Trailblazers into Safety-II: American Airlines' Learning and Improvement Team

A White Paper Outlining AA's Beginnings of a Safety-II Journey

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American Airlines' LIT Leadership

Ron Thomas, Vice President, Safety
Al Madar, Managing Director, Operations Safety and Compliance
Captain Guy Mouton, Senior Manager, LOSA / SMS
First Officer James Kwasny, APA LOSA Coordinator
Ricardo L. Campos, Senior Investigator, Flight Safety
Gregory Scheidel, Senior Analyst, LOSA

American Airlines' LIT Members

Captain Will Dismukes
First Officer Bogomir Glavan
First Officer Nicholas Peterson
Captain Michael Ford
First Officer Anand Vaswani

Safety Research Intern

Christine Jefferies, Cognitive Systems Engineering Lab (CSEL), The Ohio State University

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Abbreviations

AA	American Airlines
APA	Allied Pilots Association; AA's pilot union
AQP	Advanced Qualification Program
ATC	Air Traffic Control
CA	Captain
CAMI	Confirm-Activate-Monitor-Intervene; term to reference automation usage
DCT	Data Collection Tool
FAA	Federal Aviation Administration
FMS	Flight Management System
FO	First Officer
ICR	Inter-Coder Reliability
LOSA	Line Operations Safety Audit
OSU	The Ohio State University
PF	Pilot Flying
PM	Pilot Monitoring
RAG	Resilience Assessment Grid
SOP	Standard Operating Procedure(s)
SMS	Safety Management System
TEM	Threat and Error Management

Content

Executive Summary

American Airlines' Learning Improvement Team (LIT) has developed a new language and data collection methodology to capture pertinent Safety-II data from line flight crews operating regularly scheduled flights within their conventional domain. This document outlines the numerous lessons learned, difficulties overcome, and insights realized during the first phase of this project. This information is offered to various aviation and non-aviation organizations in the hopes that the safety of all high-risk, mission critical systems might be improved.

The novelty of this process required the development of several original and previously untested data collection tools that were created for the project. A number of iterative data collection tools were developed along the journey to support narrative data capture and were helpful in defining terms and organizing structure. Numerous data quality efforts were undertaken to validate the process and resultant data standardization and consistency for analysis. A handful of observers collected over 100 observations of narrative and tabulated data to build the initial data set for analysis and learning. The growth and development of the language and process along this journey was substantial and enlightening to the entire safety team. Providing a reliable data stream to newly required training courses currently being developed to meet new FAA requirements has become a central goal.

American Airlines' LIT group has developed a revolutionary language, data collection tool, data collection methodology and analysis process to better understand the relationship between Work-As-Imagined and Work-As-Done as it relates to resilient performance of flight crews in modern challenging systems. Intellectual aptitude and flexibility to accomplish similar gains should not be under-estimated when endeavoring on a similar journey. The concepts and ideas are novel and may not fit traditional data streams or collection methodologies.

Care should be taken to avoid forcing a Safety-II effort to fit within current programs. It is also necessary that the organization has a solid understanding of its own organizational culture and associated programs before intending to step into the realm of Safety-II. LIT is fortunate to have the support of AA's Safety Leadership in developing this Safety-II effort as its own unique data stream to complement AA's traditional Safety Management System (SMS). This investment in human and material resources has proven valuable, as early analysis efforts have demonstrated applicability of this LIT data to pilot mentoring and leadership courses in the airline training curriculum.

AA's LIT members have succeeded in demonstrating the successful development of language and then applying this language to data collection for deeper understanding of how AA's flight crews adapt to changing circumstances during routine flight operations. The future opportunities for this new stream of data to enhance an established SMS process are invigorating and provide the boost and spark to move beyond current safety accomplishments using Safety-I rationale and processes. Studying the complex and challenging environment of airline operations from a Safety-II perspective not only provides a new avenue to accelerate learning and development of hard-earned experience, but also engages a new source of pride and ownership over our crews' abilities to safely achieve organizational goals, one flight at a time.

Prologue

Introduction

In January 2018, AA embarked on a Safety-II journey. AA's Safety Leadership became interested in the concepts of Safety-II outlined in Dr. Erik Hollnagel's multiple books and were able to meet with Dr. Hollnagel to seek guidance in implementation. The AA Line Operational Safety Audit (LOSA) Program was identified as the program of choice to explore this theory and design a proof of concept to observe crews using this framework for safety and efficiency improvements. Although this Safety-I framework within LOSA was a logical starting point, it was strongly suggested by Dr. Hollnagel to separate the emerging Safety-II program from these traditional methods.

Following delivery of a plan for implementation, Guy Mouton, AA Senior Manager LOSA, and James Kwasny of the Allied Pilots Association (APA), recruited Captain Will Dismukes and First Officer Bogomir (Bog) Glavan in November 2018 to lead the Safety-II effort and design a program that could be implemented to capture Safety-II data. As professional flight crew, these line pilots started by reading as much Safety-II literature as possible to better understand the concepts and how these could be applied to AA operations. They met in Fort Worth, Texas, at the AA Safety offices in December 2018 to outline program milestones and goals. The priorities were to establish a language specific to aviation and AA and also to construct a basic framework for how the data collection would be conducted. Recognizing the centrality of learning, rather than compliance to the process of safety improvement and development, the group chose to call itself the Learning Improvement Team (LIT) with the moniker ever to be a reminder of that which must be emphasized in their work.

By describing the work of AA's LIT team during their first two years of work, this document seeks to accomplish three mutually reinforcing goals:

1. To document the actions taken and decisions made by a dedicated and enthusiastic group of AA employees for the benefit of their organization.

2. To demonstrate the utility of Safety-II inspired data collection and analysis tools and techniques.

3. To share insights recognized and obstacles overcome with others who may consider similar paths in their efforts to improve operational safety.

A second report is anticipated in early 2021 which will share analysis and results from early validated data.

Key Themes

Flight safety, Safety-I, Safety-II, resilience engineering, performance variability, resilient performance, human performance assessment, human performance improvement

Roadmap

The LIT leadership has been self-motivated and proactive in fulfilling its mission to design and implement a novel approach to safety at AA. With support and oversight from senior AA leadership, and in conjunction with the APA, the LIT group outlined a robust 15-month timeline divided into four phases:

1. Language and model development
2. Data collection and analysis
3. Solidify program structure and methods
4. Program implementation and data dissemination throughout AA and the aviation industry

Components within each phase are detailed in Figure D1 in Appendix D. At the time of this report, Phase 3 was completed on schedule in December 2019, and Phase 4 is underway.

Union Partnership

The APA, AA's pilot union, supports this initiative in conjunction with the other components of AA's existing SMS. LIT operates under the guidelines of the LOSA Memorandum of Understanding between AA and APA, which outlines protections for both the pilot crews and for the observers.

Academic Partnership

Following a daylong workshop with The Ohio State University (OSU) faculty and graduate students in June 2019, AA decided to continue its partnership with OSU to ensure continuous alignment with Safety-II core principles as well as rigorous data collection methods. A non-disclosure agreement was secured for the confidentiality of AA data during use by OSU researchers. One of the many benefits of the AA / OSU collaboration has been the opportunity for AA to call on the cutting-edge theoretical developments underway at OSU and for AA to share with the academic world the insights which can only be gained from working in a true operational environment. In-depth discussions concerning the applicability of Work-as-imagined versus Work-as-done occurred with the OSU CSEL team to further understanding and applicability for the LIT members. "Work-as-imagined is both the work that we imagine others do and the work that we imagine we or others did, do, or would do, in the past, present, or future. Work-as-done is actual activity – what people do. It takes place in an environment that is often not as imagined, with multiple, shifting goals, variable and often unpredictable demands" (Shorrock, 2016).

Safety Models at AA

Safety-I: Threat and Error Management

AA's TEM Model

AA's Threat and Error Management (TEM) process has, as its primary goal, the management and / or mitigation of the effects of threats and errors before they become operationally consequential. With the understanding that perfect adherence to standard operating procedures (SOPs) is unrealistic, and that SOPs alone cannot mitigate the myriad of situations that a flight crew may encounter, the TEM model offers flight crews a reference for organizational values and expectations during mitigation of unexpected and potentially hazardous situations (American Airlines FOM, 2019).

The model consists of a TEM target (adapted from Van Drie, 2002) to visually depict the flight crew's available tools to effectively manage threats and errors as well as the mnemonic ABCs, a framework onto which crews can scaffold their active and passive work during a flight.

