Federal Aviation Administration

DOT/FAA/AM-23/14
Aviation Safety
Office of Aerospace Medicine
Washington, DC 20591

Validation of the FAA Maintenance Safety Culture Assessment and Improvement Tool (FAA M-SCAIT)

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May 2023

This project is funded by the FAA NextGen Human Factors Division (ANG-C1) in support of the FAA Office of Aviation Safety (AVS), Flight Standards Service (AFS-300).

Deliverable Notes: This is a final report regarding the development and initial validation of a novel safety culture assessment tool for the civil aviation maintenance workforce. Recommendations for improving the survey content and future directions are included.
Product Application: To be used as preliminary evidence for future development and as a reference to support the release of the novel FAA M-SCAIT safety culture assessment tool.

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Technical Documentation Page

1. Report No. DOT/FAA/AM-23/14	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Validation of the FAA Maintenance Safety Culture Assessment and Improvement Tool (FAA M-SCAIT)		5. Report Date May 2023 6. Performing Organization Code
7. Author(s) Key, K.[1], Hu, P.[2], Choi, I.[2], Schroeder, D.[2]		8. Performing Organization Report No.
9. Performing Organization Name and Address Federal Aviation Administration Civil Aerospace Medical Institute, AAM-500 Oklahoma City, OK 73169		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Office of Aerospace Medicine Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591		13. Type of Report and Period Covered
15. Supplementary Notes		

16. Abstract

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17. Key Words Safety Culture, Safety Climate, Aviation Maintenance, Job Demands-Resources Model, JD-R, Snapshot Survey, M-SCAIT	18. Distribution Statement Unlimited		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 82	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Acknowledgments

This research was completed with funding from the Federal Aviation Administration (FAA) NextGen Human Factors Division (ANG-C1) in support of FAA Flight Standards Service (AFS) Aircraft Maintenance Division (AFS-300) and Aircraft Certification Service (AIR) Policy and Innovation Division (AIR-600). We would like to thank our FAA Program Manager Dr. Chuck Perala and technical sponsor Dr. Bill Johnson.

We are indebted to Dr. Gerard Fogarty for providing the Snapshot Survey instrument for our use. We thank the research staff members for their assistance with instrument development, data collection, analysis, and reporting - Theodore (Ted) Mofle, Blake Nesmith, Justin Durham, Hailey Grippen, Suzanne Thomas, and Janine King. We especially would like to thank the organizations who took part in testing the new survey - both the leadership who helped to shape, implement, and understand the survey, and the employees who provided their experiences and feedback.

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List of Abbreviations

Abbreviation	Definition
A&P	Airframe and Powerplant
AMT	Aviation Maintenance Technician
CAMI	Civil Aerospace Medical Institute
CFI	Comparative Fit Index
FAA	Federal Aviation Administration
FRM	Fatigue Risk Management
GA	General Aviation
GHQ-12	General Health Questionnaire
IRB	Institutional Review Board
IAEA	International Atomic Energy Agency
JD-R	Job Demands-Resources
M-LOSA	Maintenance – Line Operations Safety Assessment
M-SCAIT	Maintenance Safety Culture Assessment and Improvement Toolkit
MES	Maintenance Environment Survey
MOSS	Maintenance Operations Safety Survey
NAQ-R	Negative Acts Questionnaire-Revised
POC	Point of Contact
QR	Quick Response
RMSEA	Root Mean Square Error of Approximation
SEM	Structural Equation Modeling
SMS	Safety Management System
SPI	Safety Performance Indicator
SUS	System Usability Scale
TLI	Tucker–Lewis Index

Abstract

Safety culture has ranked as a top human factors challenge for aviation maintenance, but there is a paucity of actionable guidance for properly assessing and improving safety culture. The Federal Aviation Administration (FAA) has funded a research requirement to support the growth of a positive safety culture in aviation maintenance through the development and validation of a new safety culture toolkit, titled *FAA Maintenance Safety Culture Assessment and Improvement Toolkit (FAA M-SCAIT).* The toolkit consists of a customizable survey, scoring guidance, and a roadmap for safety culture improvement. Data from 987 valid participants across five participating organizations provided initial evidence of the *FAA M-SCAIT's* content and criterion validity. The data fit the Job Demands-Resources (JD-R) Model, whereby Individual Outcomes (e.g., health, satisfaction/morale) partially mediate the relationship between safety culture and Organizational Outcomes (e.g., errors, non-compliances). Based on the observed limitations and the lessons learned during validation testing, recommendations are provided to help improve usability and future utilization of the toolkit. This validation report enhances the understanding of safety culture in aviation contexts, which in turn supports development and refinement of safety culture assessments (including future updates to *FAA M-SCAIT*) for use across the aviation industry.

Keywords: Safety Culture, Safety Climate, Aviation Maintenance, Job Demands-Resources Model, JD-R, Snapshot Survey, M-SCAIT

Introduction

The Case for Safety Culture Promotion

One of the latest regulatory initiatives to make aviation safer is Safety Management Systems (SMSs), a top-down organization-wide systematic approach to managing safety through established policies, procedures, and practices (14 C.F.R. § 5; Advisory Circular 120-92B, 2015; Order 8000.369C, 2020; International Civil Aviation Organization, 2013).[1] One of the major components of SMS is the promotion of a positive safety culture (Safety Promotion), a critical concept underlying safety management (Office of Inspector General, 2020).The Federal Aviation Administration (FAA) defines safety culture as the shared values, actions, and behaviors that demonstrate a commitment to safety over competing goals and demands.

As the FAA continues to promote widespread implementation and expansion of SMS, it is imperative to attend to safety culture promotion, as the effectiveness of SMS critically hinges on having a positive safety culture. A positive safety culture not only helps the SMS work more effectively (French & Steel, 2017; Piers et al., 2009), but also provides the basis for continuously improving the SMS itself (Akselsson et al., 2009). Safety culture has been rigorously investigated since the 1980s, and there are over 1,000 published studies (Van Nunen et al., 2018) demonstrating the benefits of assessing and improving safety culture (Zohar, 1980, 2010, 2014).[2] These benefits of safety culture are stable across safety-critical industries and countries, attesting to their robustness (Zohar, 2014).

Despite the benefits of a positive safety culture, there is limited actionable guidance for properly assessing and improving safety culture. There are various assessment tools available, but many are proprietary, costly, require outside support to analyze and interpret the data, or do not provide assistance in identifying areas and methods for continuous improvement. There is a gap between the recognized need for organizations to improve safety culture and the limited availability of affordable and easy-to-use assessment tools. To bridge this gap, the FAA has prioritized a research requirement and allocated funding to support a growing positive safety culture, specifically in the area of aviation maintenance.

There is a mounting body of evidence that safety culture represents an important opportunity for improvement in aviation maintenance. In brief:

[1] The European Union Aviation Safety Agency has incorporated the ICAO SMS in their requirements (see Piers et al., 2009).

[2] Some of the scientific literature refers instead to safety climate, a snapshot in time, which is viewed by most researchers as one part of the larger construct of safety culture, the more enduring values in an organization. These academic and definitional differences between safety culture and climate are of limited importance from a practical perspective, and the aviation industry itself uses the two terms interchangeably. This report will use the term safety culture because the effectiveness of SMS will depend on the enduring value of safety in aviation organizations. See Griffin and Curcuruto (2016), Key et al. (2023), and Zohar (2014).

- Evidence for low psychological safety in the aviation workplace was identified by Patankar et al. (2002), who found that up to 30% of mechanics reported not trusting their supervisors to prioritize safety.
- Research has found that aviation maintenance technicians (AMTs) tend to have less positive perceptions of safety culture than other aviation professionals, including quality control personnel, engineers/managers, and planners (Atak & Kingma, 2011; McDonald et al., 2000).
- Personnel turnover, workplace pressure, and locational culture differences exacerbate the difficulty with establishing and maintaining a positive safety culture (Avers et al., 2011).
- Safety culture has been ranked as *the top* human factors challenge for aviation maintenance in an industry survey (Johnson, 2014) and a "critical foundation that must be in place before many of the human factors challenges can be addressed effectively…" (Avers et al., 2011, p. vii).

In support of FAA efforts to promote a positive safety culture in aviation maintenance, the research requirement is divided into several phases. The first phase was a review of the literature on safety culture assessment (Key et al., 2023). The second phase (the current report) is to develop and validate new assessment tools to help support safety culture, specifically in the area of aviation maintenance.

Purpose

The FAA has allocated resources to the development and validation of a new safety culture toolkit tentatively titled *FAA Maintenance Safety Culture Assessment and Improvement Toolkit (FAA M-SCAIT).* This toolkit is designed specifically for assessing safety culture among maintenance operators (i.e., product and service providers). The toolkit consists of a customizable survey (Appendix A), scoring guidance, and a roadmap for utilizing the survey results and other data to improve safety culture (Appendix B). Pending validation, the *M-SCAIT* will be released for free-use to support the continued improvement and implementation of SMS. It is expected that adoption of this new toolkit will help organizations overcome the current human factors challenges associated with safety culture assessment and promotion.

Background of the *FAA M-SCAIT*

This toolkit was developed over time by leveraging insights from both the scientific literature (see Key et al., 2023) and regulatory frameworks for safety culture management (e.g., Safety Management International Collaborative Group, 2019). Various methods available for safety culture assessment include surveys, focus group/interviews, accident/incident reviews, behavioral observations, and safety audits (Cole et al., 2013; International Atomic Energy Agency [IAEA], 2020; National Academies of Science, Engineering, and Medicine, 2016). Surveys have a good balance of tradeoffs between efficiency, resource demands, and bottom-line insights into safety culture (IAEA, 2020; Wiegmann et al., 2002).

Key et al. (2023) determined that the most common assessments used in aviation organizations to assess safety culture were anonymous self-report questionnaires that asked employees to express their perceptions, attitudes, beliefs, and values regarding workplace issues. One limitation of these questionnaires, as Key et al. found, is that they often described and compared the current safety culture perceptions across groups without considering the influence of the broader organizational context on safety culture. Employee commitment to safety is but one small part of the safety culture, so failing to measure the broader organizational context would result in an incomplete snapshot of the culture. Furthermore, a complete snapshot of the culture requires measuring the antecedents of safety culture (which supports the ability to determine what areas are in need of improvement) and the outcomes (which supports the ability to determine criterion validity of the instrument).

According to critical reviews of the literature, the early safety culture studies seldom assessed validity (Guldenmund, 2000; O'Connor et al., 2011). More recently, researchers have included measures of safety-related outcomes to assess criterion validity. Given the difficulty of obtaining objective data, these measures tended to be self-reported errors, non-compliances, and injury rates (Fogarty, 2004, 2005; Fogarty & Buikstra, 2008; Fogarty et al., 2018; Hodges & Gardner, 2014; Tokarski, 2021; Uhuegoh, 2017). Additional effort is needed to identify objective safety performance (SPIs).

Karanikas critically reviewed (organizational) SPIs and determined that the most often used ones are (2016, p. 7):

- Average duration needed to close out issues from accident/incident reports, audits safety meetings, employee reports.
- Number of safety reports.
- Number of safety meetings and attendees.
- Cost of safety events, accidents/incidents.

Although these indicators provide some insight to the safety performance of an organization, there are limitations. First, these indicators do not assess the *quality* of safety performance, so it is difficult to determine the effectiveness of SMS beyond mere compliance. They are mostly lagging indicators that focus on failures rather than the mechanisms underlying them. Furthermore, the relationships within or between indicators and outcomes are interdependent, so predictive modeling (i.e., leading indicators) can be complicated. Finally, the SPIs may be weighted in terms of their contribution to safety; however, this requires input from safety experts who may not agree about the weight of each indicator. In summary, there is no standard for measuring, tracking, or interpreting SPIs. Karanikas concluded with recommendations for the development of an effective safety performance evaluation scheme (2016); subsequent work developed metrics of safety performance and safety climate (De Boer et al., 2020), though further validation efforts are needed.

These gaps identified in the literature present an opportunity for improvement: safety culture questionnaires can be strengthened by including a more extensive set of individual, workplace, and organizational-level questions. Key et al. (2023) identified features of successful safety culture assessments (Table 1).

Table 1

Features of Successful Safety Culture Assessments Identified by Key et al. (2023)

Feature	Explanation
Respondent Demographics	Respondent demographics are needed because there can be multiple sub-cultures within an organization.
Antecedent Contributors	Antecedents contribute to and mediate/moderate the impact of the safety culture (e.g., physical and psychological health, satisfaction, morale), not just items that refer directly to safety issues.
Organizational Outcomes / Performance Indicators	These include safety behaviors, motivation, compliance and violations, errors, and accident/incident/injury data.
Job-specific Factors	In aviation maintenance, these include work pressure (i.e., the inevitable conflict between productivity and safety), usability and availability of maintenance manuals/technical procedures, equipment, tools, and parts.

In short, assessment efforts need to consider the individual, the work team, the workplace resources and demands, the nature of the task, and the organizational context, because all are involved in shaping safety culture within the organization. Only after considering all of these factors can meaningful interventions can be designed, validated, and implemented into the work environment.

The *FAA M-SCAIT* was closely adapted from a validated survey instrument, which has been applied successfully to measurement of safety climate for around 20 years (Cooper & Fogarty, 2015, 2022; Fogarty, 2004, 2005; Fogarty & Buikstra, 2008; Fogarty et al., 2018). Initially, Fogarty (2003, 2004, 2005) designed the Maintenance Environment Survey (MES) to explore how morale, psychological health, and turnover intentions relate to self-reported errors in the maintenance environment. Fogarty's questionnaires have been used extensively in the military aviation environment (see Alnoaimi, 2015; Fogarty & Buikstra, 2008; Fogarty & Shaw, 2010; Fogarty et al., 1999, 2001; Hodges & Gardner, 2014; Kleidon, 2010) and in the U.S. civil aviation environment (Uhuegoh, 2017).

The MES was refined over time to bring it in line with the Job Demands-Resources (JD-R) model (Bakker & Demerouti, 2007; Demerouti et al., 2001), and was renamed the Snapshot Survey (Cooper & Fogarty, 2015, 2022; Cooper et al., 2018). Notably, the Snapshot Survey is

one of few valid instruments for measuring safety culture that is based on a theoretical model (c.f., Cooper, 2018). The Snapshot Survey assesses the broader organizational context that influences individuals' safety behaviors, unlike existing questionnaires that focus only on employees' attitudes towards and commitment to safety. It has been validated as a safety climate assessment instrument for use by the Australian military, with groups including those assigned to aircraft maintenance (Fogarty et al., 2018) and to explosive ordnance (Fogarty et al., 2017). Safety climate, as measured by the Snapshot Survey, is a strong predictor of safety-related outcomes, explaining around 50% of the variance in errors and non-compliances (Fogarty et al., 2018).

According to the JD-R model, the organization provides employees with Job Resources and places Job Demands on the employee, which interact to influence both culture and employee behaviors (Bakker & Demerouti, 2007). In particular, these Job Resources and Job Demands shape Employee Outcomes such as satisfaction and morale, well-being, and motivation to work safely (Demerouti et al., 2019; Nahrgang et al., 2011). If Job Demands exhaust employees' mental and physical resources, health impairment (e.g., burnout, strain, fatigue) may result. Conversely, sufficient Job Resources are likely to result in positive Employee Outcomes such as satisfaction and engagement (i.e., the motivational pathway). In turn, the individuals contribute to the Organizational Outcomes such as errors and non-compliances (Fogarty et al., 2018; Hansez & Chmiel, 2010). These relationships have been well-identified and discussed in multiple meta-analyses (Clarke, 2006, 2009, 2010; Nahrgang et al., 2011) and have been validated as part of a model underpinning safety climate surveys (Fogarty et al., 2018). According to Bakker and Demerouti (2017), the JD-R model has several basic propositions describing how the components of the model interact:

- ***Proposition #1.*** "…All types of job characteristics can be classified in one of two categorizes: job demands and job resources."
- ***Proposition #2.*** "…Job demands and resources instigate two very different processes, namely a health-impairment process and a motivational process."
- ***Proposition #3.*** "Job resources can buffer the impact of job demands on strain."
- ***Proposition #4.*** Job resources particularly influence motivation when job demands are high.
- ***Proposition #5.*** "…Personal resources such as optimism and self-efficacy can play a similar role as job resources."
- ***Proposition #6.*** "…Motivation has a positive impact on job performance, whereas job strain has a negative impact on job performance."
- ***Proposition #7.*** "…employees who are motivated by their work are likely to use job crafting behaviors, which lead to higher levels of job and personal resources and even higher levels of motivation."

- ***Proposition #8.*** "Employees who are strained by their work are likely to show self-undermining behaviors, which lead to higher levels of job demands, and even higher levels of job strain."

The JD-R model has been validated previously using three large military aviation data sets spanning 2014-2016 (Fogarty et al., 2018). Although progress has been made in recent years towards developing a theoretical framework for safety culture, the model needs to be tested across different populations of workers as well as across industries to ensure it is generalizable. This model is theoretically sound but tests of competing models are needed as well. In this way, the current validation effort is an extension of the previous research.

