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The Line Operations Safety Audit Program: Transitioning From Flight Operations to Maintenance and Ramp Operations

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16. Abstract

Managing risk has become increasingly important in modern organizations, including medicine, aviation, and finance. Accident investigation concentrates on failures, which are important for discovering major breakdowns, but failures are rare events. Proactive approaches offer the flexibility of observing normal operations A Line Operations Safety Audit (LOSA) is a voluntary safety program that collects safety data during normal airline operations and was originally designed for flight deck operations. The goal of this FAA-sponsored project is to capitalize on the 10-plus years of successful audits on the flight deck. The hazards that threaten the safety of flight deck operations are not unique to that environment. Similar problems are present during maintenance and ramp operations. This report provides a review of the use of LOSA, discusses LOSA's essential operating characteristics, lessons learned on the flight deck, and describes the extension of LOSA to maintenance and ramp operations. The research team developed tools for airlines and maintenance organizations to use as they initiate their maintenance (M-LOSA) and ramp (R-LOSA) programs.

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CONTENTS

ABBREVIATIONS

ASAP-------------- Aviation Safety Action Program
ASRS ------------ Aviation Safety Reporting System
COAir ------------ Continental Airlines
CRM ------------- Crew Resource Management
FAA -------------- Federal Aviation Administration
FOD -------------- Foreign Object Damage
FOQA ------------ Flight Operational Quality Assurance
GOSA ------------ Ground Operational Safety Audit
GSE -------------- Ground Support Equipment
IATA -------------- The International Air Transport Association
ICAO ------------ International Civil Aviation Organization
ISAGO ---------- IATA Safety Audit for Ground Operations
LOSA ------------ Line Operations Safety Audit
MEDA ----------- Maintenance Error Decision Aid
M-LOSA -------- Maintenance-LOSA
NOSS ----------- Normal Operations Safety Survey
R-LOSA --------- Ramp LOSA
ROSA ----------- Ramp Operations Safety Audit
SCP -------------- Safety Change Process
SMS ------------- Safety Management System
SOPs ------------ Standard Operating Procedures
TEM ------------- Threat and Error Management
TEMSA --------- Threat Error Management Safety Analysis
UT-Austin ------- University of Texas at Austin

The Line Operations Safety Audit Program: Transitioning From Flight Operations to Maintenance and Ramp Operations

INTRODUCTION

Managing risks has become increasingly important in modern organizations, including medicine, aviation, and finance. The initial identification and interpretation of hazards are some of the most challenging aspects of risk management, since many hazards remain hidden, unnoticed, or misunderstood for long periods of time before an accident (Macrae, 2009; Turner, 1994). The risks associated with these hazards seem obvious after an accident; however, the early signs pointing to an emerging hazard and its consequent risk are often extremely weak and ambiguous (Reason, 1997; Vaughan, 1996).

Systems such as the National Aeronautics and Space Administration (NASA)'s Aviation Safety Reporting System (ASRS) and the Maintenance Aviation Safety Action Program (M-ASAP) encourage air carrier and repair station employees to voluntarily report certain safety information. These programs provide an important, previously unavailable, source of data that is captured rapidly and directly from those responsible for the day-to-day safe operation of the aviation system. However, systems like these are used proactively and are based on previous adverse events.

A Line Operations Safety Audit (LOSA) is a tool for collecting safety data during normal airline operations. As a voluntary safety program, a LOSA does not require Federal Aviation Administration (FAA) approval, acceptance, or monitoring, as stated in the FAA LOSA Advisory Circular 120-90 (2006). The agreement allows the air carrier or air agency to maintain control of the audit results.[1]

Monitoring routine operations, the cornerstone of the LOSA process, addresses an important aspect of safety auditing, namely, that risks and human error can never be completely eliminated. Recognizing correct and incorrect actions to manage these risks and errors before they manifest into larger incidents/accidents makes LOSA a truly proactive, rather than a reactive strategy, as well as a workable predictive way of risk mitigation (ICAO, 2009; Maurino, 2001). Several companies have instituted LOSA programs and have garnered many valuable lessons, safety improvements, and significant returns on their investment.