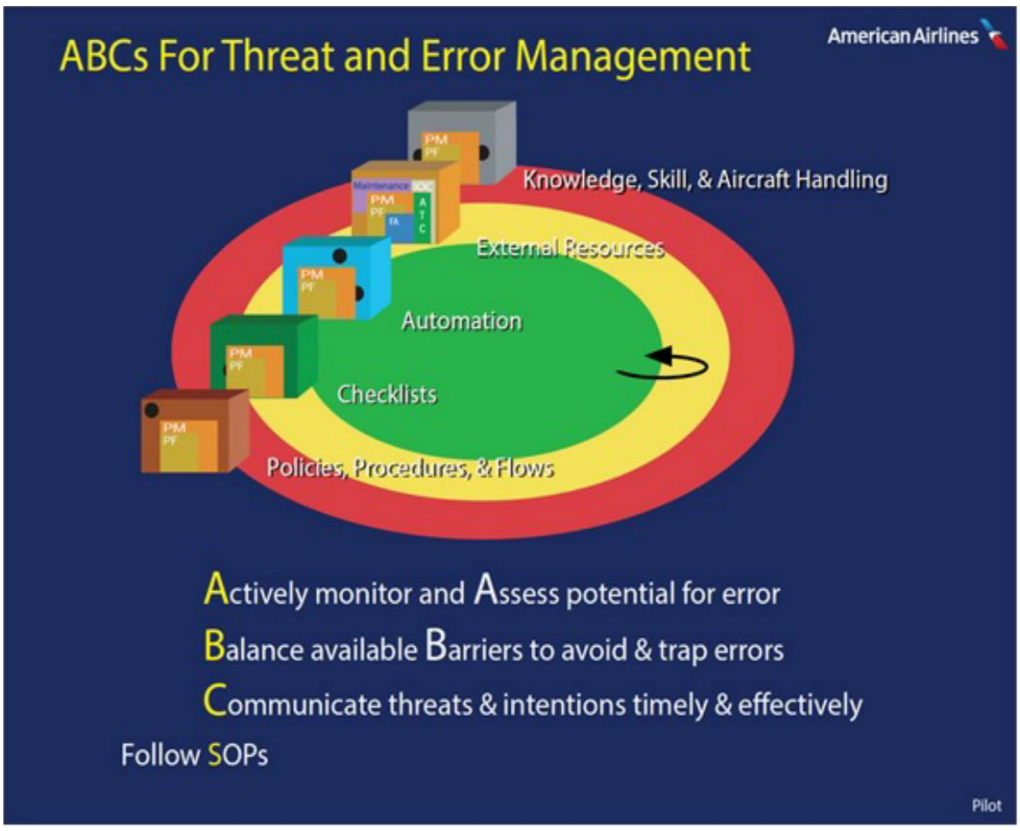

Figure 1. AA's TEM Model. (American Airlines FOM, 2019)

LOSA

TEM is the basis and language for LOSA data collection. Peer observers collect data on Threats, Errors and Undesired Aircraft States from flightdeck jumpseat observations on regularly scheduled flights with the goal to capture natural behavior as much as possible. This data stream has proven to be very beneficial in the current AA SMS process and, since the integration of LOSA to AA's SMS program in October 2016, has become the data source of choice for many recent major operational decisions at AA.

Other than their leadership teams, LIT and LOSA do not share resources, staff, or processes. Nevertheless, for this pilot project, the foundational LOSA observation practices were adopted for use by the LIT observers. This was especially true in terms of jumpseat protocols and observer guidance. These specific provisions include the obligation of the observer to speak up if they notice unsafe behavior that could greatly impact the safety of the flight. The observer also assumes responsibility at the discretion of the captain to assist the flight crew in an emergency situation.

Safety-I to Safety-II: Learning and Improvement Team

Our Name

The Learning and Improvement Team was named as such in order to emphasize learning and continuous improvement on all levels within the organization: among individual team members, between pilots in the flightdeck, and on the system level. While these aspirations reflect the existing goals of many safety organizations, LIT chose to focus on a learning approach; LIT views every interaction as having the power to generate new knowledge, engineer new ways to capture, transform, and disseminate flexing of strengths, and enact expertise that might otherwise fold into a pilot's normal workday. With its own name, LIT seeks to embody two of its primary premises: learning is central, and language matters.

Safety-II Within SMS

It is important to assert that Safety-II data collected within the LIT program is an additional data stream to complement the existing data streams available at AA and does not replace any traditional Safety-I data streams. Safety-II approaches are used in conjunction with AA's SMS framework and do not replace any current safety data programs. Additionally, the LIT model does not replace AA's TEM model nor AA's current TEM approach to LOSA, Advanced Qualification Program (AQP), or training philosophy. LIT has shown that it can complement the current system because it approaches safety in a unique light.

Building LIT's Approach to Safety-II

Greatly inspired by the work of renowned safety scientist Dr. Erik Hollnagel, especially his Resilience Assessment Grid (RAG) model, LIT leadership reached out to Dr. Hollnagel directly to discuss their interest and initial proof of concept for incorporating Safety-II into AA's SMS. Dr.

Hollnagel met with LIT leadership in Copenhagen, Denmark, in August 2018, and made two landmark recommendations:

1. *Develop your own language based on your understanding of the how RAG will be used in the cockpit*. As the essence of the potential for resilient behavior only has context within the trade space of the work being done, likewise the RAG model should be adapted to meet the unique attributes of the work of piloting commercial airliners.

2. *Devise your own data collection*. Using data acquired via a data stream anchored in "threats and errors" would be anathema to the appreciative mindset required for a Safety-II approach. The recommendation was to begin the Safety-II program by creating a separate, non-TEM driven data collection and analysis method.

The LIT group considered Dr. Hollnagel's advice carefully, given AA's safety leadership's intention to leverage LIT and LOSA data in the future. Most importantly, LIT recognized that developing a thoughtful, deliberate program design would be imperative as they would be blazing an entirely new trail within AA's SMS as well as within the Safety-II and Resilience Engineering communities.

Resilience Assessment Grid

Hollnagel's RAG model consists of four capabilities: Respond, Monitor, Anticipate, and Learn (Hollnagel, 2015). Hollnagel defines these capabilities as follows:

> Knowing what to *do*, or being able to *respond* to regular and irregular variability, disturbances, and opportunities either by adjusting the way things are done or by activating ready-made responses. This is the capability to address the *actual*.
>
> Knowing what to *look for*, or being able to *monitor* that which changes, or may change, so much in the near term that it will require a response. The monitoring must cover the system's own performance as well as changes in the environment. This is the capability to address the *critical*.
>
> Knowing what to *expect*, or being able to *anticipate* developments, threats, and opportunities further into the future, such as potential disruptions or changing operating conditions. This is the capability to address the *potential*.
>
> Knowing what *has happened*, or being able to *learn* from experience, in particular to learn the right lessons from the right experience. This is the capability to address the *factual*. (p. 279, author's italics)

LIT Potentials

As its analog to Hollnagel's capabilities, LIT designated the term "potential" to reflect the positive and recurring action observed. In discussing the four RAG capabilities in the sharp-end context of a pilot's daily work, the same four plus two new LIT potentials emerged as interdependent structures that interact in predictable ways. For example,

- Pilots *monitoring* notice alarms, anomalies, and situations that trigger their response.
- Slowing things down as a *response* mitigation strategy creates capacity for cognitive processing of the situation, thereby facilitating effective learning.
- Lessons *learned* facilitate the ability to anticipate similar situations in the future.
- *Anticipation* of concerns, focus areas, and available options inform monitoring efforts.
- Leadership (or Lead) and Communication (or Communicate) seemed to potentiate and facilitate success during the enactment of each of the other potentials.

From this point, the LIT model evolved in several ways to become what it is today (Appendix D). In recognition of the fact that communication between pilots and other team members is only the initiation of an interaction, and to reflect the forward-looking engagement that could be expected with each potential:

- Coordinate was added to better capture the inherently cooperative aspects of safe airmanship, both within the flightdeck and outside of it. It also reflects the understanding that the LIT is rooted in the front-line work of pilot crews.
- Monitor was removed as a potential in its own right, as it was recognized as a vital component of Coordinate.
- Adapt replaced Respond. Respond implies reactivity, a product behavior which is less considered and less deliberate. Adapt more accurately describes pilot performance, particularly as it relates to the active management of multi-factor trade-offs.
- Plan replaced Anticipate. While anticipation is an expert skill, recognizing the proficiencies demonstrated by pilots who leverage anticipation to devise plans that create resilient potential better encapsulates the work and mission of all pilots.

Early on, the team struggled with how to model Leadership and Communication, as they were clearly essential among the crews who exhibited positive performance yet seemed difficult to discretely observe or quantify. Eventually, the concepts of Lead and Communicate were removed as directly observable potentials but retained as overarching principles that were present in performance observations. The team continued to assert these concepts as critical to the LIT project and envisioned them as the glue that held the four potentials together.

While the team considered whether the four core potentials might make sense as a linear progression, it became clear that they were better envisioned each as a positive feedback loop with the concept of resilience: their enactment created resilience and also received input from other potentials via more resilient performance. In this way, the LIT model, with its four potentials resting on an interconnected and interdependent foundation, visually reflects the functional creation of the potential for resilient performance in any given situation. When further envisioned as a three-dimensional model the complexity of the interconnectedness of the four

potentials and how they spark resiliency becomes evident. This model continues to evolve as LIT better understands the relationships amongst the potentials.

Figure 2. AA's LIT Model.