Given the validation evidence and corresponding theoretical framework, the Snapshot Survey was selected as a platform on which to base the *FAA M-SCAIT*. The literature indicates that there are differences in safety culture both within a single industry and across industries, which warrants customization of the survey instrument. Therefore, the FAA research requirement is to develop a safety culture toolkit specifically compatible with aviation maintenance needs (e.g., of product and service providers), and then to ensure the validity of the toolkit before releasing it for public use.

To support the development of the *FAA M-SCAIT*, this report describes the survey content and initial validation testing with five aviation maintenance organizations located in the United States. As with the Snapshot Survey, the *FAA M-SCAIT* covers many important aspects of any safety-critical workplace, including employee and management commitment to safety, safety reporting, workload, workplace pressures, resource allocation, communication, and justness (see Flin et al., 2000; Guldenmund, 2000; IAEA, 2020; International Aviation Transport Association, 2020). Unlike other assessments that provide only high-level aggregated feedback, this survey has the added benefit of supporting comparisons to be made across demographic variables of interest, detect culture silos[3] and work group norms, and identify targeted areas of opportunity for improvement. This level of feedback ensures the survey results are actionable and can be used to affect meaningful change.

Validation Methodology

Overview

The initial validation testing of the *FAA M-SCAIT* was conducted in voluntary partnership with aviation maintenance organizations of various sizes and supporting various operations to ensure generalizability of the survey content to maintenance product and service

[3] See Ensor (1988), who coined the term 'functional silo syndrome' to refer to situations where people across the organization do not share common goals; rather their goals are organized by functional unit, each with their own language and buzzwords. These silos may form as a result of: work group norms, management style, organizational structure, job design/tasks, union relations, and performance standards.

providers. The five participating organizations included a large maintenance and repair operation (Organization #1), an on-demand medical helicopter operation (Organization #2), a military maintenance operation (Organization #3), a small maintenance operation providing civil and military maintenance (Organization #4), and a major air carrier operation (Organization #5). All five organizations are located in the United States and are either regulated under 14 C.F.R. § 121, § 135, and § 145, or are regulated under military regulations (see Participants). Their participation in the validation testing was voluntary and to our knowledge, the FAA does not intend to mandate the use of the *FAA M-SCAIT*.

The survey content was customized for participating organization's operational needs, with two noteworthy aspects:

1. The *FAA M-SCAIT* assesses the same core content from the Snapshot Survey, supplemented with additional topical issues[4] that are relevant to maintenance product and service provider operations (e.g., quality of reporting system, fatigue risk management [FRM]); see *Measures*.
2. Not all topics and items were identical for all participating organizations.

Thus, this initial validation testing included only the constructs that (a) are central to the JD-R model underpinning the Snapshot Survey (Fogarty et al., 2018), (b) were present in the survey for all participating organizations, and (c) were answered by all participants.

Hypotheses

We hypothesize that higher safety culture perceptions will be positively associated with outcomes, based on literature showing the many benefits of safety culture for both Employee[5] (e.g., well-being, satisfaction, morale) and Organizational[6] Outcomes (e.g., performance, errors and non-compliances, accidents). Specifically, we expect to replicate the models of safety culture observed in previous studies (i.e., Fogarty et al., 2017, 2018).

Finally, we expect to replicate group differences in safety culture from previous studies (Zohar, 2000, 2010, 2014). Research has devoted much attention to identifying group-level differences in safety culture perceptions, presumably so interventions can be targeted at the groups with relatively lower safety culture perceptions (Zohar, 2014). This research has shown:

[4] The question sets for each subscale were customized to meet each organization's needs, resulting in each survey having a different number of items.
[5] Clarke (2006, 2010, 2012), Nahrgang et al. (2011).
[6] Fogarty (2004, 2005); Fogarty et al. (2017, 2018); Zohar (1980, 2010, 2014).

- Safety culture perceptions vary by job role, as views about safety culture tend to be more positive coming from management and administrative personnel than from members of the workforce.[7] (RAND, 2013; Singer et al., 2003; Taylor, 2002; Zohar & Luria, 2005).
- Perceptions may also vary among those of the same job role who work for different work units or supervisors, potentially due to differences in leadership characteristics (Fogarty et al., 2016; Zohar, 2000; see also Zohar, 2010, 2014; Zohar & Hoffman, 2012; Zohar & Luria, 2003, 2005).
- Naturally, safety culture/climate also varies *across* organizations, due to differences in factors such as safety policies, regulatory requirements, and the level of risk associated with the tasks (Helmreich, 1999; Isla-Díaz & Díaz-Cabrera, 1997; RAND, 2013; Zohar, 1980).

Participants

Participants were recruited across five maintenance product and service provider organizations:

- *Organization #1* is a Part 145 maintenance and repair operation with several locations across the globe; three locations participated in the survey. Their primary operations are avionics, non-destructive testing, inspection, sheet metal, Airframe and Powerplant (A&P), and paint.
- *Organization #2* is a Part 135 medical helicopter operation performing mission-critical maintenance at several stationary and field locations. Notably, the organization exhibits two unique factors: (a) it engages in on-call operations and (b) it requires frequent employee travel to field locations.
- *Organization #3* is a Part 145 military maintenance operation.
- *Organization #4* is a Part 145 maintenance operation performing both civil and military maintenance. Their primary operations are fabrication, structures, avionics, A&P, inspection, and airworthiness.
- *Organization #5* is a Part 121 major air carrier operation's technical operations department.

The validation data were collected from March 2020 through July 2022 and were staggered across organizations, with each administration of the survey lasting for an average of 2 months per organization. During this time, 1,413 participants were recruited to participate. Of these, 426 were excluded because either they did not consent or they did not complete the survey. Only the remaining 987 complete survey responses were analyzed. Response rates are provided in Table 2.

[7] Though not examined in this study, it is worth noting that in most studies, AMTs have lower safety climate scores than other aviation professions, including quality control personnel, engineers/managers, and planners (Atak & Kingma, 2011; McDonald et al., 2000).

Table 2
Participant Population and Response Rate

	Target Population (*N*)	Sample Size[8] (*n*)	Response Rate (%)
Org #1 (Part 145)	1,400	215	15.4%
Org. #2 (Part 135)	250	71	28.4%
Org. #3 (Military, Part 145)	300	120	40.0%
Org. #4 (Part 145)	300	28	9.3%
Org. #5 (Part 121)	unknown	553	unknown
Total	*N/A*	*987*	*N/A*

Measures

The dimensions and subscales that make up the *FAA M-SCAIT* are described in this section (see Appendix A for a full report). Recommendations for the survey content were obtained from subject matter experts in safety culture assessment who developed the Snapshot Survey (Fogarty, personal communication, 2018). Fogarty's items recommended for inclusion in a maintenance safety culture survey were reworded slightly for civil operations in the United States. The content provided by Fogarty was supplemented with new subscales (i.e., Fatigue and FRM, Reporting System) for the following reasons:

1. Capture the relationships as expressed in the JD-R model (i.e., health impairment pathway; see Fogarty et al., 2017).
2. Increase the number of outcome measures, bolstering the tests for criterion validity of the instrument.
3. Explore topical issues (e.g., FRM, Reporting System) that are relevant for maintenance product and service providers.

It should be noted that the *FAA M-SCAIT* assesses most of the common characteristics of safety culture as identified in reviews of the literature (Cooper, 2016; Flin et al., 2000; Gadd & Collins, 2002; O'Connor et al., 2011), which include: management and supervision; safety systems; risk; work pressure; work procedures and rules; competence (see Cooper, 2018, for definitions). We intentionally omitted the risk characteristic given the wide variability in the implementation of safety management in the aviation maintenance environment (i.e., not all maintenance organizations are currently required to have a formal SMS). However, because fatigue is a well-known hazard in the aviation maintenance environment, we included items assessing the quality of organizational FRM.

Subscales were adapted from Fogarty (personal communication, 2018) unless noted. Three SMEs in safety culture revised the content iteratively, providing feedback that helped to

[8] i.e., complete responses included for data analysis.

ensure that the hypotheses, methods, materials, analyses, and results fit within the corpus of safety culture literature while addressing the needs of aviation safety.

Job Resources

- *Communication* assesses how well employees communicate across the organization.
- *Autonomy* assesses the degree to which employees believe they have freedom to make their own work-related decisions and are trusted to do their job.
- *Training* assesses whether employees receive sufficient work-related training at appropriate intervals.
- *Supervision* assesses the relationship employees have with their supervisors.
- *Management Commitment* assesses employee perceptions of management commitment to ensuring workplace safety.
- *Fatigue Risk Management* assesses how the organization manages fatigue (adapted from a fatigue instrument used currently by the FAA to assess safety culture within flight operations, developed based on subject matter expertise).
- *Just Culture* assesses whether employees feel that they can report mistakes and that workplace mistakes will be treated fairly.
- *Equipment and Tools* assesses the adequacy, availability, and ease of use.
- *Documentation* assesses the adequacy, availability, and ease of use.
- *Report System* assesses the adequacy, availability, and ease of use (adapted from an instrument used by the FAA to assess safety culture within flight operations, developed based on subject matter expertise).

Job Demands

- *Personal Role Overload* assesses the degree to which employees feel they are overtasked at an individual level.
- *Unit Role Overload* assesses the degree to which employees feel they are overtasked at a team level.
- *Workplace Restraints* assesses common challenges that employees face at work (e.g., scheduling, distractions/interruptions, and competing tasks).
- *Co-worker Concerns* assesses how well employees get along with other employees and are able to coordinate across work teams.
- *Safety Concerns* assesses the challenge of managing competing demands of safety and productivity.
- *Bullying* assesses whether employees are experiencing a persistent, unreasonable form of harassment at work (Fogarty, personal communication, 2018; supplemented with additional items from the Negative Acts Questionnaire-Revised [NAQ-R]; Einarsen et al., 2009).

Employee Satisfaction

- *Job Satisfaction and Morale* assesses whether employees are satisfied with their workplace and whether the morale in the workplace is good (Fogarty, personal communication, 2018).
- *Turnover Intentions* assesses employee intent to leave their current organization (Diener et al., 1985; Hom & Griffeth, 1991; Jaros, 1997).

Employee Well-Being

- *Strain and Fatigue* assesses employees' strain and fatigue (adapted from a fatigue instrument used by the FAA to assess safety culture within flight operations, developed based on subject matter expertise).
- *General Health* assesses aspects of employees' recent general health and well-being (General Health Questionnaire [GHQ-12]; Banks et al., 1980).

Organizational Outcomes

- *Willingness to Report* assesses the extent to which an employee is willing to report their own mistakes, and whether reporting of mistakes is encouraged by oneself, management, and fellow employees.
- *Compliance* assesses the extent to which unnecessary risk-taking behavior occurs, and whether there is compliance with policies/procedures.
- *Performance* assesses individual and team-level performance on the job.
- *Errors* assesses the frequency of occurrence for contributing factors to errors made in the last 3 months. Severity of errors was not assessed in the survey.

Additional Survey Content

- *Demographics* includes items such as years of experience; job role; certifications; aircraft focus area; shift, work hours; and travel frequency (customized to participating organizations).
- Level of agreement with *Usability* items (adapted from the System Usability Scale [SUS]; Brooke, 1996).
- Participants were asked to indicate whether they experienced any *Injuries* (Y/N) in the last 12 months. These data are neither analyzed nor reported because the response scales differ from the remaining data.
- Open-ended-text entry fields were included at the end of each subscale, offering participants an opportunity to voice their opinions, to raise concerns, and to share general feedback. Discussion of the open-ended-text responses is beyond the scope of this validation report.

Response Scales

Participants indicated their level of agreement or frequency of occurrence for each survey question item, depending on the question type. Unless otherwise noted in Appendix A, the following Likert scales were used:[9]

- Level of agreement: Strongly Disagree (1), Disagree (2), Slightly Disagree (3), Slightly Agree (4), Agree (5), and Strongly Agree (6).
- Frequency of occurrence: Never (1), Rarely (2), Sometimes (3), Frequently (4), Most of the time (5), and All of the time (6).

A not applicable (N/A) option was provided for job-specific items (e.g., Documentation, Errors), as these items were not expected to be applicable to all survey participants. (e.g., managerial and support roles). The provision of the N/A option makes the survey more inclusive for participants from all demographic roles, but also introduces the potential for insincere responses. To guard against this, one solution would have been to use display logic such that only applicable items are displayed to each participant group. However, this would require expertise in survey administration, therefore limiting the practical use of the survey.

Procedure

Researchers collaborated closely with the organizations to customize the survey content to their operational needs, create promotional materials to advertise the survey, and work out the logistics of survey administration. The survey consisted of approximately 180 items that could be completed in 30-45 minutes, depending on participants' reading pace. The survey was administered using the Qualtrics FedRamp survey platform through an anonymous online link or Quick Response (QR) code distributed to the workforce via email, posted flyers, and e-learning management systems. The link was accessible by any internet-compatible device, including personal devices and shared computers in the work area.

The Point of Contact (POC) within each organization was a mid or senior level leader. The survey was beta-tested first with approximately 10% of the planned sample, then deployed to the full workforce. Data collection was delayed largely due to the COVID-19 pandemic, where restrictions in travel resulted in disruptions to workforce and operational needs for aircraft maintenance and repair. This context should be considered when interpreting the survey results.

These reports are intended to empower management at each organization to evaluate the nature of their safety culture, identify areas in need of improvement, and assess changes arising from improvement efforts.

[9] The Likert scales were 6-point so there was no neutral response option. This was chosen so that participants would be forced to indicate a (even slight) preference favoring one side of the scale.

Data Confidentiality

The survey was reviewed and approved by the FAA Civil Aerospace Medical Institute's (CAMI) Institutional Review Board (IRB), and followed all pertinent ethical principles set forth in the Belmont Report.[10]

The invitation and informed consent identified the survey's confidentiality assurances. Specifically, participants were informed that participation is voluntary; responses are confidential and went directly to a third party FAA research contractor for removal of personally identifiable information, analysis, and reporting; only summary results would be reported; their identity would not be identifiable by management or FAA, and individual responses cannot be linked back to the participant.

To protect confidentiality of the participants, an anonymous online link was provided, and the survey itself did not collect any personally identifiable information. Further, individuals' responses were aggregated for data reporting; only analyses and reports of aggregated data (i.e., where $n \geq 8$) were produced and released to the participating organizations.

To protect confidentiality of the organizations, a third-party FAA research contractor collected survey responses for de-identification, analysis, and reporting. Data from all organizations were aggregated and stored in databases by unique code rather than by name. Only de-identified and aggregated data were included in research reports, presentations/briefings, or released to the FAA.

An executive summary of the survey results was delivered to each participating organization, with the option to request supplemental data reports and/or briefings. These reports were intended to empower management at each organization to evaluate the nature of their safety culture, identify areas in need of improvement, and assess changes arising from improvement efforts.

Scoring

To assist with comprehension, some items had response options ordered from positive to negative, while other items had options ordered from negative to positive (i.e., reverse-wording).[11] To factor in these response options for scoring, the scores with the 'Positive-Negative' direction were standardized by reversing all subscales except for the Errors subscale (i.e., "We are micromanaged" with the frequency scale from 'Never' to 'Most of the time'). All average scores were standardized from a 6-point Likert scale to a 10-point score for ease of interpretation and to allow for direct comparison of the response scores (see Equation 1). Thus, higher values always reflect more positive perceptions of the safety culture regardless of

[10] National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research (1979).
[11] Reverse-worded items (i.e., "We are micromanaged") were included because they (a) can be used to detect insincere responses, (b) can ensure fuller assessment, and (c) can promote comprehension (i.e., reverse wording can be easier to understand than double-negative wording).

meaning of all subscales except for Errors (e.g., higher values in the 'Bullying' subscale reflects a more positive safety culture).

Equation 1
Rescaling Likert Scales for Standardized Scores

$$Standardized\ score\ = \frac{Average\ score - 1}{Maximum\ scale\ score - 1} * 10$$

As noted previously, most questions did not present a 'Not Applicable (N/A)' option; however, job-specific items such as 'Documentation' and 'Errors' did provide an N/A option. The N/A responses were excluded for score averaging.

Analysis

Structural Equation Modeling (SEM) is a combination of multiple regression analysis and factor analysis that determines which observed (indicator) variables comprise each latent factor (Ullman & Bentler, 2013). *Observed* variables factors (e.g., a subscale like Management Commitment) are measured directly, whereas *latent* factors (e.g., survey subscales combined into a higher-order construct) are unobserved, but theoretically represent factors that are constructed based on a set of measured subscales. For example, Job Resources and Job Demands are latent factors, comprised of their sub-scales (see Measures). The loadings of indicator variables onto the latent factors are the correlation coefficients, and the path coefficients between the latent and observed variables are effect sizes, whereby larger coefficients indicate larger effect size.

A generally understood advantage of SEM is that it can test among different hypothesized models and pathways that describe the relationships between factors. Applied here, SEM can be used to determine the extent to which safety climate has a direct effect on the outcome measures, or whether the relationship is mediated or moderated by other variables (as hypothesized).