LOSA has evolved into a strategy comprised of systematic line observations of routine operations to provide safety data, both in the technical and human performance areas. During a LOSA observation, observers record and code potential threats to safety, how the threats were addressed, the errors generated, how the errors were managed, and how the observed behaviors could be associated with incidents and accidents. The data from LOSA observations provide indicators of organizational strengths and weaknesses, which facilitate the development of countermeasures to operational threats and errors (ICAO, 2002). Prior to the implementation of LOSA, safety analysis of the effect of human performance in aviation had been retrospective, thus overlooking processes immediately preceding the human error that resulted in incidents/accidents (Maurino, 2001). Investigators targeted those actions and inactions that did not produce desired outcomes, often without fully considering the mismanagement of processes leading to these safety breakdowns.

Accident investigation concentrates on failures, which are important for discovering major breakdowns in the system, but failures are rare events. Self-reporting of incidents and potential hazards preceding major accidents can be limited because personal biases about behavioral norms may result in overlooking significant actions, and there are always concerns about professional consequences.

In addition to flight deck operations, there is a need to study aviation maintenance and ramp operations from a neutral perspective during normal operations. Maintenance organizations and ground operators have the opportunity to benefit from the 10-year success of normal operations audits on the flight deck. LOSA provides a minimally invasive safety audit of maintenance and ramp operations to evaluate an organization (including its systems, processes, and personnel), ascertain the validity and reliability of its information, and consequently assess its internal controls. Maintenance safety audits are intended to complement other safety-data sources such as ASRS and M-ASAP by tapping different feedback mechanisms and by identifying hazards before they become events or accidents.

The purpose of this report is to document the development of LOSA in flight operations, its successes and lessons learned, and describe the extension of the flight deck version of LOSA to aviation maintenance and ramp operations.

[1] The FAA ATA Human Factors Taskforce has discussed referring to LOSA within maintenance and ramp operations as an assessment rather than audit to reflect the nonpunitive intent of the program.

BACKGROUND

LOSA development was initially started in 1991 at the University of Texas at Austin (UT-Austin) with funding from the FAA. The development of LOSA stemmed from a request by Delta Air Lines to validate the operational impact of its three-day Crew Resource Management (CRM) training course. Analysts soon realized that existing data collection methods did not assemble adequate information regarding flight crew adherence to standard operating procedures (SOPs) and environmental influences on flight crew performance. To explore the effectiveness of CRM training transfer, a partnership was established in 1994 between the UT-Austin Human Factors Research Project and Delta Air Lines. The goal was to develop a line audit methodology utilizing jump-seat observations on regularly scheduled flights (i.e., LOSA). In its early form, LOSA mostly focused on CRM performance (Klinect, Murray, Merritt, & Helmreich, 2003). The audits provided actionable data about strengths and weaknesses, allowing prioritization and improvement of CRM training. They also supported the validity of findings from the CRM training data. Other major airlines then conducted their own CRM audits in collaboration with UT-Austin.

The next major development of LOSA evolved from the advancement of systems thinking and human error research in the field of aviation human factors. In 1997, the UT-Austin team collaborated with Continental Airlines to expand the method to focus on the management of common threats and errors. This ultimately evolved into the Threat and Error Management (TEM) model and the creation of the current LOSA's underlying theoretical framework. Continental Airlines was the first to use a TEM-based LOSA to target areas for improvement (e.g., pilots' error management training). In 1997 and 1998, the UT-Austin research team conducted LOSAs at three airlines (Klinect, Wilhelm, & Helmreich, 1999). The observers documented threats (external events such as adverse weather or errors originated by non-cockpit personnel), recorded flight crew errors, and rated the crew using CRM behavioral markers in accordance with TEM performance. Along with the documented threats and errors, observers also recorded how each event was managed by the flight crew. Initial data showed that threats and errors are common. Their types and occurrences varied across airlines. Notably, LOSA data illuminated the behaviors that led to effective and ineffective threat and error management. The nuances included in this proactive data collection strategy populate a richer and more extensive library of threats and errors than reactive accident/incident reporting. LOSA examines responses to errors that have not yet resulted in an accident or incident. Capturing effective responses allows LOSA data to provide insight into normal flight operations and aid training. Follow-up studies showed a sizable improvement at Continental Airlines in safety and overall crew performance (Klinect, et al., 2003).

LOSA data collection is conducted using the LOSA observation form under strict non-jeopardy conditions, meaning that crews are not at risk of receiving reprimands due to observed actions. Establishing that there is a non-punitive policy toward errors during data collection improves the validity of the data by encouraging those being observed to carry on their natural work behaviors.