LIT Proficiencies

Hollnagel (2015) asserts that the details of each potential, that is, the specific functions that enable a system to perform in a resilient manner, are more practical to address than the potential as an idea or quality in and of itself. In essence, proxy measures are needed to qualitatively assess the potential for resilient performance in a concrete, pragmatic way.

In an effort to use language unique to LIT while avoiding confusion or implication that these proxy measures should be judged as best practices, the LIT group settled on the term "proficiency" (rather than "behavior" or "competency") to characterize the phenomena of resilient performance. Early in the development of the LIT program, the LIT group surveyed and interviewed more than fifty AA Check Airmen and LOSA Observers, recognized experts within the pilot group who know what positive performance looks like in practice. It was initially decided

to focus on positive performance to better capture credible metrics in designing observable criteria. Thematic analysis of this data provided content around which to explore LIT proficiencies as they appear in normal work. Proficiencies themselves have undergone several iterative revisions with the intent to optimize data capture, maximize inter-coder reliability, and accurately reflect vital front-line work that contributes to success. LIT proficiencies as of December 2019 can be found in Appendix C.

Leveraging LIT to Engineer System Resilience

In June 2019, the LIT group visited Dr. David Woods and Dr. Mike Rayo along with several doctoral students at OSU's Cognitive Systems Engineering Laboratory (CSEL). During the day-long meeting, the team learned that recent developments in the field of resilience engineering could be useful in offering additional theoretical grounding to LIT's mission. Importantly, the LIT group also re-centered on an essential tenet of resilience in practice: resilience is not a component to be built into the organization, but the organization and its individual workers can manage and foster the development of the potentials which will lead to resilient performance.

Resilience Engineering as a field seeks to 1) discover operational principles which allow complex systems to adapt to the often-unforeseen conditions of changing worlds, and 2) design, develop, and operate systems according to those principles. It recognizes that, though often described in linear (or near-linear) terms, modern engineered systems are multi-scale, multi-echelon, tangled, layered networks of interacting agents. The diversity of their components, though often difficult to manage and coordinate, also offers the capacity to respond to much wider range of events and challenges than more simple, homogeneous, or monolithic systems.

Recognizing that the variability of the world often means that systems (both engineered and evolved) must successfully operate under a much wider and frequently more challenging set of conditions than those for which they were created, resilience engineering begins with the foundational expectations that such systems will be challenged at their operational boundaries. Woods' theory of graceful extensibility (Woods, 2018b) argues that those systems which develop, manage, and retain the capability to flex, adapt, and grow at their limits in response to challenges and changing conditions are more likely to be successful in their operational missions and more enduring over time.

With this worldview in mind and using new language from resilience engineering, the LIT group reexamined and refined their potentials and proficiencies, further adapted the data collection tool for qualifying data, and cemented their determination to include robust narratives with each data point in order to preserve the context of the observed situation.

Methods

Strategy

AA's successful approach to Safety-II was tailored to both the aviation industry and specifically the way AA conducts operations. As with all endeavors in AA Flight Safety, a dual-faceted approach to leadership and oversight by AA and APA ensured mutual predictability and direction for the LIT program.

Proof of Concept

AA's robust, continuous LOSA program and its foundational TEM model served as the vehicle for a Safety-II proof of concept. The LOSA data set contains threats, threats managed, and errors captured by LOSA observers during routine flight operations. Threats managed, meaning they did not lead to a crew error, indicate successful performance, or "what went right or well" according to a Safety-II approach. Examining the LOSA data showed that over 80% of air traffic control (ATC) threats were successfully managed and that more than 70% of all AA flights encountered an ATC threat. ATC threats were selected as a Safety-II proof of concept data set.

A deep dive into this data set was performed by Lead Check Airmen (lead instructor pilots) from each fleet, who extracted meaningful patterns within narratives from successfully managed ATC threats during the previous 12 months. Three primary factors stood out among the LOSA narratives: the crew's experience level, their knowledge of the theater of operation, and, perhaps most interestingly, the crew's willingness to say 'Unable' in response to an ATC instruction that was too challenging or placed the crew in a precarious situation. Exploration of what factors positively and negatively contributed to this kind of open communication between pilots readily yielded some teachable best practices. Satisfied that examining data for "what went right or well" yielded leverageable insights, the LIT program was approved by AA's Flight Safety Leadership.

With the approval from the organization, LIT leadership sought the first of several academic partnerships by initiating a conversation with Dr. Erik Hollnagel, whose works they were familiar with. Heeding Dr. Hollnagel's advice (discussed in the Safety Models section of this report), LIT leadership chartered the first team members to create LIT from a blank slate, rather than adapting from LOSA. Two seasoned LOSA observers were allocated paid time away from their regular duties to research Safety-II concepts and apply them towards developing innovative safety observations.

Data Collection

Observations

In March of 2019, the first LIT observations, informally called LIT rides, were conducted by two former LOSA observers. Initially the observations were performed on pre-identified crews who were selected due to their reputations as high performers as they operated during regular scheduled flights. The intent of these early rides was to test whether flight observations undertaken with an overtly positive, proactive approach could show measurable positive resilient performance. Preliminary data as well as subjective feedback from crews and from LIT observers themselves confirmed the test hypothesis, and the decision was enthusiastically made to continue.

Data Collection Tool

The first observations, conducted in March and April 2019, were recorded in narrative form. After approximately 10 observations the team determined that a more objective and data-oriented approach would be more efficient for data capture as well as more useful for data analysis. To meet this need, a unique AA's LIT data collection tool (DCT) was developed within Microsoft Excel. Rapid prototyping and testing of the LIT DCT produced no fewer than six versions within eight weeks (Appendix E). Changes to the DCT fell into one of three categories: enhancing the data input experience for the observers, adding or changing what data to collect, or formatting changes to facilitate data extraction for database storage and future analysis.

Demographic data collected on each flight observation includes:

- Month and Year
- Aircraft type
- Crew base
- Departure and arrival ICAO airport designations
- Sequence day number of total days in that sequence
- Leg number of total legs that day
- Departure and arrival airport current weather
- Captain experience level, and whether they are a line or reserve pilot
- First officer experience level, and whether they are a line or reserve pilot
- Whether the captain or first officer was designated as the pilot flying or pilot monitoring

Space is allocated for narrative data per phase of flight, which may include special circumstances or flight-related information related to the overall context of the flight.

LIT-specific data includes:

- Phase of flight
- Observed potential
- Observed proficiency
- Qualifiers
- Narrative description of the context in which the potential was observed

While Microsoft Excel spreadsheets are currently sufficient for data collection, eventually a built-to-specification DCT is anticipated.

Qualifiers

In addition to observing potentials and proficiencies, LIT observers saw value in preserving two notable artifacts from their experience as LOSA observers: measuring the connection of observed proficiencies to each other and noting which if any outside influences were encountered by the pilots in each situation. These qualifiers can be found in Appendix B, Table B3.

Linkages

The interdependencies and interconnectedness of the potentials became apparent within the first four months of conducting observations. The team struggled with how to best describe the complexity of the relationships. Initial attempts noted if there was a linkage and then scored that connection on a scale of 1 to 4 based on how complex the series of linkages were. It quickly became evident that this was too subjective, so the collection method changed to listing which potentials were linked by a labeling system that could be referenced in the analysis phase. Later versions of the collection tool expanded to denote a “parent-child” relationship with the linkage to better explain the interdependencies and complexity of day-to-day operations, and the current version of the LIT model represents linkages with a backdrop upon which the four potentials interact.

Preliminary data has shown approximately 15% of observed potentials appear in series with other potentials. An example of this phenomenon is shown in Figure 3.

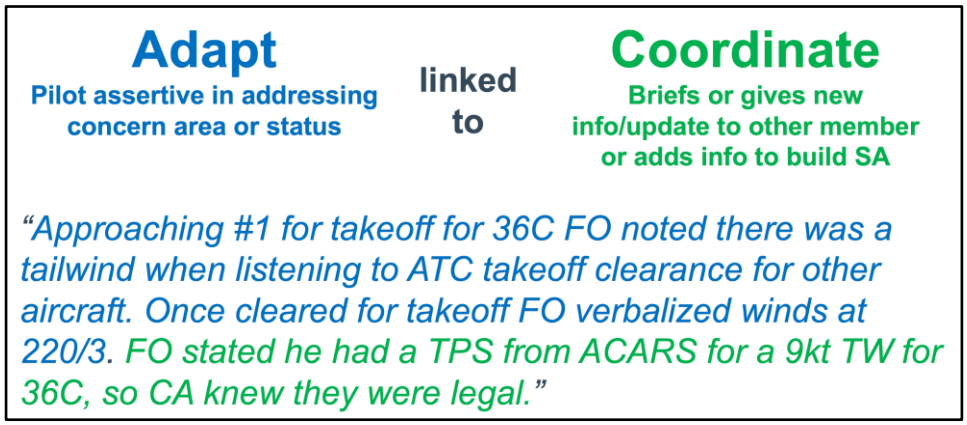

Figure 3. Linked potentials.