A good-fitting model is typically indicated by root mean square error of approximation (RMSEA) < .06, Comparative Fit Index (CFI) > .95, and/or Tucker–Lewis Index (TLI) > .95 (Hu & Bentler, 1999). Recently, procedures have changed so that the threshold is more conservative than previously accepted (i.e., CFI > .90; see Hooper et al., 2008). Note that large sample sizes can bias this statistic towards significance even when the model is a good fit to the data (McDonald & Ho, 2002). Caution must be taken to avoid overfitting the data; models that fit 100% of the data in one sample are likely to be neither generalizable nor psychologically plausible (see Cavagnaro et al., 2013; Nihm, 1976). Because the analysis is sensitive to missing data, participants with missing data were excluded ($n_{excluded}$ = 121) such that only complete responses were included in the analysis (n = 866).

Results

The data from all five organizations were aggregated together using an unweighted average. The results are aggregated and reported by subscale to aid in identifying targeted opportunities for safety culture improvement.

Descriptive Statistics

First, we sought to establish trends in the results across all participants in the sample. The question is - *what are the benchmarks or industry trends in safety culture perceptions?* Descriptive statistics assist with scale validation by (a) providing basic information about perceptions among the sampled population, (b) describing the suitability of the scales for the assessed population, and (c) informing the statistical modeling. The descriptive statistics (i.e., mean, median, standard deviation, and skewness) for each measured dimension and subscale are presented in Table 3. The average for all subscales indicated moderately positive safety culture perceptions among the sampled organizations. Table 3 reveals a fair amount of variation (i.e., standard deviation) for many of the subscales. All subscales exhibited negative skew.

Cronbach's alpha (α) is reported to characterize internal consistency or reliability of the subscales. Higher values indicate higher reliability of the subscale. Because the survey content was customized per organization, there were small wording differences across the administrations of *M-SCAIT*. The researchers, who all hold Ph.D. degrees and expertise in safety culture, convened to determine whether the survey items were measuring the same construct despite the small wording differences. A determination was made for each survey item, and Cronbach's alpha calculations included only the items that were measured across all participating organizations.

Table 3
Mean, Median, Standard Deviation, and Skewness by Subscale

Subscale	Mean	Median	Standard Deviation	Skew	Cronbach's Alpha
Job Resources					
1. Communication	6.45	7.20	2.43	-0.67	0.92
2. Autonomy	6.80	7.00	2.22	-0.82	0.83
3. Training	7.26	7.60	1.92	-0.83	0.86
4. Supervision	7.08	7.50	2.16	-0.91	0.92
5. Management Commitment	7.45	8.00	2.23	-1.12	0.94
6. Just Culture	7.14	7.60	2.09	-0.94	0.89
7. Equipment and Tools	7.25	7.67	2.07	-0.97	0.91
8. Documentation	6.73	7.00	1.84	-0.80	0.84
9. Report System	7.46	8.00	1.69	-0.86	0.87
10. Fatigue Risk Management	5.59	5.64	1.81	-0.18	0.81

Job Demands					
11. Workplace Restraints	5.84	6.00	1.61	-0.38	0.67
12. Unit Role Overload	5.92	6.00	2.06	-0.66	0.82
13. Safety Concerns	8.00	8.00	2.21	-1.47	0.85
14. Personal Role Overload	7.93	8.00	1.89	-1.17	0.79
15. Coworker Concerns	5.21	5.33	2.28	-0.20	0.71
16. Bullying	9.04	10.00	1.73	-2.46	N/A*[12]
Employee Outcomes					
17. Job Satisfaction & Morale	7.34	7.60	1.98	-0.83	0.83
18. General Health	7.41	7.64	1.48	-0.62	0.87
19. Strain and Fatigue	7.43	7.60	1.56	-0.82	0.81
20. Turnover Intention	7.22	8.00	2.71	-0.83	0.83
Organizational Outcomes					
21. Willingness to Report	8.00	8.00	1.57	-1.27	0.80
22. Performance	7.35	7.67	1.95	-0.92	0.86
23. Compliance	7.37	7.71	2.05	-0.54	0.88

Table 4 contains the correlation matrix for all measured subscales, which reveals a number of moderate but significant relationships among subscales within each dimension, as would be expected. Further, correlations were stronger within a dimension (e.g., among Job Resources subscales) than across dimensions (e.g., Job Resources subscales correlated with Employee Outcomes subscales). These correlations can be taken as evidence of the content validity for the *FAA M-SCAIT*.

[12] Cronbach's alpha was not calculated because the Bullying subscale consists of a single question.

Table 4

Pearson's Correlation Coefficients across Subscales of Safety Culture

Subscale	Job Resources										Job Demands						Employee Outcomes				Org. Outcomes	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Communication																						
2. Autonomy	.64																					
3. Training	.68	.58																				
4. Supervision	.75	.69	.70																			
5. Management Commitment	.73	.65	.71	.82																		
6. Just Culture	.68	.61	.69	.72	.77																	
7. Equipment & Tools	.63	.55	.62	.61	.67	.69																
8. Documentation	.46	.43	.53	.48	.51	.50	.46															
9. Report System	.49	.49	.50	.51	.52	.60	.51	.51														
10. Fatigue Risk Management	.54	.47	.50	.56	.59	.54	.47	.47	.48													
11. Workplace Restraints	.37	.38	.32	.36	.35	.37	.40	.41	.32	.40												
12. Unit Role Overload	.44	.41	.37	.44	.43	.39	.43	.38	.29	.50	.58											
13. Safety Concerns	.52	.52	.45	.54	.60	.53	.53	.37	.38	.51	.51	.61										
14. Personal Role Overload	.37	.37	.33	.36	.36	.38	.40	.34	.31	.42	.52	.71	.57									
15. Coworker Concerns	.56	.56	.54	.59	.56	.55	.51	.44	.40	.56	.48	.55	.53	.43								
16. Bullying	.37	.44	.36	.40	.39	.38	.34	.24	.32	.32	.31	.35	.43	.37	.39							
17. Job Satisfaction & Morale	.58	.60	.52	.56	.54	.53	.50	.42	.50	.48	.36	.45	.45	.45	.53	.40						
18. General Health	.39	.38	.35	.33	.31	.36	.36	.33	.38	.36	.39	.43	.37	.54	.34	.37	.57					
19. Strain & Fatigue	.40	.35	.35	.38	.36	.40	.41	.38	.32	.46	.43	.56	.46	.62	.44	.39	.50	.58				
20. Turnover Intention	.40	.40	.37	.36	.35	.40	.34	.27	.32	.32	.30	.33	.36	.42	.36	.33	.60	.49	.38			
21. Willingness to Report	.46	.41	.47	.49	.53	.55	.47	.37	.48	.36	.23	.22	.35	.26	.28	.22	.40	.35	.27	.34		
22. Performance	.52	.47	.51	.52	.48	.49	.45	.37	.39	.43	.31	.36	.32	.35	.53	.29	.54	.36	.37	.34	.44	
23. Compliance	.53	.42	.53	.54	.56	.59	.50	.46	.44	.46	.38	.44	.53	.45	.51	.37	.44	.42	.48	.34	.47	.43

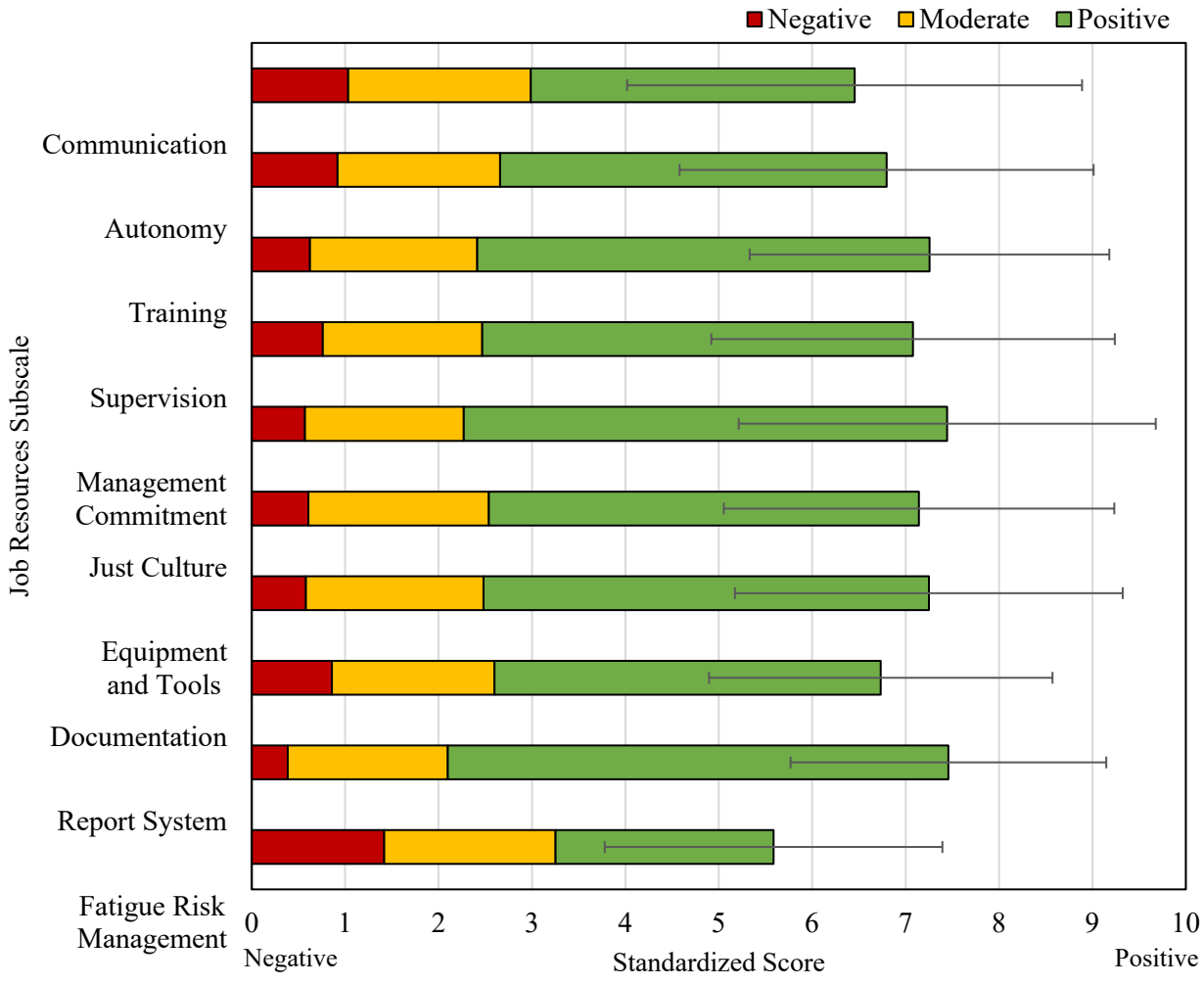
Note. *All correlation coefficients are significant at the .001 level.*

Figure 1 through Figure 4 represent the safety culture perceptions by subscale. These figures mirror the format of the executive summary delivered to each participating organization. Each bar displays the *distribution of responses* (i.e., Negative [red], Moderate [yellow], and Positive [green]). The responses were obtained by combining response options (i.e., highest two options = Positive; middle two options = Moderate; lowest two options = Negative). The numbers along the x-axis represent the standardized score, averaged across respondents. In Figure 1 through Figure 4, higher averages and higher percentages of Positive scores (green bars) reflect a more positive perception of safety culture. The black error bar represents standard deviation (i.e., variance) in perceptions.

Management can use the distribution of responses to identify areas in need of improvement with more immediate attention allocated to the subscales having a higher percentage of Negative responses. For the purposes of this report, an average score less than 7 (out of 10) indicates room for improvement.

Figure 1

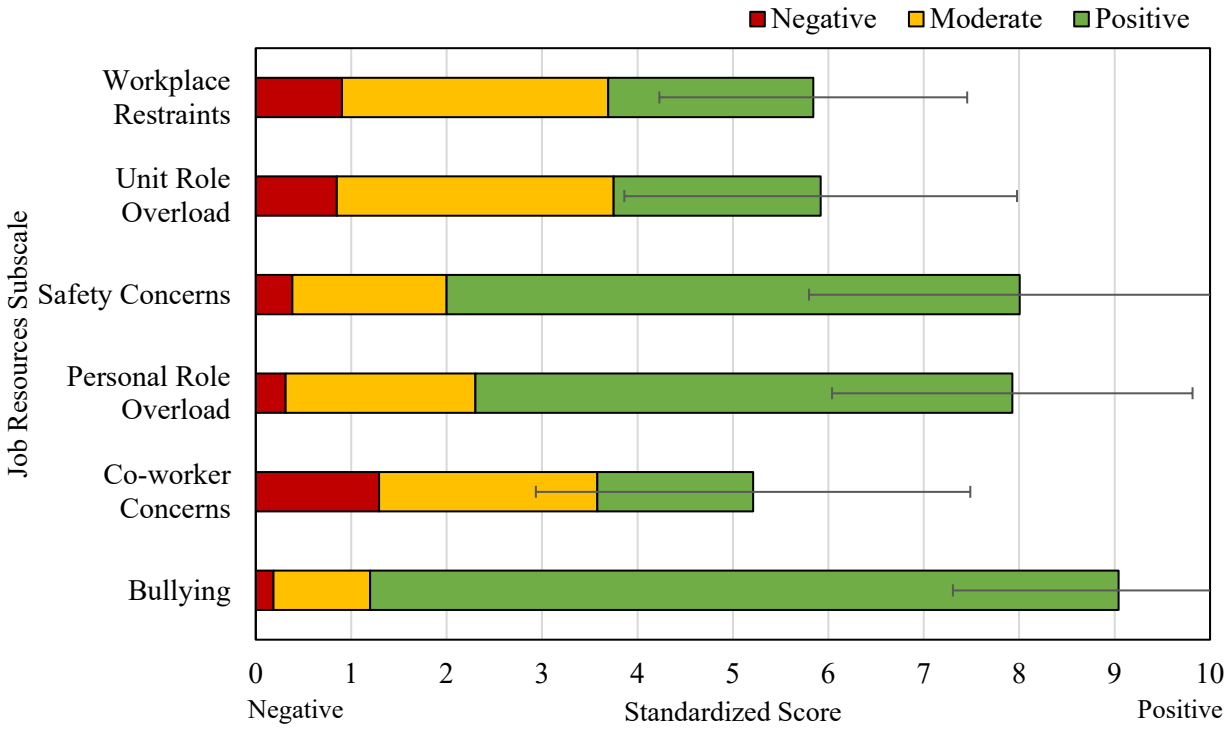
Job Resources Subscales, All Responses across Organizations



Job Resources scores were mostly positive, although Communication, Autonomy, Documentation, and FRM subscale scores suggest room for improvement (Figure 1). Job Demands had more variance across subscales, higher percentage of negative responses, and suggested more room for improvement (Figure 2). Specific Job Demands subscales of concern are Workplace Restraints (e.g., scheduling practices), Unit Role Overload, and Co-worker Concerns (e.g., equitable allocation of work tasks). Note the discrepant findings between role overload at the Unit and Personal levels, with more overload reported at the Unit level.

Figure 2

Job Demands Subscales, All Responses across Organizations



Scores were mostly positive across all subscales in terms of Employee Outcomes (Figure 3). For Organizational Outcomes (Figure 4), scores were mostly positive, especially in Willingness to Report.