LOSA was first operationally deployed as an International Civil Aviation Organization (ICAO)-endorsed safety program following the First LOSA Week,[2] which was hosted by Cathay Pacific Airways in March 2001. After several years of development and refinement, LOSA has evolved into a strategy to provide safety data comprised of normal operations in technical and human performance areas. The LOSA observations provide data to develop countermeasures to operational threats and errors (ICAO, 2002). It has since been used and validated by many international airlines and is now recognized as a key element in an airline's Safety Management System (SMS). It also provides a data-driven mechanism for measuring change (Veilette, 2008). Based on the success at many carriers that use LOSA, ICAO made LOSA a central focus of its Flight Safety and Human Factors Program and endorsed it as an industry best-practice for normal operations monitoring. The FAA also approves LOSA as one of its voluntary safety programs (Merritt & Klinect, 2006).

UT-Austin provided "how-to" guides as an open source through numerous conference presentations and papers to the airline industry about flight deck LOSA, as well as details about why and how to set up a LOSA. UT-Austin helped develop two primary guidelines: 1) Line Operations Safety Audit (ICAO, 2002),[3] and 2) Advisory Circular 120-90 Line Operations Safety Audits (FAA). Consequently, The LOSA Collaborative (a private organization) was formed in the interest of protecting the collected LOSA data.

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[2]The First LOSA Week, a pioneering event organized by the International Civil Aviation Organization, indicates the completion of a transformation from research concepts to operational tools. Since then, LOSA evolved and extended into the Normal Operations Safety Survey (NOSS), designed for air traffic control operations, and has become a successful and acknowledged contribution to the management of safety (ICAO, 2008).

[3]The ICAO LOSA manual is outdated. For example, the hierarchical "sticks and boxes" diagram in the manual implies that every error has a threat, which was found to not be true through actual LOSA observations. Most errors are "spontaneous errors" without any previous threat (J. Klinect, personal communication, April 1, 2009).

LOSA Operating Characteristics

The ICAO LOSA (2002) manual described 10 must-have LOSA operating characteristics (Table 1). These characteristics ensure the integrity of the LOSA methodology and its data. (ICAO, 2002).

Benefits of LOSA

LOSA does not rely on outcomes, such as an incident or accident, to generate data. It provides a unique opportunity to sample all activities in normal operations, both successful and unsuccessful, by noting the problems crews encounter and how they manage them (FAA, 2006).

Proactive approaches are aligned with the principles of risk management and SMS. Instead of focusing on problems, LOSA offers the flexibility of observing normal operations (where threats will always exist) and targeting problematic areas. LOSA is a project-based process, which includes advance planning, observer selection and training, data collection, analyses, and a final report. Repeating a LOSA can help maintain a broad focus of an earlier LOSA and track any targeted enhancements. ICAO recommends "to sustain safety in a constantly changing environment, data must be collected and analyzed on a routine basis to identify the targets for enhancement and then a formal Safety Change Process (SCP) to bring out improvement" (ICAO, 2002). Prior to programs like LOSA, SCPs were based on findings from incident/accident investigations, experience, and intuition. Today, SCPs must deal with the precursors of incidents/accidents and be based on the accumulated data repository and interactive detailed analysis methods generated by programs like LOSA.

Flight deck LOSA has resulted in numerous improvements including the modification of dispatch paperwork, reallocation of resources, and revision of procedures based on the problems uncovered through standardized observations and scientific data analyses. LOSA data have greater accuracy than anecdotal observations and can help answer questions about problem frequency, surrounding conditions, and events leading up to an issue. The data also provide better detail than voluntary reports and identify problematic procedures and policies by highlighting poor adherence rates (Veilette, 2008). At Continental Airlines, an airline-wide LOSA in 1996 uncovered that pilots were having trouble flying uniform approaches to company-defined standards. As it turned out, the problem was not that the pilots were managing approaches ineffectively but that the company's standards were ambiguous. LOSA results made it possible to convince management to modify SOPs for approaches, and the results, verified through a LOSA in 2000, showed a 59% reduction in nonconforming approaches (Croft, 2001). In addition, a 55% decline in unstabilized approaches was achieved by the company as a result of training developed from the LOSA findings (Tullo, 2002).