Pressures

In LOSA and TEM, a threat is any event that originates outside of the flightdeck that increases operational complexity and must be managed to maintain the margins of safety (IATA 2013). In recognition of this complexity as it relates to the potential for resilient performance, LIT includes many of the same such events in the data collection. However, instead of considering them as

events to be managed, LIT views them as influences or pressures that impact the crew's task loading and prioritization, which can be found in the qualifiers in Table B3 of Appendix B.

Pressures are important contributing factors that drive timely, responsive decisions. In addition to the pressure itself, the degree to which time is affected by the pressure is also noted. While originally a 4-point scale which noted the pressure on a scale of simple to complicated and its effect on time from no effect to significant effect, the LIT group sought to increase reliability and objectivity by simply noting whether or not time was affected, i.e. the pressure's impact on the crew's task loading and prioritization.

Radar Plot

A radar plot was included in each observation to give a subjective snapshot of how the observer rated the crew's resilient performance across the four potentials. The radar plot was inspired by Hollnagel's RAG model and served as an analogous feature to a subjective section of the LOSA data collection tool. While there is no standard or norm against which to rate the potential for resilient performance across the four potentials, each observer rates the potentials in comparison to all of the observations previously completed. The LIT group is still considering how this feature may be employed.

Version Control

With so many iterations of the DCT being used over time by LIT observers, it was necessary to scrutinize the data as previous observations were re-coded. LIT observers took into account known cognitive influences such as memory recall degradation as they re-coded their own observations. The team's research intern and data analyst reviewed and double-checked all re-coding and version control efforts.

Additionally, throughout the DCT version changes, the team was continuously collecting data with either the newest version or the most previous version. While continuity posed a challenge in this situation, clear and timely communication among LIT group members quickly mitigated any confusion that arose. The LIT data analyst maintained a Microsoft SharePoint database of all original data collected from observers as well as re-coded observations, while serving as a central point of contact for data consolidation.

Interviews

The team also expanded the collection method to include pilot interview sessions called "Shop Talk". These were conducted during downtime at recurrent simulator training or at other scheduled periods. Approximately 30 minutes in length, they provided an opportunity to delve into potentials deeper by examining how the crews analyzed and dealt with unique circumstances such as diverting to another airport, approach go arounds, emergency situations and other instances where the proficiencies could be observed. Following guidance from Klein et al. (1989) Critical Decision Method and Flanagan's (1954) Critical Incident Technique, questions were designed as open-ended probes to spark dialogue to better understand how

pilots think and make decisions. Confidentiality of data and anonymity of participants was ensured.

Interview Data Collection Guidance

Interviews with crews began as post-flight conversations during which observers asked questions (Appendix F) to better understand how the crew thinks and adapts. LIT observers were coached by their research intern in basic cognitive interviewing techniques[1] such as asking "how" as opposed to "why," using non-confrontational prompts such as "walk me through your thought process" as opposed to "why did you do that," and simple techniques for increasing accuracy of the interviewee's memory recall surrounding a decision.

In an effort to be sensitive to the word "interview" as potentially confrontational, the LIT group was careful to avoid the word and instead referred to these as "conversations," "learning sessions," and "informal debriefings". In addition to post-flight conversations, observers at the Charlotte, North Carolina and Fort Worth, Texas training centers conducted "Shop Talk" interviews with pilots who had arrived early for their recurrent training; these sessions were usually conducted via convenience sampling in the training centers' cafeterias.

Recording these conversations was discussed as a means to optimize efficiency and interviewer engagement while minimizing interviewer recall error and inadvertent analysis or bias during transcription from handwritten notes to typed reports. One LIT observer asked several of his interviewees if they would mind being recorded for the above reasons, with the assurance of confidentiality and anonymity, and each indicated their hearty consent and support of recording. After transcribing the notes from the learning session, the observer destroyed the recording to ensure that privacy concerns were met. Due to data privacy concerns regarding an off-site, contracted service proposed for transcription of these recordings, no automated transcriptions were made.

Data Analysis

Inter-Coder Reliability

Because this type of data analysis is susceptible to the introduction of data coding and categorization errors, in August 2019, the observer team underwent an inter-coder reliability (ICR) exercise to gauge the validity and reproducibility of their data collection methods. Standardization amongst the three observers was necessary in order to develop a confidence factor for the data that was to be presented. The exercise consisted of two parts: 1) each observer coding one of their peer's observations solely based on their peer's description of each data entry, and 2) each observer coding prose narratives of two flights that none of them had observed. These two arms of the ICR facilitated simple agreement matrices and original selection coding, respectively. The agreement matrix analysis showed that all three observers

[1] See Fisher & Geiselman (1992), Klein (2001), Madans et al. (2011), Dominguez et al. (2016), and others.

agreed 56% of the time while coding potentials, and two of the three agreed on the potential 95% of the time. When all three observers agreed on the coding of a potential, they agreed 53% of the time on the proficiency as well. The team was encouraged by these results, following the analysis with discussions of why each observer coded the data as they did.

Between August and December 2019, the LIT group initiated two additional agreement-matrix ICRs as well as several proficiency language reviews. A deep dive into the first 100 flight observations is planned for Phase 4 (Figure D.1., Appendix D), during which any outlying, infrequently used, or poorly worded proficiencies will be reworked or discarded.

Analysis

Preliminary data analysis began concurrently with preliminary observations, thus facilitating the rapid prototyping of the LIT DCT. Early analysis efforts focused on streamlining data collection itself as well as formatting the data collection for maximum analysis capability in the future.

Data analysis of the first nine months of observations is encouraging: experienced AA pilots, AA senior leadership, and aviation experts agree that the emerging patterns within LIT data are logical and reflect their lived experiences as flight crew members.

This report deliberately excludes a robust explanation of results from these observations for several reasons, most notably that the iterative changes to our data collection strategy required re-coding several times, thus statistically diminishing the internal validity of the data regardless of our diligence during re-coding as well as our efforts to improve inter-coder reliability. Following a robust data review during Phase 4, we believe these concerns will be addressed and future observations will contribute to an increasingly reliable data stream.

LIT Observers

Selection

As a result of their extensive experience with gathering data in a narrative format, LOSA observers were recruited to join the team and participate in LIT data collection. While the first three observers were hand-selected from within the LOSA program, the LIT group now hires new observers via applications from current line pilots, review of the pilot's record with AA, his or her resume and cover letter, recommendations from senior colleagues, and a multi-step interview process. The new hiring approach reflects the intent to add new team members who are not entrenched in the compliance-focused mindset and TEM lens that are necessary for effective LOSA observations. LIT sought recruits directly from the line pilot cadre to bring fresh perspective and an open mindset to this new safety program. Additionally, the team believed that the learning curve to successfully viewing safety through a more appreciative lens may be less steep for new observers not previously trained in LOSA methodology. This hypothesis is supported anecdotally by the LIT group's most recently hired observers.

Training

The first two LIT observers trained the third didactically via explanation and discussion of LIT's mission, safety concepts, and strategies for data collection. The third LIT observer was then mentored by the first two on several observation write-ups until the new observer felt competent enough to perform solo observations.

The first formal training of new LIT observers occurred with the onboarding of the fourth and fifth observers. Training included a review of the program's inception and development, introduction to LIT model and terminology of Safety-II, observation and jumpseat protocol, observation schedule and Federal Aviation Regulation (FAR) Part 117 compliance (flight, duty, and rest regulations), and practice with the LIT DCT. Trust was stressed as a central tenet of observations: flight crew participation is always voluntary, confidentiality is assured at all times, and anonymity is preserved. These attributes of the crew-observer relationship are familiar to AA's pilots due to the longstanding and well-received continuous LOSA program. The team recently announced plans to add two new observers by the end of 2020. Training will follow the same methodology noted above with improvements based on feedback from the newest observers.

Implementation

Observations and interviews have continued without interruption for nearly ten months, garnering support and interest from AA's team members vertically and horizontally throughout the organization. The team completed its first 100 observations and 10 interviews (post-flight and Shop Talk sessions) in early 2020. Data analysis results will be the basis of a forthcoming academic paper planned for release in 2021 or 2022.

Value

A primary aim of the LIT program is to increase organizational knowledge about work as it is done on the flightdeck, with an eye towards how pilots think about safety. With robust data collection, LIT anticipates being able to translate patterns in observed potentials and proficiencies into opportunities for pilots to increase their clarity and ability to communicate their mental models. LIT believes that building adaptive capacity among pilot teams is possible by designing opportunities to foster and manage potentials for resilient performance. At this time, these opportunities lie with training, informal and formal discussions at various levels of the organization and exploring process change.

Dissemination

Pilot Training

Early brainstorming revealed the value of using LIT data to share these new safety concepts with AA's pilots. Examples of resilient performance, case scenarios observed during LIT rides, and insights from LIT "Shop Talk" conversations were identified. Recurrent human factors and quarterly distance learning are also targeted as future platforms to expand LIT principles.