Figure 3

Employee Outcomes Subscales, All Responses across Organizations

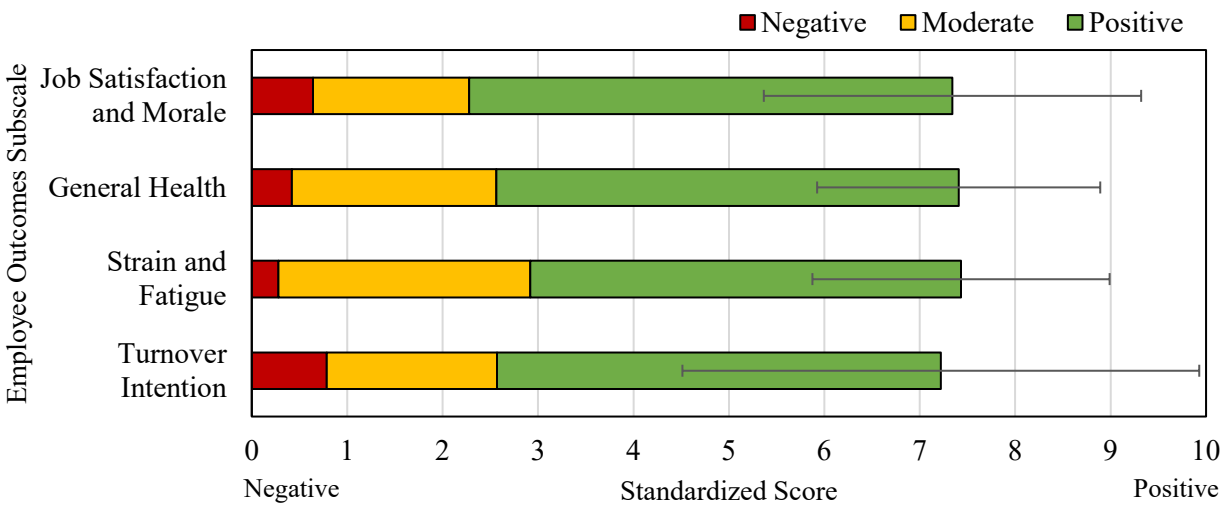
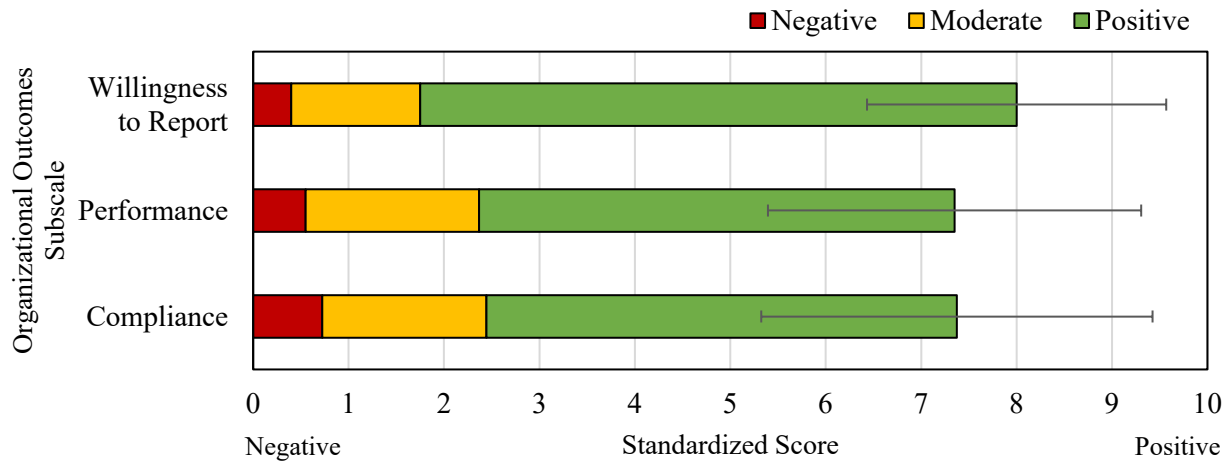


Figure 4

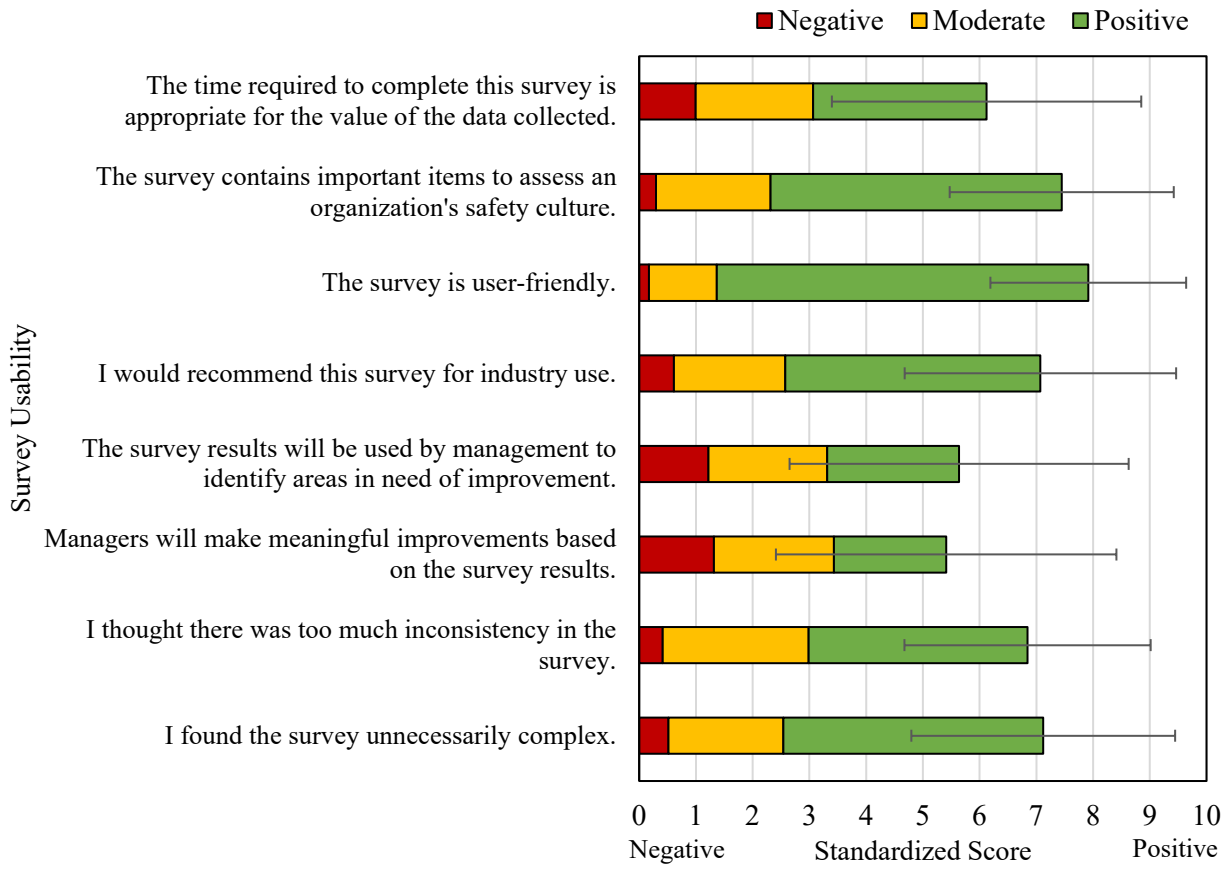
Organizational Outcomes Subscales, All Responses across Organizations



The Survey Usability scores (Figure 5) were mostly positive regarding the survey content, complexity, user-friendliness, and application to maintenance product and service providers, attesting to the content (face) validity of the *FAA M-SCAIT*. However, participants felt that the survey length could be reduced. Further, participants did not feel strongly that management would use the results to affect meaningful change, though that is beyond the scope of this research.

Figure 5

Survey Usability, All Responses across Organizations



Demographic Differences

Next, we determined whether there were any differences in perceptions of safety culture across demographic variables of interest. The question is - *do participants of different demographics (e.g., job roles, operation type) have different perceptions of safety culture?* Respondents were classified as Maintainers, Front-line Leadership, or Upper Management based on self-identification during the survey (see Appendix C. Supplemental Results, Job Role). Based on findings in the literature (see Key et al., 2023), demographic differences in safety culture perceptions were expected.

Predicted differences were tested using a two-way ANOVA examining the effects of job role (i.e., Maintainers vs. Front-line Leadership vs. Upper Management) and operation type (i.e., Part 121 vs. Part 135 vs. Part 145[13] vs. Military) on perceptions of safety culture (defined as Job Resources + Job Demands[14,15]). A squared transform was applied to safety culture in order to

[13] i.e., organizations #1 and #3.
[14] See Fogarty et al. (2017).
[15] Four participants who did not respond in Job Demands subscale were excluded.

satisfy the homogeneity of variances assumption [$F(11, 971) = 1.687$, $p = .071$]. Although the normality assumption was violated [$D(983) = .064$, $p < .001$], ANOVA test results are robust against departure from the normality assumption with large datasets such as this (see Glass, 1972; Harwell et al., 1992; Schmider et al., 2010).

The omnibus ANOVA found a significant interaction effect [$F(6, 971) = 9.866$, $p < .001$], so only simple effects were evaluated for each job role and operation type (See Table 5 and Table 6 for pairwise comparisons results for simple effects; see Figure 6 and Figure 7 for line charts of the results). Additional comparisons between demographic variables are provided in Appendix C.

The results revealed differences by job role (see Job Role in Appendix C). In Part 121, Maintainers expressed lower perceptions of safety culture than Front-line Leadership ($p < .001$) and Upper Management ($p < .001$). In Part 145, Upper Management expressed higher perceptions of safety culture than Maintainers ($p = .047$) and Front-line Leadership ($p = .002$). All other simple effects by job role were not significant.

Table 5

Pairwise Comparisons of Safety Culture Perceptions, by Demographic (Comparing Job Role)

						95% Confidence Interval[a]	
Operation Type	**Job Roles Compared**		**Mean Diff.**	**Std. Error**	**Sig.[a]**	**Lower Bound**	**Upper Bound**
Part 121	Maintainers	Front-line Leadership	-68.172*	7.420	0.000	-85.966	-50.378
		Upper Management	-63.474*	8.065	0.000	-82.814	-44.135
	Front-line Leadership	Upper Management	4.697	9.523	1.000	-18.139	27.534
Part 135	Maintainers	Front-line Leadership	9.239	21.082	1.000	-41.319	59.796
		Upper Management	-11.424	30.157	1.000	-83.743	60.896
	Front-line Leadership	Upper Management	-20.662	34.094	1.000	-102.425	61.100
Part 145	Maintainers	Front-line Leadership	5.159	11.615	1.000	-22.696	33.014
		Upper Management	-30.918*	12.753	0.047	-61.502	-0.333
	Front-line Leadership	Upper Management	-36.077*	10.478	0.002	-61.205	-10.949
Military	Maintainers	Front-line Leadership	23.424	13.044	0.219	-7.857	54.704

	Upper Management	21.649	32.637	1.000	-56.620	99.917
Front-line Leadership	Upper Management	-1.775	32.524	1.000	-79.772	76.222

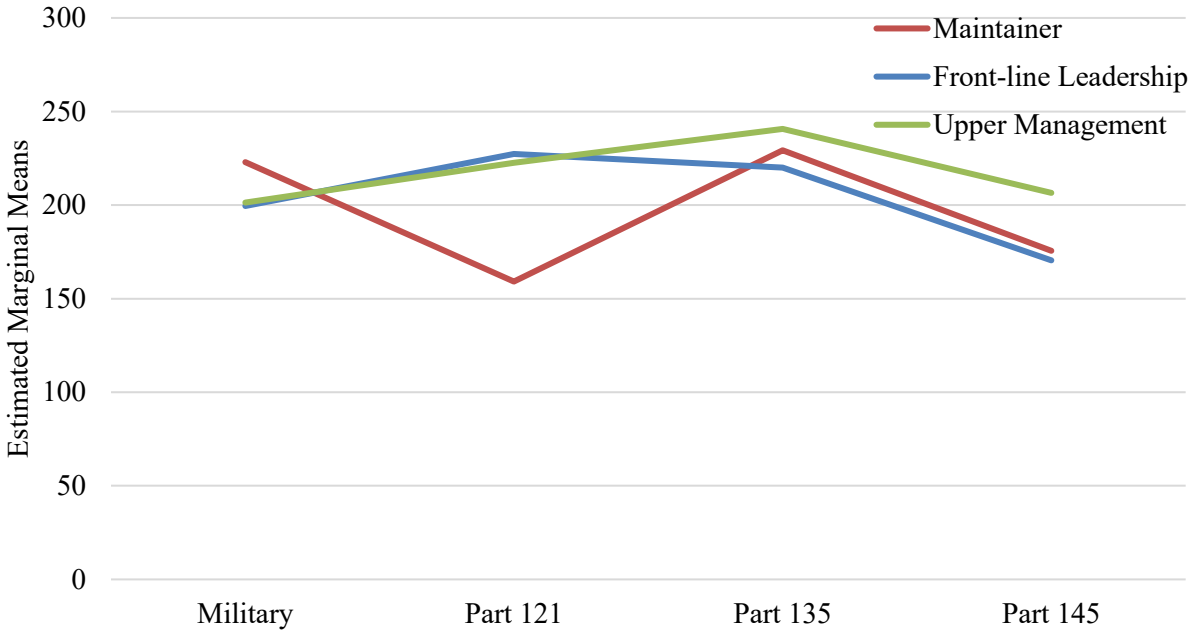
** The mean difference is significant at the .05 level.*

[a] Adjustment for multiple comparisons: Bonferroni.

***Note**. All reported values in the table are squared from the original values.*

Figure 6

Estimated Marginal Means of Safety Culture Score, by Operation Type (Comparing Job Role)



There were also significant differences across operation type. For example, there were significantly higher perceptions in Military and Part 135 operations among Maintainers, compared to Part 121 and 145 (all $p < .003$). In addition, Front-line Leadership within Part 121 had more-positive perceptions of safety culture than those within Part 145 ($p < .001$). All other simple effects by job role were not significant (see Table 6 for further comparisons).

Table 6

Pairwise Comparisons of Perceptions of Safety Culture, Comparing Operation Type

						95% Confidence Interval[a]	
Job Role	**Operation Types Compared**		**Mean Difference**	**Std. Error**	**Sig.[a]**	**Lower Bound**	**Upper Bound**
Maintainer	Military	Part 121	63.849*	10.172	0.000	36.957	90.741
		Part 135	-6.279	13.583	1.000	-42.188	29.630
		Part 145	47.361*	13.515	0.003	11.632	83.091
	Part 121	Part 135	-70.128*	10.509	0.000	-97.910	-42.346

		Part 145	-16.488	10.421	0.684	-44.037	11.062
	Part 135	Part 145	53.640*	13.770	0.001	17.237	90.044
Front-line Leadership	Military	Part 121	-27.746	11.033	0.072	-56.913	1.420
		Part 135	-20.464	20.739	1.000	-75.290	34.362
		Part 145	29.097	11.063	0.052	-0.151	58.345
	Part 121	Part 135	7.282	19.725	1.000	-44.864	59.429
		Part 145	56.843*	9.021	0.000	32.995	80.691
	Part 135	Part 145	49.561	19.742	0.073	-2.631	101.753
Upper Management	Military	Part 121	-21.274	32.043	1.000	-105.986	63.438
		Part 135	-39.351	42.310	1.000	-151.205	72.502
		Part 145	-5.205	32.329	1.000	-90.674	80.264
	Part 121	Part 135	-18.077	29.394	1.000	-95.786	59.632
		Part 145	16.069	10.913	0.847	-12.781	44.920
	Part 135	Part 145	34.146	29.706	1.000	-44.387	112.680

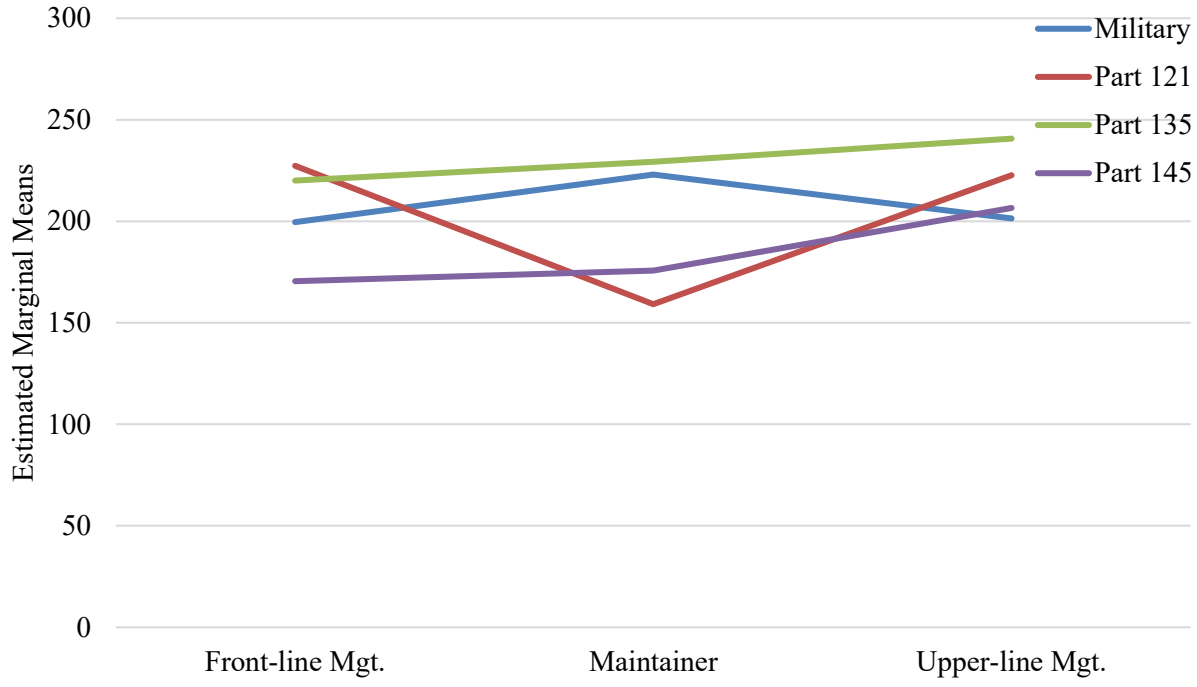
** The mean difference is significant at the .05 level.*

[a] Adjustment for multiple comparisons: Bonferroni.