Problems With LOSA Implementation

Lack of adherence to the 10 LOSA characteristics, which sometimes occurs in internal LOSA programs, can reduce the effectiveness of the LOSA audit (ICAO, 2002). First, LOSA results are not always shared with the pilots. This may be the result of management considering a particular LOSA observation result "not great news" and deciding not to take action. A potential countermeasure to this problem is to instill the concept that providing feedback will advance future LOSA efforts in the sense of (a) illustrating that pilots' opinions and inputs are taken seriously by the company and (b) motivating observers and those being observed to participate more collaboratively in future studies. Second, airlines' internal LOSA programs sometimes specify the identities of the observers and those being observed. This is a problem because potential disclosure of identity may prevent observers from providing honest feedback. Information such as name, employee identification number, flight number, and date should not be recorded on a LOSA audit form. Departure/arrival cities, aircraft type, and pilot role are the only demographic information that should be recorded. Everything possible should be done to encourage anonymity. Pilots' trust in the LOSA program is paramount, and any violation of anonymity, whether a penalty follows or not, violates that trust. Third, some internal LOSA programs logged threats and errors but did not describe how they were managed. A threat or error may not occur frequently but may still be poorly managed and have unwanted outcomes. This highlights the importance of LOSA not being just a threats-and-errors counting exercise; the management of these threats and errors is critical.

McDonald and Fuller (1994) found that some organizations focus only on auditing documentation, physical resources, and infrastructure, while neglecting observations of operational activities. Audits conducted by external agencies and internal safety departments may prompt altered and rehearsed work behaviors, which potentially lead to inaccurate data. LOSA is different but complementary to other proactive safety programs such as Flight Operational Quality Assurance (FOQA) and ASAP by providing a "neutral, third-party perspective" (FAA, 2006). Each offers unique insight; and used together they can aid understanding and mitigate operational risk.

Table 1. LOSA Characteristics with flight deck examples

Characteristic	Examples in Flight Deck LOSA
1. Peer-to-peer observations during normal operations	• Routine flights only - no line checks or training flights • No debriefings or post-flight interviews asking crews to comment on their errors and/or undesired aircraft states
2. Anonymous, confidential, and non-punitive data collection	• No crew names, flight numbers, or other identifying information • Observer identity kept anonymous • Data used for safety purposes only, not disciplinary action
3. Voluntary participation	• Flight crews have the right to decline a LOSA observation
4. Trusted and trained observers	• Observer selection – management/union list of candidates • Diverse observer team – pilots, check airmen, instructors, safety experts, members of human factors groups, external observers • Training length (5 days): ground school (2), test observations (2), & recalibration (1) • Majority should be regular pilots from within the airline
5. Joint management/union sponsorship	• Steering committee – flight operations, training, safety, and union • Symbolized with a signed agreement and sent to all pilots
6. Systematic observation instrument based on TEM	• Safety-targeted data collection form • Observers record TEM events that they see and/or hear and write narratives for contextual support
7. Secure data collection repository	• Third party or pilot association gate keeper • Pilots must believe that observations will not be “misplaced” or improperly disseminated
8. Data verification roundtables	• Three to five representatives from various parts of the airline scan the raw data for inaccuracies • TEM data checked for coding accuracy and consistency with SOP • On completion, data analysis begins
9. Data-derived targets for enhancement	• Serve as benchmarks for organizational change • LOSA adopts a “measure, change, measure again” approach
10. Feedback of results to the workforce	• LOSA findings and information on how airline management intends to respond to the findings with organizational change

Extension to Aviation Maintenance and Ramp Operations

There remains substantial opportunity for safety improvement on the ramp and in the hangar. The Flight Safety Foundation (Lacagnina, 2007) estimated that the airline industry worldwide was losing $5 billion a year in direct and indirect costs associated with aircraft damage on the ramp. It was further estimated that 243,000 people were injured on the ramp every year. Thus, we believe that additional methods of reducing damage and injuries are imperative. The LOSA process holds promise as a means of reducing the incidents and accidents in ramp and maintenance operations because LOSA enables ramp and maintenance workers to identify and develop methods to address threats and errors before they lead to an incident or accident.

Several companies have instituted LOSA themed programs aimed at reducing maintenance errors and ground operation damage. These LOSA programs predate the current LOSA effort and provide many valuable lessons. The development of numerous subject matter experts (SMEs) was one of the beneficial outcomes of these efforts: they provided guidance during the development of the current LOSA program.