Captain Leadership Training

Two Federal Aviation Administration (FAA) Advisory Circulars (AC) are currently in draft form which will outline guidance for air carriers to develop and implement two training programs:

1. Leadership and Command Training for Pilots in Command, which presents guidelines for developing and implementing leadership and command training for pilots in command (PIC).
2. Air Carrier Pilot Mentoring, which presents guidelines for developing and implementing mentoring training for PIC. This draft AC also presents guidelines for implementing a Pilot Professional Development Committee (PPDC) to develop, administer, and oversee a formal pilot mentoring program.

AA currently conducts a three-day Captain Upgrade Leadership training program. In order to comply with the above two ACs, AA will revise this program by incorporating LIT data. The LIT model provides a clear curriculum outline to meet the objectives of both mentoring and leadership / command training.

Shop Talk questions, including those relating to captain leadership, can be found in Appendix F.

Formal and Informal Discussions

Part of the LIT group's organizational charge is to inspire AA's team members to think differently about work and about the safety of their work. After LIT observations commenced in the spring of 2019, news of the program has spread by word-of-mouth throughout the pilot corps. Pilots engage eagerly with observers in the vast majority of LIT rides, with the remainder reporting being pleasantly surprised after receiving more information and experiencing a LIT ride for the first time. Acknowledging that organizational culture is universally difficult to change, the LIT group and AA's leadership are encouraged by the relative ease of adoption of this program by the pilot group.

Safety Preflight is AA's monthly internal flight safety magazine. LIT was invited to contribute to the magazine under a new section for Safety-II. The first article appeared in the February 2019 issue which served as an accessible introduction to Safety-I and Safety-II, as well as the initial efforts to extract examples of resilient behavior from within LOSA narratives. In May 2019, the first official LIT article was published which explained the concepts of Safety-II and the early language construct. The Learn potential was explained in an August 2019 article, and Plan was

explained in the January 2020 edition. Future follow up articles are planned on a quarterly basis to include sharing examples of some of the best practices observed during line operations.

Additionally, several presentations internal to AA were given in August and September of 2019. These outlined the early work of LIT and provided some examples of how the data may be effectively used.

LIT also presented at and is invited to present at the following professional gatherings:

- 1st International Workshop on Safety-II in Practice with Erik Hollnagel, St. Petersburg, Florida, February 2019
- 2nd International Workshop on Safety-II in Practice with Erik Hollnagel, Lisbon, Portugal, September 2019
- IATA Issue Review Meeting (IRM), Luxembourg City, Luxembourg, September 2019
- 2019 Aviation Safety Infoshare, Seattle, Washington, October 2019
- AA SMS Industry Forum, Dallas, Texas, March 2020 (canceled due to COVID-19)
- Safety-II in Practice with Erik Hollnagel, Edinburgh, Scotland, October 2020

Potential for Process Change

Through the success of LIT's post-flight interviews and Shop Talk sessions, much insight has been gleaned from pilots of all experience levels and in both the captain and first officer roles. A common theme throughout the interview responses was a sense that a semi-structured conversation between the PF and PM would be beneficial to knowledge discovery and sharing, sensemaking (individual and joint), and collegiality between roles. Since AA does not currently formalize a post-flight debrief as other commercial airlines are known to do, there is an opportunity to, at minimum, offer support and direction to pilots who wish to engage in a professional, performance-reflective conversation either pre- or post-flight.

Below is a sample of the kinds of questions asked of pilots by LIT observers.

> *Do crews ever discuss with each other past events they have learned from? Do they brief how they plan to handle the same event now? How do they implement these lessons learned?*
>
> *Talk about debrief / learning culture. Do you have any feedback on how to improve the learning culture at AA?*
>
> *How would you feel about adding a debrief function to discuss any issues that come up during a flight?*
>
> *How would you create time and space for debriefs during everyday line operations?*

As their name reflects, the LIT group believes that the Learn potential is of critical importance. With the expected retirement of senior pilots over the next decade, harnessing opportunities to learn from these vastly experienced professionals is a timely endeavor. Ideally, AA can turn these lessons learned into valuable teaching tools for the anticipated influx of new talent. LIT seeks to answer questions of where and how learning takes place on the flightdeck and how it can be facilitated in a light, spontaneous manner, without tedious formalization.

Towards Organizational Integration

The LIT program is approaching completion of the first step towards demonstrating value to the organization: connecting a dataset from which statistical analysis of coded data can achieve statistical and practical significance. The team continues to identify meaningful patterns within the data, though vigorous data review is needed before it is shared externally.

Conclusion

American Airlines' Flight Safety and LIT Leadership group have endeavored down an aggressive and meaningful journey into Safety-II foundations to learn more about pilot performance, system complexities, and safety system design in large, modern, global, commercial airline operations. The journey has not been simple or straightforward; the purpose of documenting these efforts to date is for others to gain insight into the successes as well as lessons learned. All indications are that senior leadership at AA will officially adopt and formalize LIT as a Safety-II data stream and long-term contributor to AA's SMS process within the next fiscal year. This adoption will be a monumental success for the development and evolution of the LIT effort at AA. The primary aim of LIT remains to learn and share expertise leveraged by individuals, their interactions, and the overall system, towards the ultimate goal of improving safety and efficiency during daily work on the flightdeck.

LIT leadership and core members are encouraged by preliminary analysis results of data from the original 100 observations collected throughout 2019 and early 2020. The connections, linkages and demonstration of the shared mental model concept by outstanding AA flight crews is clearly evident and quantifiable through a newly developed language of Potentials and Proficiencies. AA's LIT members developed this new language upon recommendation from Dr. Erik Hollnagel in early discussions on the program development planning. The learning and introspection that occurred during the language development phase of the current process was extremely valuable to the team members and to AA as a whole. Applying the lessons learned and insight to the complex system that is modern worldwide airline operations is the next challenge.

AA's LIT Leadership team and senior management envision great promise in the introduction of this new and enlightening data stream. The opportunities to share hard-earned lessons from more experienced aviators to new-hire pilots over the next few years are exciting and even paradigm-shifting for traditional training and Human Factor scenarios. The level of training and indoctrination that is required at most U.S.-based modern airlines is daunting, and this new knowledge and practical approach to accomplishing work is key to improving safety and subsequently reap the benefits of a better and more supportive system within which to operate aircraft.

The data currently being collected and analyzed by AA's LIT program is ground-breaking and is already providing enhanced knowledge and insight to facilitate AA's transition to the next level of safety. Continued analysis of this critical data stream is necessary to fully understand and facilitate the potentials for resilient performance among modern flight crews in their own domain.

Appendix A. Evolution of LIT Model: Potentials

Table A1. Original LIT Model, May 2019.

RAG Capability*	**Capability Definition***	**AA v1.0 Potential**	**AA v1.0 Definition**	**AA v1.0 Tagline**	**Rationale**
Respond	Knowing what to do, being capable of doing it	Respond	Effectively react to normal triggers, alarms, threats and anomalies	Act given current condition SLOW THINGS DOWN	Mindset of TEM
Monitor	Knowing what to look for	Monitor	Proactively watch for normal triggers, alarms, threats and anomalies	Watching now STAY ENGAGED	Daily work of a pilot
Anticipate	Finding out and knowing what to expect	Anticipate	What could happen? What ifs	Thinking in future THREAT FORWARD- TALK	Resonates with newly adopted Threat-Forward Briefing
Learn	Knowing what has happened	Learn	Active process of improving future performance. When I was last here X happened, and this time will do Y.	What will I do/ change next time? SHARE EXPERIENCE	Continuous quality improvement mindset as well as personal experience
N/A	N/A	Leadership	Professional and builds a team effectively	Professional	Extrapolated from Check Airmen interviews and LOSA Observer data as well as personal experience
N/A	N/A	Communication	Proactive and open environment. CA sets the tone at start of sequence	Open and Proactive	Extrapolated from Check Airmen interviews and LOSA Observer data as well as personal experience

*Hollnagel, 2015.