Note. *All reported values in the table are squared from the original values.*

Figure 7

Estimated Marginal Means of Safety Culture Score, by Job Role (Comparing Operation Type)



Structural Equation Modeling

Next, we sought to establish the criterion validity of the *FAA M-SCAIT*. The question is *can safety culture scores predict the outcomes of interest?* Per Fogarty et al. (2018) and the JD-R model, we hypothesized that safety culture would significantly predict Employee and Organizational Outcomes, and that the relationship between safety culture and Organizational Outcomes would be (at least partially) mediated through Employee Outcomes. We tested this hypothesis by applying SEM.

Typically, researchers test among competing SEM models because SEM, like any other predictive modeling technique, cannot be used to confirm a hypothesis; it can only be used to rule out ill-fitting models and assist in choosing the best-fitting model. Importantly, researchers should compare among different SEM models that are psychologically plausible and have theoretical backing to guard against selecting a data-driven model purely based on maximum fit.[16] Thus, we tested among three psychologically plausible models derived from previous studies (i.e., Fogarty et al., 2017, 2018). In each case, the analysis examined the effect of Job Demands and Job Resources on Organizational Outcomes, indirectly through Employee Outcomes.

Model 1 was a replication of Fogarty et al.'s most-recently published model (2018), which explored the impact of Job Demands and Job Resources on Employee Outcomes including Well-being and Satisfaction and combined Organizational Outcomes (Errors, Compliance, Willingness to Report, and Unit Performance). Note that Fogarty et al. (2018) found support for this theoretical model using regression analyses, but could not successfully test the SEM model itself. When replicating Fogarty et al. using *FAA M-SCAIT* validation data, the model failed to converge when we included the Job Demands → Employee Satisfaction pathway and the Job Resources → Employee Well-being indirect pathway to predict Organizational Outcomes, indicating a potential misspecification or over-fitting of the model. When those pathways were removed from the model, Model 1 was able to fit the data, although with room for improvement (see Table 7, below, for a comparison of fit indices across models).

Model 2 was a hybrid between the theoretically framed analysis by Fogarty et al. (2018) and the more data-driven models of the past (i.e., Fogarty et al., 2017). Specifically:

(1) Model 2 expanded upon Model 1, the JD-R model (Fogarty et al., 2018) to include the new *FAA M-SCAIT* subscales (i.e., Job Resources: Fatigue Risk Management, Reporting System, Documentation, and Just Culture).
(2) Model 2 was based on Fogarty et al. (2017, p. 67), who found different pathways for errors and compliance. Thus, Model 2 predicted Organizational Outcomes separately, mimicking Fogarty et al. (2017).

[16] Rodgers and Rowe (2002); see also Roberts and Pashler (2000, 2002). See Hintzman (1991) for a discussion on how the requirements for statistical models also apply to mathematical models.

Model 2 displayed better goodness-of-fit compared to Model 1. However, the Employee Well-being mediator had a significant negative regression coefficient with Willingness to Report, which appeared to be psychologically implausible. To investigate this relationship and to enhance the model fitness, we proposed Model 3. Model 3 explored whether the model fitness could be improved by removing subscales with (relatively) low inter-rater reliability (Cronbach's alpha) below 0.8.[17] Thus, Model 3 replicated Model 2 but without the Co-worker Concerns (α = .71) and Workplace Restraints (α = .67) subscales. Further, Model 3 only included Willingness to Report items that focused on employee willingness to report and not management response to reported concerns.

To compare these competing models, the lavaan package was used (version 0.6-9 in R version 3.6.1; Rosseel, 2012, 2021). We reported standardized solutions for ease of interpretation. Model 3 was the best fitting model, so only its results are described in full (See Table 7 for fit indices for all three models).

Table 7
Fit Indices for SEM Models

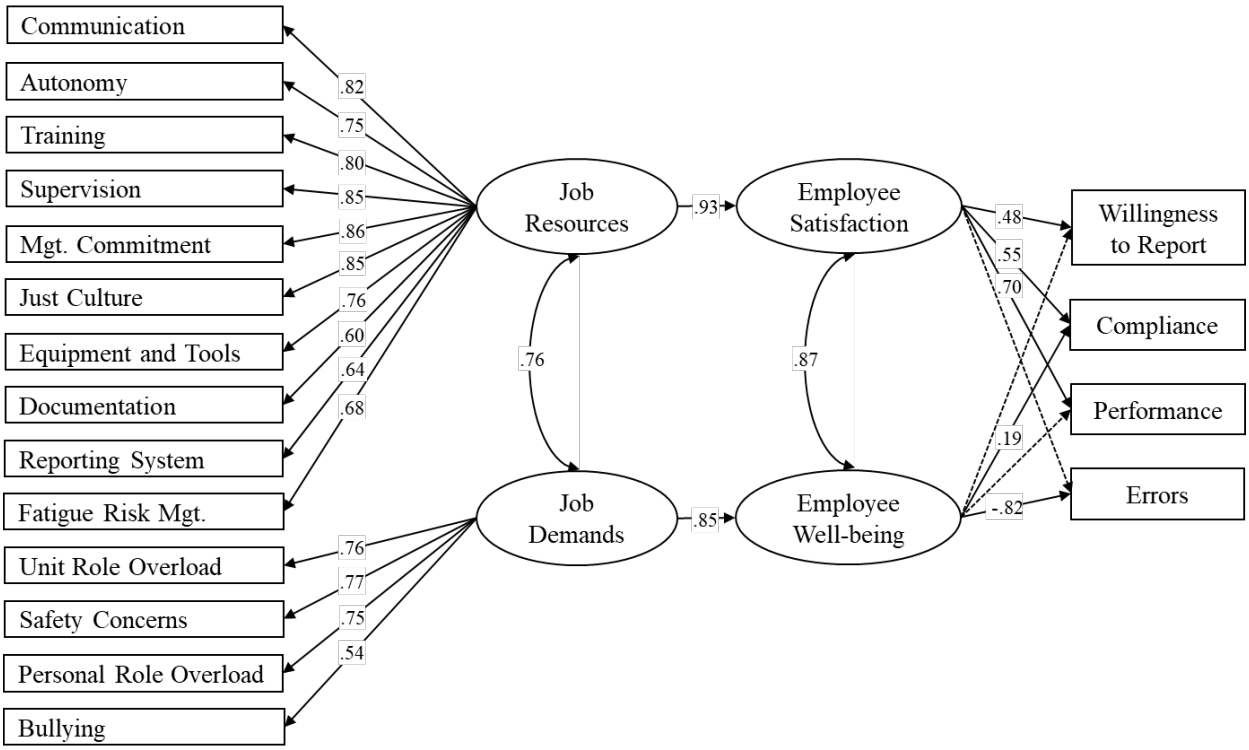
Model	RMSEA [90% CI]	CFI	TLI
Model 1 – Replicating Fogarty et al. (2018)	.10 [.096, .105]	.871	.851
Model 2 – Hybrid of Fogarty et al. (2017, 2018)	.086 [.082, .090]	.888	.870
Model 3 – *FAA M-SCAIT* with reliable subscales	.076 [.071, .080]	.922	.906

Figure 8 depicts the best fitting model (i.e., Model 3). Several variable covariances were added in the model as alternative pathways to improve the fit of the model by inspecting modification indices (Fogarty & Mckeon, 2006). The fit of the model was acceptable, $\chi^2(190, n = 770) = 1031.68$, $p < .001$, CFI = .922; TLI = .906; RMSEA = .076, 90% CI [.071, .080] (See Table 8 for additional model coefficients not provided in Figure 8).

[17] Personal Role Overload was kept in the model because its Cronbach's alpha was close to the 0.8 threshold, and because there was no a priori theoretical justification to remove it from the model.

Figure 8

Structural Equation Model Diagram for Best Fitting Model (Model 3)



Note. *Observed factors are denoted in rectangles; latent factors are denoted in ovals. The sub-scale loadings onto latent factors are the (standardized) factor loadings, such that higher values represent a stronger relationship between the latent factor (e.g., Job Demands) and its constituent (e.g., Safety Concerns). Single-headed arrows represent the influence of one variable on another such as regression effects (directional), while double-headed arrows represent the covariance or correlation between two variables (bidirectional). Solid lines indicate significant effects, while dashed lines indicate non-significant effects. Significant path coefficients indicate that there is a significant relationship between the variables.*

Table 8

Additional Coefficients for Model 3

Covariances	**Standardized Beta**
Job Satisfaction & Morale ~~ Turnover Intentions*	0.38
Supervision ~~ Management Commitment*	0.33
Unit Role Overload ~~ Personal Role Overload*	0.32
Management Commitment ~~ Safety Concerns*	0.25
Reporting System ~~ Willingness to Report*	0.24
Compliance ~~ Willingness to Report	0.08

Compliance ~~ Errors	-0.14
Factor Loadings	
Employee Satisfaction =~ Turnover Intentions	0.52
Employee Satisfaction =~ Job Satisfaction & Morale	0.74
Employee Well-being =~ General Health	0.73
Employee Well-being =~ Strain & Fatigue	0.81

* Covariances added to improve the fit of the model by inspecting modification indices.

First, the direct effect of Job Demands and Job Resources on Employee Outcomes were tested. Job Resources significantly predicted Employee Satisfaction ($\beta = .93$, $p < .001$), and Job Demands significantly predicted Employee Well-being ($\beta = .85$, $p < .001$). In addition, the results of the latent variable covariances suggested that Job Resources and Job Demands were significantly correlated ($\beta = .76$, $p < .001$).

The mediation effect of Employee Outcome on the Job Demands and Job Resources on Organizational Outcomes relationship was tested. The results of covariance analysis showed that Employee Satisfaction and Employee Well-being were significantly correlated ($\beta = .87$, $p < .001$). As expected, Employee Outcomes partially mediated the relationship between Job Demands and Job Resources with Organizational Outcomes (per Fogarty et al., 2018). Employee Satisfaction was a significant predictor of Compliance ($\beta = .55$, $p < .001$), Willingness to Report ($\beta = .48$, $p < .001$), and Performance ($\beta = .70$, $p < .001$), but not Errors ($p = .14$). Employee Well-being significantly predicted Compliance ($\beta = .19$, $p < .001$) and Errors ($\beta = -.82$, $p < .001$), but neither Willingness to Report ($p = .20$) nor Performance ($p = .35$). The only significant covariance correlations among outcome variables were between Compliance and Willingness to Report ($\beta = .08$, $p = .036$), and between Compliance and Errors ($\beta = -.14$, $p = .003$).

Discussion

Safety culture is critical to the effective implementation of SMS and is a predictor of many SPIs, such as non-compliance, injuries, incidents/accidents, and employee reporting. This research intends to provide the FAA with safety culture tools that overcome the human factors challenges associated with many available tools, such as proprietary nature, cost, and lack of guidance for safety culture promotion. This report described the development and initial validation evidence for the novel *FAA M-SCAIT*. The toolkit contains a customizable survey (Appendix A), scoring guidance, and a roadmap of safety culture improvement best practices (Appendix B). The direct benefits of the *FAA M-SCAIT* are organizational customization, identification of targeted opportunities for improvement, and strategic planning for safety culture promotion.

The initial validation testing of the *FAA M-SCAIT* was conducted in partnership with maintenance product and service providers with operations of various scope (i.e., Part 121 air

carrier technical operations department, Part 145 maintenance repair organizations, Part 135 on-demand operations, and Military maintenance). Complete survey responses were collected from 987 employees (including Maintainers, Front-line Leadership, and Upper Management) across five participating maintenance product and service provider organizations.

Key Findings

The descriptive statistics indicated that, at least for the organizations sampled, aviation maintenance product and service providers are performing well regarding provision of most Job Resources, which serves to enhance Employee Outcomes (i.e., Employee Satisfaction, Employee Well-being) and Organizational Outcomes (i.e., Willingness to Report, Performance). There is more room for improvement in Job Demands, particularly concerning Workplace Restraints (e.g., scheduling), Unit Role Overload, and Co-worker Concerns (i.e., equitable allocation of work tasks). The usability data were mostly positive regarding the survey content, complexity, user-friendliness, and application to industry, attesting to the content (face) validity of the *FAA M-SCAIT*.

SEM was performed to provide initial evidence of the criterion validity of the *FAA M-SCAIT*. As hypothesized based on the JD-R model (Bakker & Demerouti, 2007) and Fogarty et al.'s validation evidence (2018), the results showed that safety culture (Job Demands + Job Resources) was a significant predictor of both Employee and Organizational Outcomes. Further, the model showed that the relationship between safety culture and Organizational Outcomes is partially mediated by Employee Outcomes. This demonstrates the importance of management attention to employees' well-being and satisfaction, as these factors may ultimately translate to improvements in SPIs within the organization. These results are in line with the scientific literature[18] and attest to the criterion validity of the *FAA M-SCAIT* for measuring safety culture and its outcomes.

This validation effort revealed notable differences across demographic characteristics. There were differences between MROs and air carrier operators, potentially owing to differences in both regulatory requirements and their operational demands. Additionally, as seen in the literature, Maintainers often held lower perceptions of safety culture compared to leadership and management. However, results must be interpreted with caution given the relatively small percentage of Maintainers who participated in this survey.

While such results provide initial validation evidence of the *FAA M-SCAIT*, we recommend further investigation using a more robust participant sample to strengthen representation across the population of maintenance product and service providers. Further

[18] Bakker and Demerouti (2007), Demerouti et al. (2001, 2019), Fogarty et al. (2018), Hansez and Chmiel (2010), Nahrgang et al. (2011).

research is warranted to improve the usability of the *FAA M-SCAIT* instrument and to support the independent utilization of the toolkit by product and service providers.

Future Directions

This report provides initial validation evidence of the *FAA M-SCAIT*; however, some limitations exist. When using models such as SEM to analyze the relationship between safety culture and its outcomes, the results may not be stable. Instead, the results can vary as a function of researcher degrees of freedom such as sample size of the dataset, choice of analysis method, and the statistical model chosen (e.g., exactly which variables are incorporated where). Therefore, the model(s) presented in this report should be considered exploratory in service of better understanding the relationships among the variables assessed. Additional research is needed to explore the relationships among safety culture and its outcomes, test theoretical frameworks of safety culture, and strengthen the human factors understanding of safety culture within an aviation context. Tracking the relationships between safety climate, mediators, and safety performance across time is also needed (Beus et al., 2010).

One recommendation from the literature is the need to incorporate objective measures of safety outcomes and safety culture itself, as questionnaires only reflect beliefs and thoughts, not behaviors (Cooper, 2000; see also Beus et al., 2010). Future research is needed to gather and validate objective measures of safety outcomes. A more holistic picture can emerge by examining perceptions combined with objective data, such as safety audits or checklists (McSween, 2003), observations of normal operations,[19] or event investigation data. Other indicators in maintenance include aircraft damages, flight delays and cancellations, in-flight turnbacks (return to service), in-flight shutdown, rework, ratio of findings per inspection, personnel injuries (MEDA handbook; others). Acquiring this type of data can be challenging for researchers, but it is worthwhile to understand issues related to safety culture. Continued efforts are needed to identify the most effective and resource-efficient means of assessing safety culture and its outcomes in aviation maintenance operations. Collection and analysis of such data would support the development of predictive models, with safety culture serving as a proactive or predictive SPI. This will help to establish the relationship between safety culture perceptions and future-state safety performance, and help illustrate the importance of safety culture as a foundational component of an effective SMS and risk management approach.

Further, the validation test utilized a non-random, convenience sample and the survey was voluntary in nature. As with any survey, the results are subject to self-selection and self-report biases;[20] therefore, there is no guarantee that the results are a true and accurate

[19] See Ma et al. (2011) for a review of the use of Maintenance – Line Operations Safety Assessment (M-LOSA) for flight operations; see Langer and Braithwaite (2016) for a review of the use of Maintenance Operations Safety Survey (MOSS) for aircraft maintenance operations.

[20] Even with the abundance of promotional materials (handouts, PowerPoint slides, a safety culture operator manual, newsletter articles, etc.), we estimate that about one organization was recruited for every 100-200 organizational representatives/stakeholders reached with the promotional materials.

representation of the safety culture of the aviation maintenance industry. Evidence supporting this idea can be found in the *FAA M-SCAIT* validation dataset:

1. The response rate of eligible employees ranged between 9% and 40% across participating organizations, with many respondents in managerial or support positions. There were disproportionately fewer responses from Maintainers, who presumably make up the bulk of the workforce in a given maintenance organization. Ideally, the distribution of respondents should be proportional to the population.
2. Some *M-SCAIT* items yielded more favorable results than would be predicted based on the literature (e.g., fatigue, compliance), likely due to the high proportion of respondents in managerial job roles. As noted above, managers and administrative personnel tend to have more favorable perceptions of culture than do Maintainers.
3. Respondents provided responses that were more favorable for *Personal Role Overload* compared to *Unit Role Overload*, perhaps due to some hesitation of respondents to give an accurate account of their own workload vis-a-vis the workload of their unit.

Therefore, a clear recommendation for future tests is to capture a larger, more representative sample of Maintainers to get a snapshot of safety culture across maintenance product and service providers.

One opportunity to improve the survey usability is to reduce the survey length, as evidenced by participants' responses to the usability items. The survey content was developed carefully to reflect the broad range of safety culture topic areas identified in the literature and theoretical frameworks (e.g., JD-R). Further research could explore whether a reliable assessment of this theoretical framework could be conducted using the more limited number of dimensions. A short form, particularly one focusing on the subscales that are most useful in supporting SEM Model 3, may improve perceived usability and content validity of the *FAA M-SCAIT*.