These companies have also experienced marked success as a result of their efforts. Continental Airlines, Delta Airlines, and Qantas Airlines reported benefits from their LOSA programs and are listed below.

Continental Airlines[4]

Ramp-LOSA (R-LOSA). In 2008, among 447 problems identified by the flight operations LOSA at COAir, 147 (29%) were ground safety issues. An examination of flight operations LOSA archival data revealed that the industry average is only 16% for flight operations ground safety issues.

To improve ground safety performance, COAir established several safety programs under the umbrella of its SMS—for example, the Safety Recognition Program and R-LOSA. Station #1 had the same ground safety programs as Station #2 but, Station #1 added the R-LOSA program in 2007. Both stations improved their group safety performance dramatically over a three-year span (2006-2009). Data for 2009 are only available from January through October. Monthly averages for the first 10 months were used to estimate November and December 2009 ground damage mishaps, and consequently, the averages for the entire year. However, the improvement observed by Station #1 is more than Station #2, which can potentially be attributed to the effectiveness of R-LOSA program (Note that Station #1's initial safety performance was better than Station #2). Ground safety performance was assessed using three measures: (1) ground damage mishaps (total number of occurrences), (2) ground damage mishaps (mishap rate per 10,000 departures), and (3) cost of ground damage mishaps.

Ground operation mishaps can further be categorized as attributable mishaps and non-attributable mishaps. Attributable mishaps are a result of human error and are charged back to the responsible department or vendor. Non-Attributable Mishaps include Foreign Object Damage (FOD). The costs are not recovered for these mishaps. Both stations showed a dramatic decrease in the total number of ground damage mishaps from 2006 to 2009. The number of attributable and non-attributable mishaps for Station #1 dropped 73% and 85%, respectively, whereas the drops for Station #2 were 58% and 67%, respectively. The cost of ground damage also decreased overall between the years of 2006 and 2009 in both stations. However, the cost of attributable mishaps for Station #1 increased very slightly in 2008.

For Station #1, the ground damage mishap rate also decreased significantly from 2006 to 2009: per 10,000 departures, attributable mishaps dropped 61% and non-attributable mishaps dropped to zero. For Station #2, both attributable and non-attributable mishap rates decreased from 2006 to 2009 (43% and 45%, respectively). The cost of ground damage also decreased overall between the years of 2006 and 2009 in both stations. The most significant improvements were observed in the following four areas: ground handling operations, struck by vehicle in motion, taxi-tow-push, and maintenance operations.

Maintenance LOSA (M-LOSA). M-LOSA findings help make deactivation procedures more workable, efficient, and safer. As an example, B767 leading edge device deactivation and reactivation procedures used to take three hours to properly lock out and tag out[5] without individual sign-offs. An M-LOSA auditor identified this inefficiency, which was then addressed by Tech Publications by rewriting their deactivation/reactivation procedures. Previously, the lockout and tag out process

[4]The information in this section is based on a site visit to George Bush Intercontinental Airport on March 18, 2008 and personal communications with Doc Garrett (Senior Manager, Maintenance Human Factors, Logistics & GSE Systems, Tech Ops); Rodney Luetzen (Managing Director, Reliability); Gerry McGill (Regional Manager, Safety & Regulatory Compliance, Flight Ops); and Guy Schroeder (Director Ground Safety, Safety & Regulatory Compliance) between March 2008 and April 2009.

[5]"Lock out and tag out" refers to specific practices and procedures to safeguard employees from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy during service or maintenance activities.

involved unnecessary deactivation of some systems following a 37-page procedure. Some steps required personnel to repeatedly reference different sections of the manual and there were no individual sign-offs when following the manual (e.g., deactivate the slats per AMM 27). The new workcard is 2-pages long with clearly defined steps. Now, with individual sign-offs, this modified process takes between 30 and 45 minutes to complete. The new standardized procedures also help to avoid problems caused by shift changes (deactivation and reactivation are often carried out on different shifts) and interruptions. This deactivation/reactivation procedure has been implemented in the entire Continental Airlines fleet. Because of the changes implemented by M-LOSA, the threats have been reduced tremendously, and no damage to the aircraft has occurred at the time of this publication.