Table A2. LIT Model Evolution.

v1.0 Potential May 2019	**v2.0 Potential June 2019**	**Rationale for Change**	**v3.0 Potential September 2019**	**Rationale for Change**	**v4.0 Potential October 2019**	**Rationale for Change**
Respond Effectively react to normal triggers, alarms, threats and anomalies *Act given current condition* *SLOW THINGS DOWN*	Adapt Effectively react to normal triggers, alarms, threats and anomalies. Recognize disturbances / pressures to the plan as they arise. Evaluate, respond, and intervene to minimize impact of the disturbance or redirect to positive outcome. *Act given current condition* *SEMPER GUMBY*	Respond implies reactivity. Adapt more accurately describes pilot performance.	Adapt Effectively react to normal triggers, alarms, threats and anomalies. Recognize disturbances / pressures to the plan as they arise. Evaluate, respond, and intervene to minimize impact of the disturbance or redirect to positive outcome. *Act given current condition* *SEMPER GUMBY*	No change	Adapt Effectively react to normal triggers, alarms, threats and anomalies. Recognize disturbances / pressures to the plan as they arise. Evaluate, respond, and intervene to minimize impact of the disturbance or redirect to positive outcome.	Updated graphic, no change to language Removed “tagline” for professional audience

v1.0 Potential May 2019	v2.0 Potential June 2019	Rationale for Change	v3.0 Potential September 2019	Rationale for Change	v4.0 Potential October 2019	Rationale for Change
Monitor Proactively watch for normal triggers, alarms, threats and anomalies *Watching now* *STAY ENGAGED*	Coordinate Proactively build the team and establish a shared mental model. Utilize all available resources, both internal and external. The response to the altered plan with other team members. Ensure the crew has shared a mental model for getting the plan back on track or normalized as quickly as possible. Continue until the plan has stabilized. *Get the team on the same page* *STAY ENGAGED*	Monitor joined Communicate to become Coordinate.	Coordinate Proactively build the team and establish a shared mental model. Utilize all available resources, both internal and external. The response to the altered plan with other team members. Ensure the crew has shared a mental model for getting the plan back on track or normalized as quickly as possible. Continue until the plan has stabilized. *Get the team on the same page* *STAY ENGAGED*	No change	Coordinate Proactively build the team and establish a shared mental model. Utilize all available resources, both internal and external. The response to the altered plan with other team members. Ensure the crew has shared a mental model for getting the plan back on track or normalized as quickly as possible. Continue until the plan has stabilized.	Updated graphic, no change to language Removed “tagline” for professional audience
Anticipate What could happen? What ifs *Thinking in future* *THREAT-FORWARD TALK*	Anticipate What could happen? What ifs Create, discuss, initiate and monitor in action for disturbances. Proactively act to keep it on track. *Thinking in future* *THREAT-FORWARD TALK*	Expanded language for clarity.	Plan What could happen? What ifs *Thinking in future* *THREAT-FORWARD TALK*	Planning more fully encapsulates pilots’ work and mission	Plan What could happen? What ifs	Updated graphic, no change to language Removed “tagline” for professional audience

v1.0 Potential May 2019	**v2.0 Potential June 2019**	**Rationale for Change**	**v3.0 Potential September 2019**	**Rationale for Change**	**v4.0 Potential October 2019**	**Rationale for Change**
Learn Active process of improving future performance. When I was last here X happened, and this time will do Y. *What will I do / change next time?* *SHARE EXPERIENCE*	Learn Active process of improving future performance. When I was last here X happened, and this time will do Y. Reflect on outcome of the disturbance / pressure for future planning. Review materials / flight documents / previous lessons learned before making the next plan. *What will I do / change next time?* *SHARE EXPERIENCE*	Expanded language for clarity.	Learn Active process of improving future performance. When I was last here X happened, and this time will do Y. Reflect on outcome of the disturbance / pressure for future planning. Review materials / flight documents / previous lessons learned before making the next plan. *What will I do / change next time?* *SHARE EXPERIENCE*	No change	Learn Active process of improving future performance. When I was last here X happened, and this time will do Y. Reflect on outcome of the disturbance / pressure for future planning. Review materials / flight documents / previous lessons learned before making the next plan.	Updated graphic, no change to language Removed “tagline” for professional audience
Leadership Professional and builds a team effectively	Leadership / Professionalism Professional and builds a team effectively	No change	*Leadership* *Professional and builds a team effectively*	*Foundational, not a Potential*	*Leadership* *Professional and builds a team effectively*	*Updated graphic, no change to language*
Communicate Proactive and open environment. CA sets the tone at start of sequence	N/A	Communicate joined Monitor to become Coordinate	*Communicate* *Proactive and open environment. CA sets the tone at start of sequence*	*Foundational, not a Potential*	*Communicate* *Proactive and open environment. CA sets the tone at start of sequence*	*Updated graphic, no change to language*

Appendix B. Evolution of LIT Model: Proficiencies and Qualifiers

Table B1. Proficiencies.

Learn	Apply what was previously learned Demonstrates a positive interest in acquiring knowledge and improving Used some sort of debrief to discuss what went well or could have been handled differently Verbalize what was previously learned Other
Coordinate	Ask ATC for clearance verification or request relief of restriction Ask other crew member for input or assistance Briefs or gives new info / update to other member or adds info to build SA Effective teamwork, delegate and divide tasks (Divide and Conquer) Monitor automation, PM or PF deliberately references FMA or other aircraft system PM or PF reviews, verifies and cross-checks other's actions deliberately Re-centers crew to SOP adherence when deviation observed Update other pilot of change to plan to build shared mental model, ask if unsure Used Jeppesen charts or other information to monitor route and follow along Other
Adapt	Address unanticipated new pressure Adjust communication method or pauses based on the other pilot's workload Change automation level / mode / programming for changing condition Delay task until more appropriate time Heightened awareness or focus before non-standard or complex task (MEL, revised ATC clearance, runway or approach change) PF or PM intervention for unwanted condition Pilot assertive in addressing change in task loading (color coding language, heads up, etc.) PM initiates action to decrease PF workload before being asked Slow down pace or stop. Push back on external stimulus or create more time. Other
Plan	Conducts a thorough briefing Develops "what if" scenarios and plans for contingencies Discuss expected actions or plan beforehand (taxi route, clearance, STAR, approach, runway change, TPS, tailwinds, 10-7 info) Establish countermeasures to pressures, enhance future SA (reminders, secondary flight plan, fixes) Gather information from internal or external sources (ATC, EFB resources, etc.) Prioritizes and schedules tasks States expectation for flight with other crew members Other

Table B2. Archived proficiencies.

Leadership	Acknowledge and thank crew members for efforts CA adjusts to experience level of crew CA empowered FO to make decisions regarding flight CA empowered the FO to speak up and created a more candid environment. CA levels authority gradient to enhance open comms CA recognized and complimented FO CA sets positive and open communication tone Change duties to adapt to workload or environment / situation Conducts a thorough flight attendant briefing Deals with adversity or stress in a courteous and respectful manner Delegate where appropriate Enforces sterile cockpit Keeps crew and / or external stakeholders updated as plan or conditions change Keeps entire crew and dispatch informed of changes to plan and schedule Professionally explains operational philosophy and goals during initial introduction to other crew member Provides tools for crew members to accomplish tasks Shows enthusiasm at being a leader and staying on top of the situation Solicits inputs from other crew members States expectation crew will not be rushed and slows things down when pace begins to overwhelm the crew States expectation for sterile cockpit Stop interruptions to flightdeck duties by closing door, stopping FAs, pre- briefing no interruptions to briefs or checklists Takes responsibility for mentoring and professionally developing other crew members Talks to passengers frequently and clearly to inform and update Uses EFB or other tools to enhance crew members' SA (FAs). Professional cabin crew brief
Communication	Ask for clarification on item Ask for info or prior experience from other crew member if unsure Conducts a thorough flight attendant briefing Ensure all pilots have the same shared mental model Gives update or new info to group outside flightdeck (FAs, Maint or Dispatch) Keeps crew and / or external stakeholders updated as plan or conditions change Pilot assertive in addressing concern area or status (color coded language, heads up, etc.) Tell other pilot the plan to build shared mental model Work to build rapport with soft people skills. Demonstrates empathy, respect and tolerance for other people

Table B3. Qualifiers.

Phase of Flight	Crew report to door closing Pushback Taxi out to runway Takeoff and clean up Climb to TOC Cruise TOD to FAF (STAR) Approach and Landing Taxi in and Park
Pressure	Aircraft Mechanical Airport ATC Automation Cabin (Flight Attendants or Passenger) Dispatch or Paperwork Environment (air or ground traffic, terrain) Ground or Ramp Maintenance Ops Pressure (Gate agent, CS, operational changes) Weather Impact (Gusty winds, tailwind, convective, turbulence)
Time	Pressure did not impact crew's task loading and prioritization Pressure did impact crew's task loading and prioritization

Appendix C. Knowledge Elicitation

Table C1. Summary Responses from Check Airmen and LOSA Observers.

Question	**Summary Responses**
What are the best Pilot monitoring behaviors and actions you have observed other than those outlined in SOPs?	PM follows along closely via FMS / charts / CAMI to “fly” along with PF Assertive backup that is spoken. Always engaged. Speaks up to ask PF what the plan is if unsure. Anticipate threats and ATC needs before being asked by PF.
How do crews best anticipate what could happen before departure, enroute and before arrival?	Leverage Experience. Use engaged threat forward briefing. Verbalize What ifs. Constantly collecting info and processing with understanding of cause and effect relationships
If high performing crews communicate more effectively than others, what makes their communication more effective? What do they do best?	Open communication. CA sets the tone at the start. Encourages assertiveness and creates an environment where speaking up is not seen as criticizing nor second guessing pilot. Rapport is built. PF tells plan and thinks out loud so PM knows when something is not going according to plan and can intervene.
How do crews deal with feeling rushed and compressed for time? How do they slow things down or other positive behaviors when task loading increases?	Create more time by stopping or slowing down. Use color coding language. Delegate. CA sets tone to bring everyone back into green. Be aware of task loading of other pilot.
What barriers have you seen regularly employed to prevent distractions and interruptions? How do crews deal with them?	Tell external influence to wait. Use nonverbal communication. Create space and time. Delegate or delay duties.
Do crews ever discuss with each other past events they have learned from How do they implement these lessons learned?	Opportunity to improve in this area but those who do show learned behaviors talk about previous experiences during briefings or when asked by other pilots.