It is worth mentioning that the *FAA M-SCAIT* is not much longer than other surveys of organizational culture (e.g., the Employee Attitude Survey; Hackworth et al., 2004), which average about 125-150 items (excluding demographics). Post-hoc analyses[21] on respondents who did not complete our full survey revealed a 20% higher response rate when the number of survey items was reduced by half. Increasing the response rate, even by 20%, may justify the development of a shorter version of *M-SCAIT*. Future research to develop a 'short form' of the survey would reduce the length of time needed and thus help lower administrative costs, and potentially bolster the response rate.

[21] This post-hoc analysis only included Organization #5 data collected in 2021.

Practical Applications

The *FAA M-SCAIT,* introduced in this report, is the first step in an effort to provide maintenance product and service providers with a safety culture assessment toolkit that can be administered quickly and independently to get a snapshot of an organization's safety culture. It is intended to be a stand-alone process that allows maintenance product and service providers to have control and ownership of their cultural assessment and associated proprietary data. The value of the *FAA M-SCAIT* is that it will empower any provider, large or small, to implement the safety culture assessment internally without support from researchers or consultants. This will ultimately help maintenance product and service providers assess, promote, and enhance the safety culture within their organization.

One key feature of the *FAA M-SCAIT* is that it can be adapted to specific operational needs. Exactly how much customization is allowable before a survey loses validity is an empirical question. Caution is warranted when customizing the FAA M-SCAIT, as we can make no claims about the validity of modified instruments. Further research could determine the tolerance of the toolkit for modification, and establish safeguards to protect against misuse of this toolkit.

We are hopeful that the *FAA M-SCAIT* will be utilized by industry, and we look forward to improving its usefulness. Our future research will improve *FAA M-SCAIT* by (a) providing operational guidance for safety culture change, and (b) broadening the scope to encompass additional areas of aviation operations.

Provide Operational Guidance for Safety Culture Change

It is important to recognize that safety culture assessment is one part of a larger change management strategy. Maintenance organizations may need guidance about how to implement change and improve safety culture. Further work is needed, however, best practices and lessons learned from the change management literature provide a useful starting point.

Critical features of any successful change management involve: an assessment of the need for change, development of a shared vision and strategy, involvement of employees in identifying and implementing the change plan, effective leadership, engaging communication, and assessing of the outcome (Armenakis & Harris, 2002, 2009; Burnes, 2004; By, 2005; Krause, 2005; Nytrø et al., 2000).

Employee involvement in all steps of the change process is essential. Recommendations to ensure employees are involved include guarantee data confidentiality, provide incentives for participation beyond participation 'on the clock,' and answer the question, "what's in it for me." Designating safety champions to advocate for the assessment and following actions may be critical for obtaining workforce buy-in and participation (see Key et al., 2023).

A final recommendation is to articulate the action plan for the survey results, as research shows that failure to do so may lead to distrust of management, reduced participation in surveys,

and lowered organizational climate/culture (Born & Mathieu, 1996; Taylor & Patankar, 2001). The need for a clearly communicated action plan is underscored by our finding that survey respondents did not agree that their management would use the results. Thus, future efforts are needed to support maintenance product and service providers with communicating and using the results to affect meaningful change.

Broaden the Scope

Another area of improvement concerns the applicability of the survey to product and service providers of various operational types. Throughout the validation effort, several safety management representatives indicated the need for the following:

- A General Aviation (GA) version of the toolkit that has data reporting and interpretation capabilities even with very few participants.
- Items tailored to other areas of the aviation industry (e.g., flight crew, ground handlers, and air traffic controllers).
- Guidance for targeted mitigations based on survey results.

Utilizing the same survey methodology to assess safety culture across areas of the aviation industry will foster consistency, reliability and synergy that allows determination of a cultural baseline for the NAS. More generally, broadening the scope of the *FAA M-SCAIT* may yield a richer database for identifying areas of concern and developing action plans to address those concerns. Thus, additional research is warranted to determine the level of scalability of the *FAA M-SCAIT* to other segments, ultimately to foster its widespread adoption.

Conclusions

The *FAA M-SCAIT* has the advantage of having been tested by a variety of organizations, each with their own safety culture. In performing this initial validation, the *FAA M-SCAIT* was customized for maintenance product and service providers' independent use. Results from 987 participants collected across five maintenance product and service providers demonstrated content, face, and criterion validity of the *FAA M-SCAIT*. However, further efforts are needed to fully validate the toolkit and support operational deployment. Additionally, the same data provide support for the JD-R model (Fogarty et al., 2017, 2018) for safety culture within aviation maintenance. Overall, we believe the *FAA M-SCAIT* can supplement efforts to assess and promote safety culture in aviation.

References

Akselsson, R., Koornneef, F., Stewart, S., & Ward, M. (2009). Resilience safety culture in aviation organisations. *HILAS (Human Integration into the Lifecycle of Aviation Systems) 2009: Chapter 2; draft version*.

Alnoaimi, M. (2015). *Safety climate and safety outcomes in aircraft maintenance: A mediating effect of employee turnover and safety motivation* [Doctoral dissertation, University of Central Florida]. https://stars.library.ucf.edu/etd/644/

Armenakis, A. A., & Harris, S. G. (2002). Crafting a change message to create transformational readiness. *Journal of Organizational Change Management, 15*(2), 169-183. https://doi.org/10.1108/09534810210423080

Armenakis, A. A., & Harris, S. G. (2009). Reflections: Our journey in organizational change research and practice. *Journal of Change Management*, *9*(2), 127-142. https://doi.org/10.1080/14697010902879079

Atak, A., & Kingma, S. (2011). Safety culture in an aircraft maintenance organization: A view from the inside. *Safety Science*, *49*(2), 268-278. https://doi.org/10.1016/j.ssci.2010.08.007

Avers, K. E., Johnson, W. B., Banks, J. O., Wenzel, B., & Nei, D. (2011). *Prioritizing maintenance human factors challenges and solutions: Workshop proceedings.* (DOT/FAA/AM-11/11). Federal Aviation Administration Office of Aviation Medicine. https://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/2010s/media/201111.pdf

Bakker, A. B., & Demerouti, E. (2007). The Job Demands-Resources model: State of the art. *Journal of Managerial Psychology*, 22, 309-328. http://dx.doi.org/10.1108/02683940710733115

Banks, M. H., Clegg, C. W., Jackson, P. R., Kemp, N. J., Stafford, E. M., & Wall, T. D. (1980). The use of the General Health Questionnaire as an indicator of mental health in occupational studies. *Journal of Occupational Psychology*, *53*(3), 187-194. https://doi.org/10.1111/j.2044-8325.1980.tb00024.x

Beus, J. M., Payne, S. C., Bergman, M. E., & Arthur, W., Jr. (2010). Safety climate and injuries: An examination of theoretical and empirical relationships. *Journal of Applied Psychology, 95*(4), 713-727. http://dx.doi.org/10.1037/a0019164

Born, D. H., & Mathieu, J. E. (1996). Differential effects of survey-guided feedback: The rich get richer and the poor get poorer. *Group & Organization Management, 21*(4), 388-403. https://doi.org/10.1177/1059601196214002

Brooke, J. (1996). SUS: A quick and dirty usability scale. *Usability Evaluation in Industry, 189*(194), 4-7.

Burnes, B. (2004). *Managing change: A strategic approach to organizational dynamics*. Pearson Education.

By, R. T. (2005). Organizational change management: A critical review. *Journal of Change Management, 5*(4), 369-380. https://doi.org/10.1080/14697010500359250

Cavagnaro, D. R., Myung, J. I., Pitt, M. A., & Myung, J. (2013). Mathematical modeling. *The Oxford Handbook of Quantitative Methods*, *1*, 438-453.

Clarke, S. (2006). The relationship between safety climate and safety performance: A meta-analytic review. *Journal of Occupational Health Psychology*, *11*(4), 315-327. https://doi.org/10.1037/1076-8998.11.4.315

Clarke, S (2009). Accidents and safety in the workplace. In S. Cartwright & C. L. Cooper (Eds.), *Oxford handbook of organizational well being.* Oxford University Press. http://doi.org/10.1093/oxfordhb/9780199211913.003.0003

Clarke, S. (2010). An integrative model of safety climate: Linking psychological climate and work attitudes to individual safety outcomes using meta-analysis. *Journal of Occupational and Organizational Psychology*, *83*, 553-578. https://doi.org/10.1348/096317909X452122

Clarke, S. (2012). The effect of challenge and hindrance stressors on safety behavior and safety outcomes: A meta-analysis. *Journal of Occupational Health Psychology, 17*(4), 387–397. https://doi.org/10.1037/a0029817

Cole, K. S., Stevens-Adams, S. M., & Wenner, C. A. (2013). *A Literature Review of Safety Culture* (Report No. SAND2013-2754). Sandia National Laboratories. https://www.osti.gov/servlets/purl/1095959

Consolidated Appropriations Act 2021, P.L. 116-260 (Dec. 27, 2020). https://www.govinfo.gov/link/plaw/116/public/260

Cooper, M. D. (2016). *Navigating the safety culture construct: A review of the evidence*. https://www.behavioral-safety.com/articles/safety_culture_review.pdf

Cooper, M. D. (2018). The Safety culture construct: Theory and practice. In C. Gilbert, B. Journé, H. Laroche, & C. Bieder (Eds.), *Safety cultures, safety models: Taking stock and moving forward* (pp. 47-61). Springer Open. https://library.oapen.org/bitstream/handle/20.500.12657/23084/1007074.pdf?sequence=1

Cooper, M. D. (2000). Towards a model of safety culture. *Safety Science*, *36*, 111-136. https://doi.org/10.1016/S0925-7535(00)00035-7

Cooper, R. & Fogarty, G. J. (2015). The Snapshot survey: An x-ray view. *Aviation Safety Spotlight*, 3, 34-39. http://eprints.usq.edu.au/id/eprint/29124

Cooper, R., & Fogarty, G. J. (2022, September 26-30). *A demands-resources view of safety climate in military aviation* [Conference presentation]. 34th European Aviation Psychology Conference, Gibraltar.

Cooper, R., McMahon, S., & Fogarty, G. J. (2018). Snapshot: A safety climate survey. http://eprints.usq.edu.au/id/eprint/34102

De Boer, R., Karanikas, N., Kaspers, S., Piric, S., Roelen, A., Van Aalst, R., Vardy, A. Plioutsias, A., & Papanikou, M. (2020). *Measuring safety in aviation: Developing metrics for safety management systems.* Amsterdam University of Applied Sciences, Aviation Academy Research Program.

Demerouti, E., Bakker, A. B., Nachreiner, F., & Schaufeli, W. B. (2001). The Job Demands-Resources model of burnout. *Journal of Applied Psychology, 86*(3), 499-512. https://doi.org/10.1037/0021-9010.86.3.499

Demerouti, E., Veldhuis, W., Coombes, C., & Hunter, R. (2019). Burnout among pilots: Psychosocial factors related to happiness and performance at simulator training. *Ergonomics*, 62(2), 233-245. https://doi.org/10.1080/00140139.2018.1464667

Diener, E. D., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The satisfaction with life scale. *Journal of Personality Assessment*, *49*(1), 71-75. https://doi.org/10.1207/s15327752jpa4901_13

Einarsen, S., Hoel, H., & Notelaers, G. (2009). Measuring exposure to bullying and harassment at work: Validity, factor structure and psychometric properties of the Negative Acts Questionnaire-Revised. *Work & Stress*, *23*(1), 24-44. https://doi.org/10.1080/02678370902815673

Ensor, P. S. (1988). The functional silo syndrome. *AME Target, 16*(Spring), 16.

Ethridge, M. C. (2016). *Relationship between safety climate, job tenure, and job satisfaction among railroad workers* [Doctoral dissertation, Walden University]. https://scholarworks.waldenu.edu/cgi/viewcontent.cgi?article=3223&context=dissertations

Federal Aviation Administration. (2015). *Safety management system for aviation service providers* (Advisory Circular No. AC 120-92B). U.S. Department of Transportation. Federal Aviation Administration. https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentid/1026670

Federal Aviation Administration. (2020). *Safety management system* (Order No. 8000.369C). Department of Transportation. Federal Aviation Administration. https://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.current/documentNumber/8000.369

Flin, R., Mearns, K., O'Connor, P., & Bryden, R. (2000). Measuring safety climate: Identifying the common features. *Safety Science*, *34*(1-3), 177-192. https://doi.org/10.1016/S0925-7535(00)00012-6

Fogarty, G. J. (2003, April 14-17). *Errors, violations, and reporting behavior in aviation maintenance* [Conference presentation]. 12th International Symposium on Aviation Psychology, Dayton, Ohio, United States.

Fogarty, G. J. (2004). The role of organizational and individual differences variables in aircraft maintenance performance. *International Journal of Applied Aviation Studies*, *4*(1), 73-90.

Fogarty, G. J. (2005). Psychological strain mediates the impact of safety climate on maintenance errors. *International Journal of Applied Aviation Studies*, *5*(1), 53-64.

Fogarty, G. J., & Buikstra, E. (2008). A test of direct and indirect pathways linking safety climate, psychological health, and unsafe behaviours. *International Journal of Applied Aviation Studies, 8*(2), 199-210.

Fogarty, G. J., Cooper, R., & McMahon, S. (2016, November 8-10). *The influence of demographics on safety climate surveys* [Conference Presentation]. 12th International Symposium of the Australian Aviation Psychology Association (AAvPA), Adelaide, Australia.

Fogarty, G. J., Cooper, R. & McMahon, S. (2018). A demands-resources view of safety climate in military aviation. *Aviation Psychology and Applied Human Factors*, *8*(2), 76-85. https://doi.org/10.1027/2192-0923/a000141

Fogarty, G. J., & Mckeon, C. M. (2006). Patient safety during medication administration: The influence of organizational and individual variables on unsafe work practices and medication errors. *Ergonomics*, *49*(5-6), 444-456. https://doi.org/10.1080/00140130600568410

Fogarty, G. J., Murphy, P. J., & Perera, H. N. (2017). Safety climate in defence explosive ordnance: Survey development and model testing. *Safety Science, 93*, 62-69. http://dx.doi.org/10.1016/j.ssci.2016.11.010

Fogarty, G. J., Saunders, R., & Collyer, R. (1999, May). Developing a model to predict aircraft maintenance performance. In *Proceedings of the Tenth International Symposium on Aviation Psychology* (pp. 1-6). The Ohio State University. https://eprints.usq.edu.au/1035/

Fogarty, G. J., Saunders, R., & Collyer, R. (2001). The role of individual and organisational factors in aviation maintenance. In *Eleventh International Symposium on Aviation Psychology*.

Fogarty, G. J., & Shaw, A. (2010). Safety climate and the theory of planned behavior: Towards the prediction of unsafe behavior. *Accident Analysis & Prevention, 42*(5), 1455-1459. https://doi.org/10.1016/j.aap.2009.08.008

French, S., & Steel, T. (2017). *The investigation of safety management systems and safety culture* (International Transport Forum Discussion Paper No. 2017-20). Organisation for Economic Co-operation and Development (OECD), International Transport Forum.

Gadd, S., & Collins, A. M. (2002). *Safety culture: A review of the literature* (Report No. HSL/2002/25). Health and Safety Laboratory. https://www.hse.gov.uk/research/hsl_pdf/2002/hsl02-25.pdf

Glass, G. V., Peckham, P. D., & Sanders, J. R. (1972). Consequences of failure to meet assumptions underlying the fixed effects analyses of variance and covariance. *Review of Educational Research, 42*(3), 237-288. https://doi.org/10.3102/00346543042003237

Griffin, M. A., & Curcuruto, M. (2016). Safety climate in organizations. *Annual Review of Organizational Psychology and Organizational Behavior*, *3*, 191-212. https://doi.org/10.1146/annurev-orgpsych-041015-062414

Guldenmund, F. W. (2000). The nature of safety culture: A review of theory and research. *Safety Science*, *34*(1-3), 215-257. https://doi.org/10.1016/S0925-7535(00)00014-X

Gyekye, S. (2006). Organisational tenure and safety perceptions: A comparative analysis. *Journal of Occupational Health and Safety - Australia and New Zealand, 22*(4), 359-371.

Hackworth, C. A., Cruz, C. E., Goldman, S., Jack, D. G., King, S. J., & Twohig, P. (2004). *Employee attitudes within the Federal Aviation Administration* (Technical Report No. DOT/FAA/AM-04/22). Federal Aviation Administration. Office of Aerospace Medicine. https://rosap.ntl.bts.gov/view/dot/58250

Hansez, I., & Chmiel, N. (2010). Safety behavior: Job demands, job resources, and perceived management commitment to safety. *Journal of Occupational Health Psychology*, *15*(3), 267. https://doi.org/10.1037/a0019528

Harwell, M. R., Rubinstein, E. N., Hayes, W. S., & Olds, C. C. (1992). Summarizing Monte Carlo results in methodological research: The one-and two-factor fixed effects ANOVA cases. *Journal of Educational Statistics, 17*(4), 315-339. https://doi.org/10.3102/10769986017004315

Helmreich, R. L. (1999). Building safety on the three cultures of aviation. In *Proceedings of the IATA Human Factors Seminar* (pp. 39-43). International Air Transport Association.

