluntary Safety Program with the publication of the LOSA Advisory Circular (120.90). In addition to LOSA achievements, ICAO now requires TEM to be integrated in all flight crew training and pilot licensing as governed by ICAO Annex 1 (Operation of Aircraft) and Annex 6 (Personnel Licensing). In supporting these developments, the majority of the effort completed during this grant was spent on providing presentations and documents to the aviation industry with LOSA and TEM source material.

LOSA and TEM Defined

LOSA uses non-jeopardy, cockpit observations to capture flight crew performance on regularly scheduled flights. The performance measure for LOSA is TEM, which proposes that threats and errors must be managed by flight crews on a daily basis to maintain adequate safety margins. The result is a proactive data source that airlines can use to identify systemic strengths and

weaknesses without relying on an incident or accident to stimulate safety change. The TEM framework is shown and described on the next page:

Figure 1 - Threat and Error Management Framework
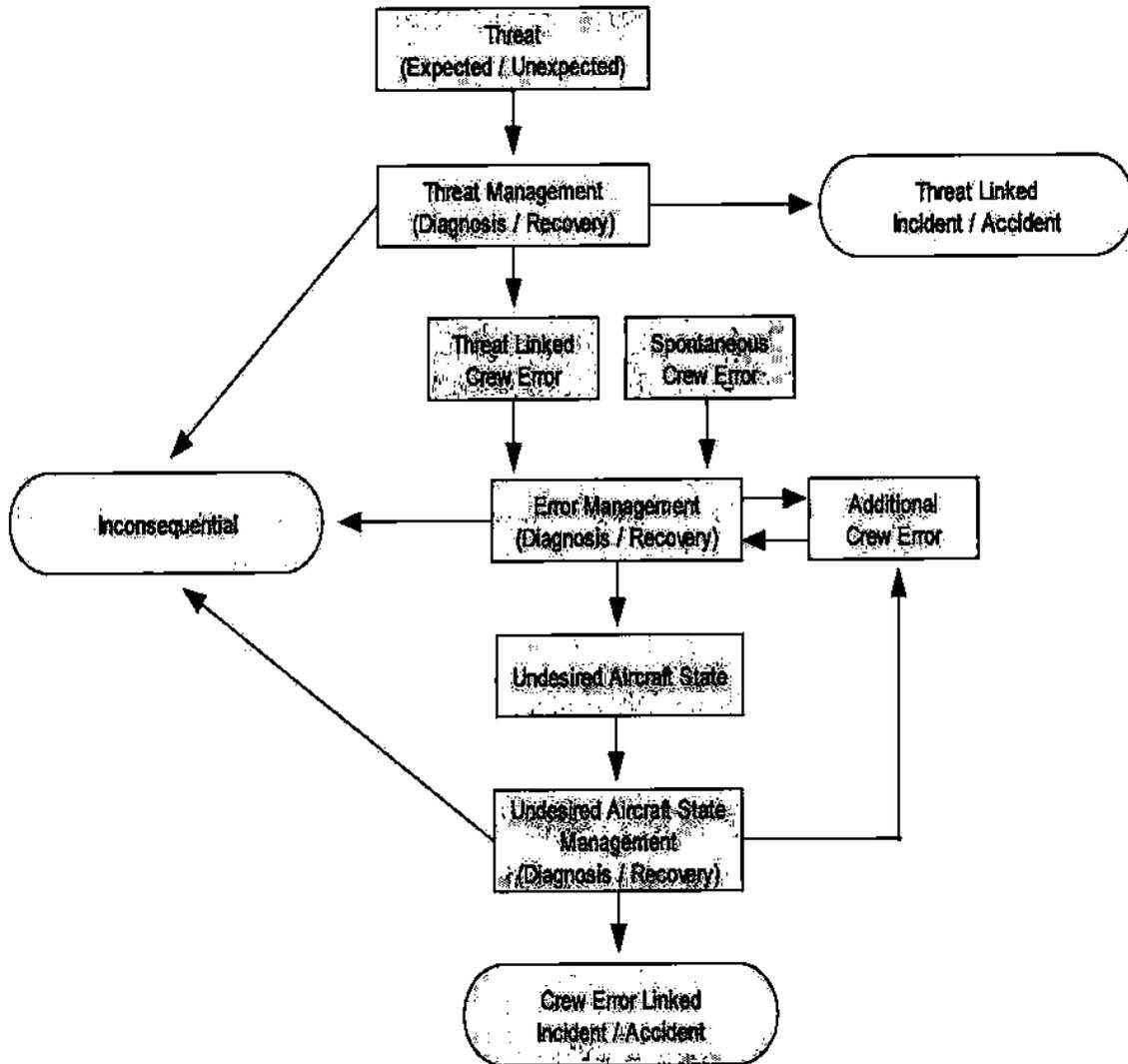
The TEM framework posits that threats and errors are part of everyday operations that flight crews must manage to maintain adequate safety margins. Airline management and most importantly, pilots are able to quickly grasp the concepts of threat and error management, because of its face validity. The definitions of the Threat and Error Management Framework are shown in Table 1.