Appendix D. Figures

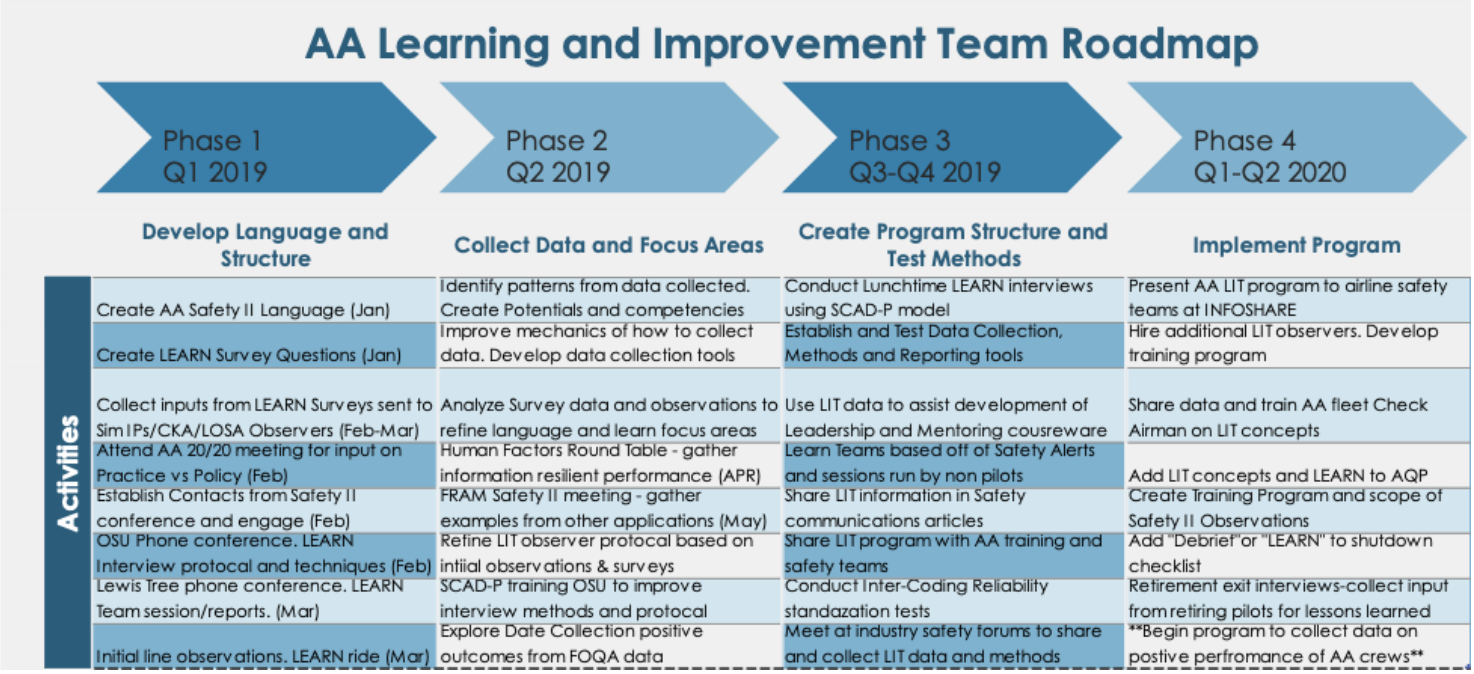

Figure D1. AA's LIT Program Design and Implementation Schedule.

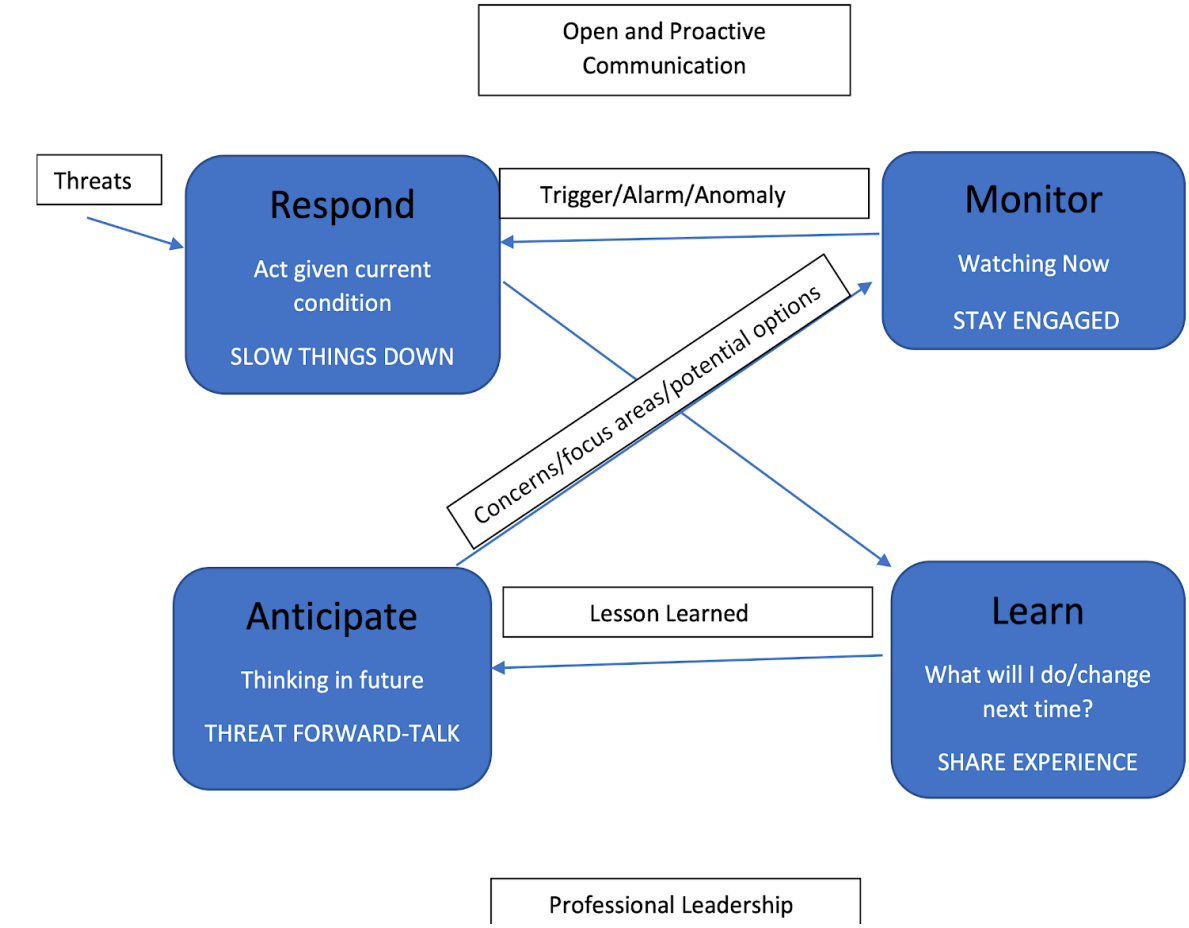

Figure D2. AA's LIT Model, Version 1.0, May 2019.