Delta Air Lines[6]

Due to ground operations safety concerns, the Delta leadership team made several requests to the Atlanta Airport Authority asking that they repaint the clearance lines in the international concourse. However, the requests were ignored until Delta presented the results of a Ramp Operations Safety Audit (ROSA) at an airport operator meeting. ROSA is considered an effective communication tool and a critical component of Delta's SMS. ROSA data are reactive in addressing existing problems and proactive in helping the leadership team form goals and objectives with a reasonable timeline.

The ROSA data illustrated serious problems caused by the missing clearance lines. The Atlanta Airport Authority was convinced of the urgency in repainting the clearance lines by the ROSA data. Following repainting, ground equipment operators have consistently obeyed the rule of parking outside the clearance lines when airplanes are not at the gate. This practice has been consistently implemented across six different concourses. Consequently, parking violation-induced ground equipment damage and occurrence of FOD on the ramp have decreased. The ready availability of the equipment has also improved significantly.

Qantas Airways[7]

In January 2008, Qantas Airways successfully conducted its first Ground Operational Safety Audit (GOSA), an adaptation of the airlines' long-established LOSA methodology to the ramp environment. GOSA was used to observe the behavior of ramp teams during aircraft turnarounds and provided quantitative data on the threats, errors, and undesirable operational states that threatened the operational safety of ground operations. GOSA provided Qantas ramp management a means of gathering data on strengths and weaknesses of the operation, interface problems, effectiveness of training, quality and usability of procedures, and a rationale for resource allocation. It has also provided quantitative and qualitative data on the processes undertaken by staff that result in work shortcuts, injury, or risk to other staff. The implementation of GOSA has resulted in positive tangible outcomes for Qantas. Many simple day-to-day procedures have been adapted to reflect the results of the audits. This has had the beneficial effects of streamlining ramp practices and contributing to staff engagement.

GOSA has allowed Qantas to gather data on the work practices of external ramp service providers, and subsequently work with those providers to eradicate ineffective procedures. Qantas was then able to further satisfy its customers by ensuring compliant, efficient, and cohesive ramp service.

Air Transport Association (ATA) Human Factors Task Force

In December 2008, a group of FAA and Saint Louis University researchers began collaborating with the Air Transport Association (ATA) Maintenance and Ramp Human Factors Task Force (ATA HF Task Force). The Task Force developed M-LOSA and R-LOSA forms, training documentation, and the base structure for data warehousing and reporting. Development progressed through numerous consultations, combined with iterative development, testing, and refinement. The development of the maintenance and ramp LOSA forms, procedures, and software involved a core team of approximately 30 experts from the maintenance, ramp, and human factors communities. The team produced more than 20-line, base maintenance, and ramp operations forms designed for use in various LOSA audits (see sample, Appendix A).

[6]The information in this section is based on personal communication with Mr. Alex Vargas, Manager of Aviation Safety, Delta Airlines ROSA (A. Vargas, personal communication, February 19, 2009).

[7]The information in this section is based on personal communication with Shaun Trimby, Coordinator Human Factors and Safety Programs, Qantas Airways (S. Trimby, personal communication, March 5, 2009).

Form Development

The ATA HF Task Force found that forms comprising a combination of checklists and comments would be more effective for this domain, rather than the narrative method used with the flight deck LOSA. The forms and checklists were constructed to reflect the procedures followed by maintenance and ramp workers. Maintenance forms are based on procedures such as *Troubleshooting* and *Prepare to Install* with ramp forms based on procedures such as *Downloading* and *Uploading*. The line items on the forms follow the general flow of activities found during each procedure. This makes it easier for a LOSA observer to locate where a particular item should be recorded. If the observer encounters activities, threats, and errors that are not encompassed by the forms, he or she is instructed to address these items in detail in the general comments for that form.

The most common categories of threats and errors (e.g., fatigue, incorrect maintenance manual) are assigned codes. The codes provide the ability to query and analyze the data more quickly and in ways not possible (e.g., inferential statistics) with a largely narrative approach. The comments provide additional detail that can be accessed as needed but come with the drawback of requiring more time to read, comprehend, and interpret the information.

Beta Testing

After initial development of the forms, beta testing allowed input from more than 100 maintenance technicians and ramp personnel. We conducted beta tests for ramp, line maintenance, and base maintenance at numerous locations across the United States. The task force selected Part 135 and Part 121 carriers representing both passenger and cargo operations for beta testing. For each beta test, a team of 10-15 experts were deployed. LOSA trainers preceded the team to prepare the maintenance and ramp workers for being observed and to train a carefully chosen team to conduct the initial observations. The instructors provided information on the basics of LOSA, including the confidential, non-jeopardy characteristics of the observations, as well as detailed training on how to conduct a LOSA including the recording and coding of data.