Table1 - Threat and Error Management Framework Definitions

Element	Definition	Examples
Threat	Event or error that occurs outside the control of the flight crew but still requires their management to maintain safety.	Thunderstorms Late ATC clearance Ground / ramp error Aircraft malfunction
Error	Crew action or inaction that leads to a deviation from crew or organizational intentions or expectations.	Missed checklist item Omitted approach callout Incorrect flap setting Wrong automation entry
Undesired Aircraft State	A crew error induced aircraft state that reduces existing safety margins.	Altitude deviation Unstable approach Runway incursion Long landing

Threats – Threats are external events or errors outside the influence of the flight crew that increase the operational complexity of a flight. Threats may be anticipated by the crew, for example, by briefing a thunderstorm in advance, or they may be unexpected, occurring suddenly and without warning such as in-flight aircraft malfunctions. Threats are everywhere in flight operations and flight crews have to divert their attention from normal flight duties to manage them. The effectiveness of a crew's ability to manage threats depends first on whether a threat is detected. Once detected, flight crews can then manage threats to maintain safety.

Errors – Crew error is defined as action or inaction that leads to a deviation from crew or organizational intentions or expectations. In the operational context, crew errors reduce the safety envelope, thereby increasing the probability of an incident or accident. As with threats, the severity of errors can vary from minor deviations such as entering the wrong altitude but quickly catching it, to something more severe such as failing to set flaps before the airplane lines up for takeoff. Regardless of severity, the outcome of an error depends on whether the 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 focusing on error commission.

Undesired Aircraft States – Undesired aircraft states are defined as error-induced aircraft deviations or incorrect configurations associated with a clear reduction in safety margins. As

with threats and errors, they vary in severity but nevertheless all have the potential to lead to an incident or accident. A few examples include unstable approaches, exceeding ATC speed restrictions, overshooting a localizer, long landing, or takeoff with incorrect weight and balance.

Grant Achievements

The primary objective of this grant was to promote the education and use of LOSA and TEM. Other areas of the aviation industry have benefitted from this information as well such as air traffic control, ramp, cabin, and dispatch operations with documented versions of their own LOSA-style programs based on TEM (e.g., Continental's Ground Operations Safety Audit). The achievements, publications, technical reports, and presentations listed below provide evidence to the objective being met for the grant.

- Drafted the FAA LOSA Advisory Circular on LOSA (AC 120.90). The document was published in 2006 and can be downloaded on the FAA website (www.faa.gov).

- Completed doctoral dissertation on the development and demonstration of LOSA by James Klinect. A copy of the dissertation can be obtained online from The University of Texas library (www.utexas.edu).

- Organized the First LOSA User Group. The meeting was hosted by Cathay Pacific Airways in Hong Kong and over 45 participants from 17 LOSA airlines were in attendance. The meeting consisted of several breakout group discussions around four central questions.

  1. What are some of your airline's benefits and frustrations with LOSA data?

  2. How did your airline structure its "safety change process" in response to LOSA results?

  3. What are some of the organizational changes made as a result of LOSA? Did they work?

  4. What are some your airline's recommended improvements to LOSA?

- Published a technical report on LOSA best practices and lessons learned based on the analysis of over 40 hours of break-out group transcripts from the LOSA User Group. The document will be published as an addendum to the FAA LOSA Advisory Circular.

4

- Presented LOSA and TEM information at four ICAO/IATA sponsored LOSA/TEM conferences in Seattle, Kuala Lumpur, Toulouse, and Mexico City to over 700 participants from airlines and aviation organizations around the world. These presentations can be downloaded on the ICAO Flight Safety and Human Factors website (www.icao.int/anb/humanfactors).

- Supported the development of a new observational methodology for ATC called the Normal Operations Safety Survey (NOSS). The ICAO-sponsored ATC working group used LOSA and the TEM taxonomies as a starting point for their methodology.

- Conducted LOSA workshops at FAA Shared Vision of Aviation Safety Conferences in Denver and San Diego, FH Joanneum University in Graz, Austria, and at IFALPA conference in Rio de Janeiro, Brazil.

- Prepared a primer on TEM for the Guild of Air Pilots and Navigators (GAPAN). The primer was turned into a technical report providing an introduction to TEM titled, *Defensive Flying for Pilots: An Introduction to Threat and Error Management*. This document can be downloaded from The University of Texas Human Factors Research Project website (www.psy.utexas.edu/HumanFactors).

- Provided Boeing and the Commercial Aviation Safety Team (CAST) Automation Working Group with LOSA expertise and data in their efforts to improve aircraft design, pilot training, and automation procedures.