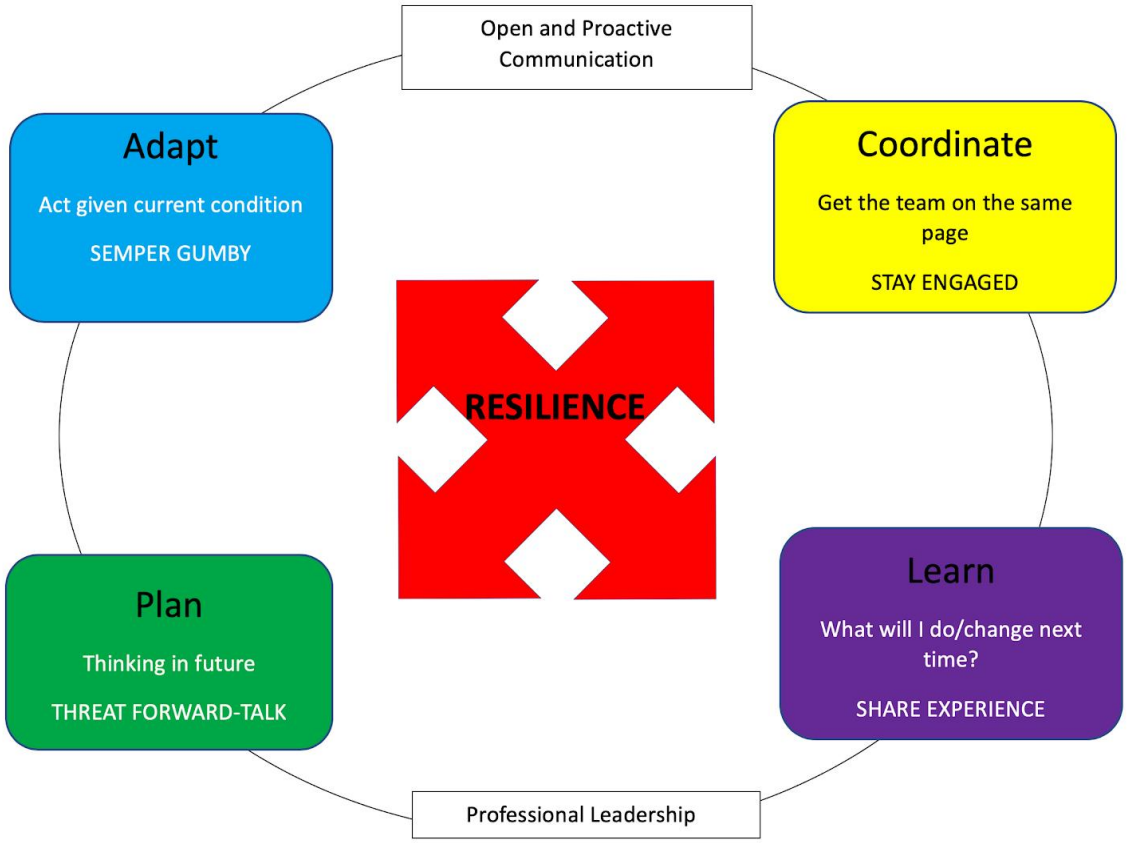

Figure D3. AA's LIT Model, Version 2.0. June 2019.

Figure D4. AA's LIT Model, Version 3.0, September 2019.

Figure D5. LIT Model, Version 4.0, October 2019.

Appendix E. LIT Data Collection Tools

Table E1. LIT DCT Evolution.

Version	Month	Collection of Data	Data Set	Proactive Formatting of DCT
0	March	Format facilitated natural thought progression of observer	Narrative, setup and description of start of sequence, phase of flight in which behavior was observed	Formatting not considered.
1.0	April	Short narrative blocks	Guidance to consider potentials: respond, monitor, anticipate, learn, leadership, communicate	Microsoft Excel for ease of data analysis
2.0	May	Listed interview questions	Standardized interview questions	
3.0	June	Drop-down menus of phase of flight, potentials, and proficiencies	Collect flight specifics and environmental information	
4.0	June		New potentials: anticipate, monitor, respond, learn	
5.0	June		New potentials: adapt, coordinate, plan, learn Removed leadership, communication as potentials New proficiencies per potential Radar plot for subjective assessment of potentials Added pressures and pressure score Added outcome score based on linkage complexity	

Version	Month	Collection of Data	Data Set	Proactive Formatting of DCT
6.0	July	Alphabetized lists Hid extracted-data tabs Time and Outcome levels changed to be more intuitive. E.g. 0 = time not affected; 2 = 2 potentials used.	Added Automation to Pressures Deleted N/A options Pressure score (4 options) changed to Time Affected (yes / no) Outcome score descriptions modified Changed “competency” to “proficiency” in this version	Hid cell outlines as an alternative to merging cells Asked observers to update tab name with observation number Created extracted-data tab for easier manual database input Background calculation added to extracted-data tabs to prevent “0” from being recorded as “null”
7.0	August	Significant interface redesign		Set print areas Changed file naming convention
8.0	October	Combined preflight phases into crew report to door closing Combined approach and landing phases into terminal phase	Added experience input similar to LDCT Removed outcome score Added reference to proficiency label for linkage.	Added proficiency label column to aid with data extraction
9.0	November		Linkages changed to Parent-Child Proficiencies revised after data review	DataID reflects option for Parent-Child linkage
9.1	December	Added notes for data entry assistance	Minor changes to Coordinate proficiencies	

Appendix F. LIT "Shop Talk" Cognitive Interview Questions

Table F1. All forms of question probes, by question category. Not all questions were asked during each conversation.

Category	**Question**
Adaptations	Can you tell me about an event or incident you had where you had to deviate or adapt from a policy in some way? Was there ever a situation at work where you had to adapt, or things didn't go according to plan? Tell me about a time you experienced a situation that required significant adaptation, or you could not follow the textbook procedure to respond to the situation? Can you recall a situation you and your first officer experienced that required significant adaptation? Can you tell me about an event you had that required severe adaptation or your response was not textbook?
Captain	What is the hardest part about being a CA? What was most challenging for you about becoming a captain? As you approach retirement, is there any advice you or knowledge from your experience as a captain that you can pass on to new captains? Knowing what you know now, is there anything you would have liked to have been told when you first upgraded? Can you tell me about some of your favorite captains and what you enjoyed or liked about them? Can you tell me about some captains that were poor leaders or ineffective? What should new CAs know? How should we adapt training for them? What, if any, leadership training would you like to see at the company? What kind of company leadership training would be helpful to you when you upgrade? What content would you like to be included in leadership training? What could the company do better to prepare you for captain?
First Officer	What's the hardest part about being an FO? Are there certain things your captains do that bother you or reduce overall TEM? Are there certain things your captains do that increase or are beneficial to TEM?
High functioning crew	What makes a high functioning crew? Why are some crews higher functioning than others?

Category	Question
Debrief	How would you feel about adding a DEBRIEF function to discuss any issues that come up during a flight? How would you feel about adding a post-flight debrief to discuss issues that come up during a flight? How do you learn from your previous flights or outcomes? Have you engaged in any form of debrief with the crew? How did it go? Do you have any suggestions on how to implement that within our pilot group? How to create time and space for that during a typical line flight? Understanding the potential negative aspect and cultural shift of adding a de-brief, or some mechanism for a discussion, how would you incorporate that into everyday work? How would you create time and space for debriefs during everyday line operations? How would you create time to conduct a debrief? If we were to add a debrief during the flight, how would you find time to have it?
Learning culture	How do you think the company can improve the learning culture? How would you characterize the learning culture at AA?
Operations	Have you had any go arounds lately? How do you deal with the clean ramp policy? How do crews deal with feeling rushed and compressed for time? How do you deal with feeling rushed or pressed for time?

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Glossary

Adapt	Effectively react to normal triggers, alarms, threats and anomalies. Recognize disturbances / pressures to the plan as they arise. Evaluate, respond, and intervene to minimize impact of the disturbance or redirect to positive outcome. (AA's LIT v4.0)
Anticipate	Finding out and knowing what to expect (Hollnagel, 2015); What could happen? What-ifs (AA's LIT v1.0)
Coordinate	Proactively build the team and establish a shared mental model. Utilize all available resources, both internal and external. The response to the altered plan with other team members. Ensure the crew has shared a mental model for getting the plan back on track or normalized as quickly as possible. Continue until the plan has stabilized. (AA's LIT v4.0)
Error	Any practice that deviates from a written policy or procedure, or deviates from the crew's intention. (AA's Flight Operations Manual, 2019)
Learn	Knowing what has happened (Hollnagel, 2015); Active process of improving future performance. When I was last here X happened, and this time will do Y. Reflect on the outcome of the disturbance / pressure for future planning. Review materials / flight documents / previous lessons learned before making the next plan (AA's LIT v4.0)
Monitor	Knowing what to look for (Hollnagel, 2015); Proactively watch for normal triggers, alarms, threats and anomalies (AA's LIT v1.0)
Plan	Create, discuss, initiate and monitor in action for disturbances. Proactively act to keep it on track.
Potential	Positive, recurring capability to adjust performance by responding to changes disturbances and opportunities under actual operating conditions in a flexible and timely manner
Pressure	Influences or pressures originating outside of the flightdeck that impact the crew's task loading and prioritization
Proficiency	Specific function whose presence serves as a proxy measure to resilient capability (potential)

Resilience Engineering	Engineering what a system needs for its continued existence and growth, hence addresses both safety and core business processes (productivity, quality, and effectiveness). (Hollnagel, 2015); Resilience Engineering as a field, seeks to 1) discover operational principles which allow complex systems to adapt to the often-unforeseen conditions of changing worlds; 2) design, develop and operate systems according to those principles.
Resilient performance	The ability to sustain required operations under both expected and unexpected conditions by adjusting its functioning prior to, during, or following events such as changes, disturbances, and opportunities (Hollnagel, 2015)
Respond	Knowing what to do, being capable of doing it (Hollnagel, 2015); Effectively react to normal triggers, alarms, threats and anomalies (AA's LIT v1.0)
Safety-I	Protection and prevention against harmful events (Hollnagel, 2015)
Safety-II	Enhancing the system's ability to function in a way that produces acceptable outcomes (Hollnagel, 2015)
Threat	An event, external to a pilot or flight crew, which increases operational complexity and occurs outside the influence of the flight crew. (AA's Flight Operations Manual, 2019)

Authors

Christine Jefferies, The Ohio State University
Bogomir Glavan, American Airlines
Nicholas Peterson, American Airlines
James Kwasny, American Airlines
Guy Mouton, American Airlines
Gregory Scheidel, American Airlines
E. Asher Balkin, The Ohio State University