The task force beta testing team remained on site and answered questions and recorded feedback throughout the initial weeks of testing. Following each shift, we debriefed and addressed questions and captured lessons learned on LOSA procedures and checklist content. The task force discussed the lessons learned at ensuing meetings and made changes as necessary.

Database Development

Databases were created to streamline audit information. Currently, users enter data collected from audits into an Access® database for future analyses and reporting. Efforts are underway to develop a more robust and powerful software tool based on Structured Query Language. The tool under development will allow LOSA teams to enter the data from a virtually unlimited number of LOSA observations. The new system will also allow connections from a greater number of observers, stations, and organizations. These factors are critical as the numbers of observations are anticipated to rapidly extend into the thousands.

Training

Training was developed to ensure effective implementation of the LOSA program that described the purpose of LOSA, theoretical foundation (TEM model), how to conduct a LOSA via the checklist forms, and data management. Computer-based training via scenario-based, guided presentation allows companies the flexibility to introduce the basics of LOSA while considering practical examples. The training materials provide the necessary background to prepare LOSA observers who have no background in TEM or LOSA. The initial training module provides an introduction to threat and error management, how it relates to the maintenance or ramp environment, and the initial foundation for LOSA. The second module in the training provides detailed information on LOSA, how and why it was developed, previous successes, and what it means for ramp and maintenance workers. The third and final module provides the observers with scenario-based practice. The scenarios allow the observer to experience a distilled version of several real-world observations, practice recording the data, and the chance to review what LOSA experts have recorded for each scenario.

The task force's goal was to develop a practical, customizable, and scalable methodology and deliver it to the industry as a part of a freely available toolset. The culmination of that goal was realized when the ATA HF Task Force released the M-LOSA and R-LOSA forms, procedures, software, and training materials for the public on the Internet (https://hfskyway.faa.gov/HFSkyway/LOSAHome.aspx).

CONCLUSIONS

This report provides a review of the development and implementation of flight deck LOSA, as well as description of attempts to transit LOSA to aviation maintenance and ramp operations. The R-LOSA and M-LOSA methodologies aim to use pre-identified *visible precursors* to ramp or maintenance events, thus ensuring an efficient, reliable, and valid audit of normal activity.

Precursors may lay hidden for years waiting for the chance to team up with other factors to cause an incident. The R-LOSA and M-LOSA audits are expected to encourage behavior change in ramp and maintenance operations and allow sub-units of an organization to build in some flexibility to address their key problems and conquer them one at a time. The periodic audits can help ensure that specific problems identified have been resolved, as well as assess the effectiveness of safety recommendations.

The development of R-LOSA and M-LOSA will build upon existing knowledge regarding safety across high-consequence industries. In particular, the impact of observation of normal behaviors in the aircraft maintenance and ramp operations will help qualify and quantify the efforts made by aircraft mechanics and ramp agents to prevent or reduce incidents and accidents.

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Appendix A
Sample LOSA Observation Form
Install

Threat Codes Legend	
T/A. Information	T/G. Environment / Facilities
T/B. Equipment / Tools / Safety Equipment	T/H. Organizational Factors
T/C. Aircraft Design / Configuration / Parts	T/I. Leadership / Supervision
T/D. Job / Task	T/J. Communication
T/E. Knowledge / Skills	T/K. Quality Control
T/F. Individual Factors	T/L. Other Contributing Factors

Observation Number:____________ ☐Did not observe this section

		Safety Risk N/A, Safe (S), At Risk (AR), Didn't Observe (DNO)	**Threat Code** (See Threat Codes List)	**Threat Effectively Managed** Y/N	**Error Outcome** 1.Inconsequential 2.Undesired state 3.Additional error **& Remarks**
	Safety				
1	Notes, cautions, and warnings reviewed				
2	Notes, cautions, and warnings followed				
	Personnel				
3	Required personnel available				
	Procedures				
4	Effectivity/configuration verified				
5	Materials utilized				
6	Servicing procedures followed				
7	Installation procedures followed				

Describe the threat(s). How did the technician(s) manage or mismanage the threat(s)?
Describe the technician error(s) and associated undesired states
Comments - Good or bad (Please provide examples)