- Fielded approximately one phone call or e-mail every week of the granting period from airlines and other aviation organizations wanting information on LOSA and TEM for their internal evaluations, line check programs, or pilot training curriculum.

- Presented the keynote address at The Multimodal Symposium on Safety Management and Human Factors Conference in Melbourne, Australia.

- Presented LOSA methodology and TEM concepts at the 7th International Symposium of the Australian Aviation Association in Manly, Australia.

Grant Publications, Technical Reports, and Presentations

Publications

Merritt, A. C. (2004). Cross-cultural factors in aviation safety. *Human Factors Digest, 16*, 1-39.

Klinect, J.R. (2005). Line Operations Safety Audit: A Cockpit Observation Methodology for Monitoring Commercial Airline Safety Performance (Doctoral dissertation, The University of Texas at Austin, 2005).

Federal Aviation Administration (FAA). (2006). *Advisory Circular 120-90: Line Operations Safety Audit*. Washington DC: FAA AFS-230.

Technical Reports

Merritt, A.C., & Klinect, J.R. (2006). Defensive Flying for Pilots: An Introduction to Threat and Error Management. The University of Texas Aerospace Crew Research Project Technical Report 06-01.

Klinect, J.R., & Merritt, A.C. (2008). LOSA User Group: Lessons Learned and Best Practices. The University of Texas Aerospace Crew Research Project Technical Report 08-01.

Conference Presentations

Klinect, J.R. (2004). A Practical Overview of the Line Operations Safety Audit (LOSA). Presented at Second ICAO-IATA LOSA & TEM Conference, Seattle, Washington.

Klinect, J.R. (2005). Line Operations Safety Audit (LOSA). Presented at International LOSA and TEM Workshop, Sindicato Nacional dos Aeronautas, Rio de Janeiro, Brazil.

Klinect, J.R. (2005). Threat and Error Management (TEM) / Line Operations Safety Audit (LOSA). Presented at FAA Shared Vision of Aviation Safety Conference, Denver, Colorado.

Helmreich, R.L. (2005). What Crews Do: Context and Concepts of Threat and Error Management (TEM). Presented at Third ICAO-IATA LOSA & TEM Conference, Kuala Lumpur, Malaysia.

Klinect, J.R., & Murray, P. (2005). Line Operations Safety Audit (LOSA): A Practical Overview. Presented at Third ICAO-IATA LOSA & TEM Conference, Kuala Lumpur, Malaysia.

Merritt, A.C. (2005). A Glimpse at Archie: The LOSA Archive. Presented at Third ICAO-IATA LOSA & TEM Conference, Kuala Lumpur, Malaysia.

Klinect, J.R. (2006). Line Operations Safety Audit (LOSA): Introduction and Practical Experience. Presented at LOSA-Line Operations Workshop. FH JOANNEUM, Graz, Austria.

Klinect, J.R. (2006). The LOSA Archive (Archie): The Value of Benchmarking. Presented at LOSA-Line Operations Workshop. FH JOANNEUM, Graz, Austria.

Helmreich, R.L. (2006). Beyond the Cockpit: The Spread of LOSA and Threat and Error Management. Presented at Fourth ICAO-IATA LOSA & TEM Conference, Toulouse, France.

Klinect, J.R. (2006). Line Operations Safety Audit (LOSA): A Practical Overview. Presented at Fourth ICAO-IATA LOSA & TEM Conference, Toulouse, France.

Klinect, J.R. (2006). LOSA Data Analysis: From Diagnostic Counts to Targets for Enhancement. Presented at Fourth ICAO-IATA LOSA & TEM Conference, Toulouse, France.

Merritt, A.C. (2006). Archie Tells All! Surprising Statistics from the LOSA Archive. Presented at Fourth ICAO-IATA LOSA & TEM Conference, Toulouse, France.

Helmreich, R.L. (2007). Riding the Tsunami of Threat and Error: Neil Alston Memorial Lecture. Presented at the 7th International Symposium of the Australian Aviation Psychology Association, Manly, Australia.

Merritt, A.C. (2007). Archie Tells All! Surprising Statistics from the LOSA Archive. Presented at the 7th International Symposium of the Australian Aviation Association, Manly, Australia.

Klinect, J.R. (2008). An Introduction to the Line Operations Safety Audit (LOSA). Presented at FAA Shared Vision of Aviation Safety Conference, San Diego, California.

Klinect, J.R. (2008). Line Operations Safety Audit (LOSA): A Practical Overview. Presented at ICAO/ASAP Regional Seminar: TEM, LOSA & NOSS – Essential SMS Tools, Mexico City, Mexico.

Klinect, J.R. (2008). LOSA Data Analysis: From Diagnostic Counts to Targets for Enhancement. Presented at ICAO/ASAP Regional Seminar: TEM, LOSA & NOSS – Essential SMS Tools, Mexico City, Mexico.

6