Hintzman, D. L. (1991). Why are formal models useful in psychology? In W. E. Hockley & S. Lewandowsky (Eds.), *Relating theory and data: Essays on human memory in honor of Bennet B. Murdock* (pp. 39–56). Lawrence Erlbaum Associates.

Hodges, M. E., & Gardner, D. (2014). Examining the influence of error climate on aviation maintenance performance. *Australasian Journal of Organisational Psychology, 7*(e1), 1–11. http://doi.org/ 10.1017/orp.2014.1

Hom, P. W., & Griffeth, R. W. (1991). Structural equations modeling test of a turnover theory: Cross-sectional and longitudinal analyses. *Journal of Applied Psychology*, *76*(3), 350-366. https://psycnet.apa.org/doi/10.1037/0021-9010.76.3.350

Hooper, D., Coughlan, J., & Mullen, M. (2008). Structural equation modelling: Guidelines for determining model fit. *Electronic Journal of Business Research Methods, 6*(1), 53-60.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1-55. https://doi.org/10.1080/10705519909540118

International Atomic Energy Agency. (2020). *A harmonized safety culture model* (Working Document). https://www.iaea.org/sites/default/files/20/05/harmonization_05_05_2020-final_002.pdf

International Aviation Transport Association. (2020). *Creating a positive safety culture: Best practices to align with Annex 19's new recommendations* [I-ASC Whitepaper]. https://go.updates.iata.org/safety-culture

International Civil Aviation Organization. (2013). *Annex 19 - Safety Management* (1st ed.). ICAO.

Isla- Díaz, R., & Díaz-Cabrera, D. (1997). Safety climate and attitude as evaluation measures of organizational safety. *Accident Analysis and Prevention, 29*(5), 643-650. https://doi.org/10.1016/S0001-4575(97)00015-8

Jaros, S. J. (1997). An assessment of Meyer and Allen's (1991) three-component model of organizational commitment and turnover intentions. *Journal of Vocational Behavior*, *51*(3), 319-337. https://doi.org/10.1006/jvbe.1995.1553

Johnson, B. (2014). A revisit of top modern maintenance human factors challenges. *Aviation MX Human Factors*, *2*(3), 2-4. https://www.faa.gov/about/initiatives/maintenance_hf/fatigue/publications/media/Aviation_MX_HF_Newsletter_Vol2Issue3.pdf

Karanikas, N. (2016). Critical review of safety performance metrics. *International Journal of Business Performance Management, 17*(3), 266-285. https://doi.org/10.1504/IJBPM.2016.077244

Key, K. N., Hu, P. T., Choi, I., Schroeder, D. J. (2023). *Safety culture assessment and promotion in aviation: A literature review* (Technical Report No. DOT/FAA/AM-23/13). Federal Aviation Administration, Office of Aerospace Medicine.

Kleidon, M. W. (2010). *The role of fatigue, safety climate, and emotional intelligence in shaping safety behaviors in aviation maintenance* [Doctoral dissertation, University of Southern Queensland]. https://eprints.usq.edu.au/19939/1/Kleidon_2010_whole.pdf

Krause, T. R. (2005). *Leading with safety*. Wiley.

Langer, M., & Braithwaite, G. R. (2016). The development and deployment of a maintenance operations safety survey. *Human Factors, 58*(7), 986-1006. https://doi.org/10.1177/0018720816656085

Ma, J., Pedigo, M., Blackwell, L., Gildea, K., Holcomb, K., Hackworth, C., & Hiles, J. J. (2011). *The line operations safety audit program: Transitioning from flight operations to maintenance and ramp operations* (Report No. DOT/FAA/AM-11/15). Federal Aviation Administration, Office of Aerospace Medicine. https://rosap.ntl.bts.gov/view/dot/57082

McDonald, N., Corrigan, S., Daly, C., & Cromie, S. (2000). Safety management systems and safety culture in aircraft maintenance organizations. *Safety Science*, *34*(1-3), 151-176. https://doi.org/10.1016/S0925-7535(00)00011-4

McDonald, R. P., & Ho, M. H. R. (2002). Principles and practice in reporting structural equation analyses. *Psychological Methods*, *7*(1), 64. https://doi.org/10.1037/1082-989X.7.1.64

McSween, T. E. (2003) *Value-Based Safety Process: Improving your Safety Culture with Behavior-Based Safety*. Wiley.

Nahrgang, J. D., Morgeson, F. P., & Hofmann, D. A. (2011). Safety at work: A meta-analytic investigation of the link between job demands, job resources, burnout, engagement, and safety outcomes. *Journal of Applied Psychology, 96*(1), 71-94. http://doi.org/10.1037/a0021484

National Academies of Science, Engineering, and Medicine. (2016). Safety culture assessment and measurement. In *Strengthening the safety culture of the offshore oil and gas industry*. National Academies Press. https://doi.org/10.17226/23524

National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (1979). *The Belmont Report.* U.S. Department of Health and Human Services. https://www.hhs.gov/ohrp/regulations-and-policy/belmont-report/read-the-belmont-report/index.html

Nihm, S. D. (1976). Polynomial law of sensation. *American Psychologist, 31*, 808-809. https://psycnet.apa.org/doi/10.1037/0003-066X.31.11.808

Nytrø, K., Saksvik, P. Ø., Mikkelsen, A., Bohle, P., & Quinlan, M. (2000). An appraisal of key factors in the implementation of occupational stress interventions. *Work & Stress*, *14*(3), 213-225. https://doi.org/10.1080/02678370010024749

O'Connor, P., O'Dea, A., Kennedy, Q., & Buttrey, S. E. (2011). Measuring safety climate in aviation: A review and recommendations for the future. *Safety Science*, *49*(2), 128-138. https://doi.org/10.1016/j.ssci.2010.10.001

Office of Inspector General (2020). *FAA has not effectively overseen Southwest Airlines' systems for managing safety risks* (Report No. AV2020019). Department of Transportation. https://www.oig.dot.gov/library-item/37731

Operating requirements: Commuter and on demand operations and rules governing persons on board such aircraft, 14 C.F.R. §135 (2022). https://www.ecfr.gov/current/title-14/chapter-I/subchapter-G/part-135

Operating requirements: Domestic, flag, and supplemental operations, 14 C.F.R. §121 (2022). https://www.ecfr.gov/current/title-14/chapter-I/subchapter-G/part-121

Piers, M., Montijn, C., & Balk, A. (2009). Safety culture framework for the ECAST SMS-WG. *European Commercial Aviation Safety Team (ECAST)*. European Union Aviation Safety Agency. https://www.easa.europa.eu/sites/default/files/dfu/WP1-ECASTSMSWG-SafetyCultureframework1.pdf

RAND. (2013). *Charting the course for a new Air Force inspection system.* https://apps.dtic.mil/sti/citations/ADA580957

Repair Stations, 14 C.F.R. § 145 (2022). https://www.ecfr.gov/current/title-14/chapter-I/subchapter-H/part-145

Roberts, S., & Pashler, H. (2000). How persuasive is a good fit? A comment on theory testing. *Psychological Review, 107*(2), 358–367. https://doi.org/10.1037/0033-295X.107.2.358

Roberts, S., & Pashler, H. (2002). Reply to Rodgers and Rowe (2002). *Psychological Review, 109*(3), 605–607. https://doi.org/10.1037/0033-295X.109.3.605

Rodgers, J. L., & Rowe, D. C. (2002). Theory development should begin (but not end) with good empirical fits: A comment on Roberts and Pashler (2000). *Psychological Review, 109*(3), 599–603. https://doi.org/10.1037/0033-295X.109.3.599

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling and more. Version 0.5–12 (BETA). *Journal of Statistical Software*, *48*(2), 1-36. https://doi.org/10.18637/jss.v048.i02

Rosseel, Y. (2021). *The lavaan tutorial*. https://lavaan.ugent.be/tutorial/index.html

Safety Management International Collaboration Group (2019). *Industry safety culture evaluation tool and guidance.* https://www.skybrary.aero/index.php/Industry_Safety_Culture_Evaluation_Tool_and_Guidance

Safety Management Systems, 14 C.F.R. § 5 (2015). https://www.ecfr.gov/current/title-14/chapter-I/subchapter-A/part-5

Schmider, E., Ziegler, M., Danay, E., Beyer, L., & Bühner, M. (2010). Is it really robust? Reinvestigating the robustness of ANOVA against violations of the normal distribution assumption. *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences*, *6*(4), 147.

Singer, S. J., Gaba, D. M., Geppert, J. J., Sinaiko, A. D., Howard, S. K., & Park, K. C. (2003). The culture of safety: Results of an organization-wide survey in 15 California hospitals. *BMJ Quality & Safety*, *12*(2), 112-118. http://dx.doi.org/10.1136/qhc.12.2.112

Taylor, J. C. (2002). *Tools and techniques for evaluating the effects of Maintenance Resource Management (MRM) in air safety*. National Aeronautics and Space Administration, Ames Research Center. https://ntrs.nasa.gov/citations/20020046777

Taylor, J. C., & Patankar, M. S. (2001). Four generations of maintenance resource management programs in the United States: An analysis of the past, present, and future. *Journal of Air Transportation World Wide, 6*(2), 3-32. https://ntrs.nasa.gov/citations/20010103213

Tokarski, R. V. (2021). Examining the safety climate of a general aviation maintenance, repair, and overhaul (MRO) organization: A replication study and application of Bandura's reciprocal causation model [Doctoral dissertation, Florida Institute of Technology]. https://repository.fit.edu/etd/41/

Uhuegho, K. E. (2017). Examining the safety climate of U.S. based aviation maintenance, repair, and overhaul (MRO) organizations [Doctoral dissertation, Florida Institute of Technology]. http://repository.lib.fit.edu/handle/11141/1371

Ullman, J. B., & Bentler, P. M. (2013). Structural equation modeling. In I. B. Weiner (Ed.), *Handbook of psychology* (2nd ed.). Wiley.

Van Nunen, K., Li, J., Reniers, G., & Ponnet, K. (2018). Bibliometric analysis of safety culture research. *Safety Science, 108*, 248-258. https://doi.org/10.1016/j.ssci.2017.08.011

Wiegmann, D. A., Zhang, H., Von Thaden, T., Sharma, G., & Mitchell, S. (2002). *A synthesis of safety culture and safety climate research* (Technical Report No. ARL-02-3/FAA-02-2). Federal Aviation Administration. https://www.nrc.gov/docs/ML1025/ML102500649.pdf

Zohar, D. (1980). Safety climate in industrial organizations: Theoretical and applied applications. *Journal of Applied Psychology, 65*(1), 96-102. https://doi.org/10.1037/0021-9010.65.1.96

Zohar, D. (2000). A group-level model of safety climate: Testing the effect of group climate on microaccidents in manufacturing jobs. *Journal of Applied Psychology, 85*(4), 587-596. https://doi.org/10.1037/0021-9010.85.4.587

Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. *Accident Analysis and Prevention, 42*(5), 1517-1522. https://doi.org/10.1016/j.aap.2009.12.019

Zohar, D. (2014). Safety climate: Conceptualization, measurement, and improvement. In B. Schneider & K. M. Barbera (Eds.). *The Oxford Handbook of Organizational Climate and Culture* (pp. 317-334). Oxford University Press.

Zohar, D., & Hofman, D. A. (2012). Organizational culture and climate. In S. W. J. Kozlowski (Ed.), *Oxford Handbook of Industrial and Organizational Psychology* (pp. 643-666). Oxford University Press.

Zohar, D., & Luria, G. (2003). The use of supervisory practices as leverage to improve safety behavior: A cross-level intervention model. *Journal of Safety Research, 34*(5), 567-577. https://doi.org/10.1016/j.jsr.2003.05.006

Zohar, D., & Luria, G. (2005). A multilevel model of safety climate: Cross-level relationships between organizations and group-level climates. *Journal of Applied Psychology*, *90*(4), 616-628. https://doi.org/10.1037/0021-9010.90.4.616

Appendix A.
The FAA M-SCAIT Survey Content

FAA Aviation Maintenance Safety Survey

You are invited to participate in this online survey titled, "**FAA Aviation Maintenance Safety Survey**," to assess employee perceptions of safety in your workplace. This survey was co-developed by your organization and researchers at the FAA. Please provide your honest feedback, because your responses along with those of your colleagues will provide the information needed to help improve safety and performance in your organization.

The survey takes about 20-30 minutes to complete. Participation in this survey is completely voluntary. You may choose freely to participate or not. Answers to the items are optional, and you may stop and exit the survey at any time without penalty.

Confidentiality: Your survey responses are **confidential** and go directly to a contractor for removal of your personally identifiable information. Your responses will be combined with those of others and summary results will be reported. Essentially, who you are in your organization will not be identifiable to your managers or the FAA, and your individual responses cannot be linked back to you.

On the next page you will be asked to indicate whether you consent to participate in the survey.

Informed Consent

Note: Click here for an Adobe®PDF copy of the informed consent terms and conditions, which you can print and/or save to your computer (opens in a new window).

Please indicate whether you consent to participate.

- o I consent to participate
- o I do not consent to participate

[display if "I do not consent to participate" is selected]

You indicated that you do not want to participate in the survey. While getting as many participants as possible is important, the survey is voluntary and your choice to decline must be respected.

To decline participation, select "Exit Survey". If you would like to participate, select "Return to Informed Consent" and select "I consent to participate".

- o Exit survey
- o Return to Informed consent

Sample Demographics[1]

D1 **How long have you worked in the aviation industry in <u>years</u>?** (required)

[dropdown] Less than 1…More than 50

D2 **How long have you worked for your current organization in <u>years</u>?** (required)

[dropdown] Less than 1…More than 50

D3 **What is your current job role?** (required)

- Senior management (e.g., Director, V. P.)
- Mid-level management (e.g., Program Manager, Division or Department Manager)
- Front-line management (e.g., Project Manager)
- Non-management Leadership (e.g., Lead, Alt. Lead Technician, Inspector)
- Non-management/Maintainer (e.g., Technician, Painter, Aircraft Cleaner, etc.)
- Non-management/Non-maintainer (e.g., Production Control, Tool Room, etc.)
- Safety or Quality Department

D4 **How long have you worked under your current job role in <u>years</u>?** (required)

[dropdown] Less than 1…More than 50

D5 **Which area do you work most of the time?** (required)

- Regional Aircraft Service Department (RASD)
- Major Aircraft Service Department (MASD)
- Base location
- Field location
- Admin or Support
- Management
- Safety or Quality Department

D6 **What size team do you work with?** (required)

- I do not work as part of a team
- 1-5 other technicians/repairmen
- 6-10 other technicians/repairmen
- More than 10 other technicians/repairmen

[1] Note, example response options provided; response options were tailored to the organization's operational needs.

D1 **How long have you worked in the aviation industry in <u>years</u>?** (required)

[dropdown] Less than 1…More than 50

D7 **Which Aviation Maintenance certificate(s) do you <u>currently</u> hold?** (required)
[mark all that apply]

- ☐ Repairman Certificate
- ☐ Mechanic Certificate with Airframe Privileges
- ☐ Mechanic Certificate with Powerplant Privileges
- ☐ Mechanic Certificate with Airframe and Powerplant Privileges
- ☐ Inspection Authorization Designation
- ☐ I do not currently hold an Aviation Maintenance certificate

D8 **During the past 3 months on a typical work<u>day</u>, how many hours do you work for your current organization?** (required)

- o 1 to 4 hours
- o 5 to 8 hours
- o 9 to 12 hours
- o 13 to 16 hours
- o 17 to 20 hours
- o More than 20 hours

D9 **During the past 3 months in a typical work<u>week</u> how many hours did you work for your current organization <u>(including ALL assigned work)</u>?** (required)

- o Fewer than 30 hours
- o 30-40 hours
- o 41-50 hours
- o 51-60 hours
- o More than 60 hours

D10 **On average, how often do you work overtime?**

- o Never
- o A few times per year
- o 1-2 times per month
- o Once a week
- o Twice a week
- o More than twice a week

D11 **On average, how often do you travel for work?**

- o Never
- o A few times per year
- o 1-2 times per month
- o Once a week
- o Twice a week
- o More than twice a week

D1 **How long have you worked in the aviation industry in <u>years</u>?** (required)

[dropdown] Less than 1…More than 50

D12 **What shift do you work?** (required)

- 1st Shift
- 2nd Shift
- 3rd Shift
- On-Call

D13 **Are you a Contract or Direct employee of your company?** (required)

- Contract employee
- Direct employee

D14 **Do you have prior military experience?** (required)

- Yes
- No

D15 **What area of aircraft do you work most of your time?**

- Avionics
- NDT
- Inspection
- Sheet metal
- A&P
- Paint
- Admin or Support
- Management
- Safety or Quality

Job Resources[2]

This section assesses your perceptions of the support you receive in your work environment.

Q1.1 Please indicate your <u>level of agreement</u> with each statement.

Communication

Q1.1_1	We are adequately informed about work-related issues.
Q1.1_2	Work issues are openly discussed between front-line (floor) employees and <u>management</u> (mid/upper).
Q1.1_3	Work issues are openly discussed between front-line (floor) employees and <u>supervisors</u>.
Q1.1_4	There is good communication across the different sections/work groups.
Q1.1_5	A good communication flow exists up and down the chain of command (or equivalent).

[2] All 'Agreement' responses are measured on a 6-point Likert anchored at 'Strongly disagree (1)', 'Disagree (2)', 'Slightly disagree (3)', 'Slightly agree (4)', 'Agree (5)', and 'Strongly agree (6)', except open-text items.

Communication

Q1.1txt	Please share any additional feedback regarding Communication: *[open-text]*

Q1.2 Please indicate your level of agreement with each statement.

Autonomy

Q1.2_1	We are encouraged to show initiative.
Q1.2_2	We are treated as responsible people.
Q1.2_3	We are trusted to do our work.
Q1.2_4	We are micromanaged.*
Q1.2txt	Please share any additional feedback regarding Autonomy: *[open-text]*

Q1.3 Please indicate your level of agreement with each statement.

Training

Q1.3_1	Our training is effective in preparing us for the duties of our jobs.
Q1.3_2	Work related training is carried out at appropriate intervals.
Q1.3_3	Safety issues are given a high priority in training courses within our organization.
Q1.3_4	Safety is consistently emphasized during our training.
Q1.3_5	We understand the safety rules and policies.
Q1.3_6	We agree with the safety rules and policies.
Q1.3txt	Please share any additional feedback regarding Training: *[open-text]*

Q1.4 Please indicate your level of agreement with each statement.

Supervision

Q1.4_1	We see our manager/upper manager on the floor often.
Q1.4_2	We know who our managers are.
Q1.4_3	Supervisors set clear goals and objectives for the team.
Q1.4_4	We trust our supervisors.
Q1.4_5	We consider our supervisor part of our team.
Q1.4_6	Supervisors devote sufficient effort to safety in the workplace.
Q1.4_7	Supervisors carefully listen to safety concerns.
Q1.4_8	Supervisors appropriately react to safety concerns.
Q1.4_9	Management ensures the crew/team is prepared for assigned tasks.
Q1.4txt	Please share any additional feedback regarding Supervision: *[open-text]*

Q1.5 Please indicate your level of agreement with each statement.

Management Commitment

Q1.5_1	Management values safety.
Q1.5_2	We receive managerial support even if following safety rules affects operational activities.
Q1.5_3	Supervisor/Front-line management is committed to our safety objectives.
Q1.5_4	Middle management is committed to our safety objectives.

Management Commitment

Q1.5_5	Senior management (Owner/CEO) is committed to our safety objectives.
Q1.5_6	Employee input is used to develop and improve safe work procedures.
Q1.5txt	Please share any additional feedback regarding Management Commitment: *[open-text]*

This section assesses your perceptions of how your organization responds to individuals who make an honest mistake.

Q2.1 Please indicate your level of agreement with each statement.

Just Culture

Q2.1_1	We seek to learn from honest mistakes rather than place blame.
Q2.1_2	We can report safety problems without fear of negative consequences.
Q2.1_3	We are confident that when we report our errors we will be treated fairly.
Q2.1_4	Corrective action for unsafe practices is appropriate.
Q2.1_5	Corrective action for unsafe practices is consistent.
Q2.1_6	Corrective action for violations of safety procedures/rules is appropriate.
Q2.1_7	Corrective action for violations of safety procedures/rules is consistent.
Q2.1_8	People will speak up when someone is working unsafely.
Q2.1txt	Please share any additional feedback regarding Just Culture: *[open-text]*

Q2.2 Please indicate your level of agreement with each statement.

Equipment and Tools

Q2.2_1	Our work facilities are adequate for the safe performance of our duties.
Q2.2_2	There is sufficient personal protective clothing and equipment available for tasks to be carried out safely.
Q2.2_3	Necessary safety equipment is always accessible.
Q2.2_4	Available safety equipment is in good condition.
Q2.2_5	We have the equipment/tools that we need to do our job properly.
Q2.2_6	We have the parts/consumables that we need to do our job properly.
Q2.2txt	Please share any additional feedback regarding Equipment and Tools: *[open-text]*

This section assesses your perceptions of job role-specific factors.[3]

Q3.1 Please indicate your level of agreement with each statement.

Documentation

Q3.1_1	Technical manuals are easy to use.
Q3.1_2	Technical manuals are up-to-date.
Q3.1_3	Technical manuals are easy to access.
Q3.1_4	Technical manuals are easy to learn.

[3] *Note,* questions were tailored to the organization's operational needs.

Documentation

Q3.1_5	Updates to our technical manuals are handled in a timely manner.
Q3.1_6	Operating procedures are accurately described in our technical manuals.
Q3.1_7	Our electronic manuals have all the functions and capabilities we expect them to have.
Q3.1_8	Electronic devices are an effective way to present technical manuals.
Q3.1_9	I am committed to following the procedures documented in the technical manual.
Q3.1_10	We have enough time to read all the documentation.

Documentation

Q3.2	**Do you know about the standard method of reporting missing or unclear procedures in our technical manuals?** *[Yes/No]*

Q3.3 Please indicate your level of agreement with each statement. *[Agreement scale with N/A option]*

Documentation

Q3.3_1	There are too many sources of information that we need to consult in addition to our manuals.*
Q3.3_2	It is easy to get lost in our electronic manuals when following procedures that require access to multiple screens.*
Q3.3_3	I report missing or unclear procedures.[4]
Q3txt	Please share any additional feedback regarding Documentation: *[open-text]*

[4] This item was reclassified into Willingness to Report subscale for the SEM modeling.

This section assesses your perceptions of your organization's voluntary reporting system. A voluntary reporting system is a formal (non-verbal) way of reporting hazards and safety violations or incidents in your environment.

Report System

Q4.1	**Our organization has a voluntary reporting system.** *[Yes/No]*
Q4.2	**Our organization's voluntary reporting system is electronic.** *[Yes/No]* [display if Q4.1 = yes]
Q4.3	**I know how to use our organization's voluntary reporting system.** *[Yes/No]* [display if Q4.1 = yes]

Q4.4 Please indicate <u>how well</u> each statement represents your organization's voluntary reporting system. [display if Q4.1 = yes]

Report System

Q4.4_1	Easy to use.
Q4.4_2	Accessible to everyone.
Q4.4_3	Confidential.
Q4.4_4	Allowed to make reports while on the clock.
Q4.4_5	Everyone is included in our safety reporting and resolution system.

Report System

Q4txt	**Please share any additional feedback regarding <u>Report System</u>:** *[open-text]*

Job Demands[5]

This section explores challenges you may encounter at work.

Q5.1 Please indicate <u>how often</u> you encounter each of these challenges.

Workplace Restraints

Q5.1_1	We are given enough notice of variations to schedules/duty rosters.
Q5.1_2	We are concerned about loss of skills because of the lack of opportunity to practice.*
Q5.1_3	We spend more time on paperwork than our real jobs.*
Q5.1_4	Unimportant tasks or activities interfere with our real jobs.*
Q5.1_5	Conflicting job assignments are given (e.g., told to do flight control functional checks while avionics has power off changing boxes).*
Q5.1_6	We are interrupted part-way through tasks to perform other, more urgent tasks.*
Q5.1txt	Please share any additional feedback regarding <u>Workplace Restraints</u>: *[open-text]*

Q5.2 Please indicate <u>how often</u> you encounter each of these challenges.

Unit Role Overload

Q5.2_1	We have trouble keeping up with our workload.*
Q5.2_2	We have to work overtime to get our work done.*
Q5.2_3	We feel pressure because of the critical nature of our work.*
Q5.2_4	Work requirements (e.g., absences or extended hours) put pressure on our personal lives.*
Q5.2_5	We are required to rush tasks to meet job requirements.*
Q5.2_6	We have enough time to carry out our tasks properly.
Q5.2_7	We have insufficient staffing to achieve allocated tasks on time.*
Q5.2txt	Please share any additional feedback regarding <u>Team Role Overload</u>: *[open-text]*

Q5.3 Please indicate <u>how often</u> you encounter each of these challenges.

Safety Concerns

Q5.3_1	There is pressure from management to quickly complete assigned tasks at the cost of safety.*
Q5.3_2	We cannot work safely and keep up with our work schedule.*
Q5.3txt	Please share any additional feedback regarding <u>Safety Concerns</u>: *[open-text]*

Q5.4 Please indicate <u>how often</u> you encounter each of these challenges.

Personal Role Overload

Q5.4_1	I am pressured to work long hours.*
Q5.4_2	I have unachievable deadlines.*
Q5.4_3	I have unrealistic time pressures.*
Q5.4_4	I have to neglect some tasks because I have too much to do.*

[5] All 'Frequency' responses are measured on a 6-point Likert anchored at 'Never (1)', 'Rarely (2)', 'Sometimes (3)', 'Frequently (4)', 'Most of the time (5)', and 'All of the time (6)', except open-text items.

Personal Role Overload

Q5.4txt	Please share any additional feedback regarding Personal Role Overload: *[open-text]*

Q5.5 Please indicate how often you encounter each of these challenges.

Co-worker Concerns

Q5.5_1	Underperformance is dealt with effectively.
Q5.5_2	We have to cover for underperforming colleagues.*
Q5.5_3	Inexperienced staff are promoted/appointed too quickly into supervisory/ management roles.*
Q5.5txt	Please share any additional feedback regarding Co-worker Concerns: *[open-text]*

Organizational Outcomes
This section assesses your reporting behavior.

Q6.1 Please indicate your level of agreement with each statement.

Willingness to Report[6]

Q6.1_1	I always make the effort to report my own mistakes and incidents.
Q6.1_2	I encourage others to report safety hazards, their mistakes, and safety incidents.
Q6.1_3	Reporting safety hazards, mistakes, and incidents makes a difference to safety.
Q6.1_4	Employees who report safety hazards are given positive recognition by management.
Q6.1_5	Management encourages the reporting of safety hazards, mistakes, and safety incidents.
Q6.1txt	Please share any additional feedback regarding Willingness to Report: *[open-text]*

This section explores your views on how well you and your team are performing.

Q7.1 Please indicate your level of agreement with each statement.

Performance

Q7.1_1	We work efficiently.
Q7.1_2	Our work output is high.
Q7.1_3	We consistently meet our objectives.
Q7.1_4	We review our work processes for opportunities to improve.
Q7.1_5	It is acceptable to challenge the way things are done.
Q7.1_6	There is a genuine focus on continuous improvement.
Q7.1txt	Please share any additional feedback regarding Performance: *[open-text]*

Q7.2 During the past 12 months...

Injury (12 months)

Q7.2_1	Have you experienced any job-related repetitive strain injuries that required medical attention (e.g., carpal tunnel, tendinitis)? *[Yes/No]*
Q7.2_2	Have you experienced any job-related moderate to serious acute injuries (e.g., fractured/broken bones, head or eye injuries)? *[Yes/No]*

[6] Items Q6.1_3, Q6.1_4, and Q6.1_5 were excluded from SEM Model 3.

This section asks you about your work-related mistakes or errors during the past 3 months.

Keep in mind that these items are meant to assess your own, personal experience, not those of your co-workers. Answer these items based on your own, personal experience. Please be honest, and remember that your responses are confidential and cannot be linked back to you.

Q8. Everyone makes mistakes. Below are some of the common reasons why people make errors on the job.
Please answer the following items based on your own, personal experience. Please consider ALL mistakes and errors, big or small.

During the past 3 months, how often has each of the following contributed to your work-related mistakes or errors (big or small)? *[Frequency scale with N/A option]*

Errors (3 months)	
Q8.1_1	Stress.
Q8.1_2	Distractions.
Q8.1_3	Tiredness.
Q8.1_4	Time pressure.
Q8.1_5	Apathy.
Q8.1_6	Complacency.
Q8.1_7	Too many things to do.
Q8.1_8	Lack of concentration.
Q8.1_9	Lack of knowledge.
Q8.1_10	Forgetfulness.
Q8.1_11	Poor teamwork.
Q8.1_12	Not having the right equipment/tools.
Q8.1_13	Not having the right parts/consumables.
Q8.1_14	Not having correct/current documentation.
Q8.1_15	Physical work environment (e.g., lighting, temperature, noise).
Q8.2_1	Failing to detect a fault when completing a visual inspection.
Q8.2_2	Misunderstanding how a particular aircraft system worked.
Q8.2_3	Resuming at the wrong place when returning to a task after an interruption.
Q8.2_4	Missing a step(s) in a maintenance task.
Q8.2_5	Installing a part the wrong way.
Q8.2_6	Fitting/applying an incorrect part or component into an aircraft.
Q8.2_7	Refitting an aircraft panel incorrectly after a task.
Q8.3_1	Forgetting to check that all steps in a procedure were completed.
Q8.3_2	Leaving a tool or some other items in the aircraft/system.
Q8.3_3	Finding a part left over after a job was completed.
Q8.3_4	Forgetting to sign off a task.
Q8.3_5	Signing off a task without completely/ thoroughly checking.

Errors (3 months)

Q8.3_6	Incorrectly entering the details of a component into the documentation.
Q8.3_7	Variance in model of aircraft we work on.
Q8.3_8	Changes in the assignment of aircraft that we work on.
Q8txt	Please share any additional feedback regarding Errors: *[open-text]*

Q9.1 Please indicate your level of agreement with each statement.

Compliance

Q9.1_1	I have taken risks, beyond those inherent in my job, in order to get a task done.*
Q9.1_2	I am prepared to overlook some rules in order to get the job done more quickly.*
Q9.1_3	Supervisors sometimes 'turn a blind eye' when rules are bent.*
Q9.1_4	People use undocumented and/or unauthorized workarounds to get the job done.*
Q9.1_5	People have intentionally not complied with an approved procedure or process to get the job done.*
Q9.1_6	Written procedures often do not reflect how the job is done.*
Q9.1_7	My workgroup uses locally developed processes to perform work tasks.*
Q9txt	Please share any additional feedback regarding Compliance: *[open-text]*

Employee Outcomes
This section explores satisfaction and morale at work.

Q10.1 Please indicate your level of agreement with each statement.

Job Satisfaction and Morale

Q10.1_1	I am satisfied with my current job.
Q10.1_2	I like the type of work I do.
Q10.1_3	I find my job rewarding.
Q10.1_4	The morale in my unit/workplace is high.
Q10.1_5	I like my co-workers.

Q10.2 Please indicate your level of agreement with each statement.

Turnover Intentions

Q10.2_1	I often think about quitting this organization.*
Q10.2_2	I intend to search for a position with another employer in the next year.*
Q10txt	Please share any additional feedback regarding Job Satisfaction and Morale: *[open-text]*

This section assesses your general health.

Q11 Please indicate how often you encounter each of these challenges.

Recently, how often have you…

General Health Questionnaire

Q11.1_1	Been able to concentrate on what you are doing.
Q11.1_2	Lost sleep over worry.*
Q11.1_3	Felt that you are playing a useful part in things.
Q11.1_4	Felt capable of making decisions about things.
Q11.1_5	Felt continually under strain.*
Q11.1_6	Felt you could not overcome your difficulties.*
Q11.2_1	Been able to enjoy your normal day-to-day activities.
Q11.2_2	Been able to face up to your problems.
Q11.2_3	Felt unhappy and/or depressed.*
Q11.2_4	Experienced a lack of confidence in yourself.*
Q11.2_5	Thought of yourself as worthless.*
Q11.2_6	Felt happy.
Q11txt	Please share any additional feedback regarding General Health: *[open-text]*

Fatigue
This section assesses your fatigue.

Strain and Fatigue

Q12.1 Our organization has a formal Fatigue Risk Management System. *[Yes/No/Don't Know]*

Q12.2 Please indicate your level of agreement with each statement.

Strain and Fatigue

Q12.2_1 Fatigue represents a significant risk in our organization.[7]
Q12.2_2 Our organization is aware of impact of fatigue on employee's performance.
Q12.2_3 Our organization attempts to mitigate employee's fatigue.
Q12.2_4 All maintenance employees have received fatigue awareness training provided by the organization.

Q12.3 Please indicate your level of agreement with each statement.

Strain and Fatigue

Q12.3_1 Our organization assesses for extended duty shifts (+12 hours).
Q12.3_2 Our organization assesses for excessive consecutive days on duty (+7 days).
Q12.3_3 Extended duty shifts (+12 hours) are common practice for our organization.*
Q12.3_4 Excessive consecutive days on duty (+7 days) are common practice for our organization.*
Q12.3_5 There are special considerations to address fatigue risk on the graveyard shift (early morning or night shift).
Q12.3_6 Workers can use sick leave to call in fatigued.
Q12.3_7 Management/Supervisors schedule to minimize fatigue.

Q12.4 Please indicate how often you have experienced each of the following:

Strain and Fatigue

Q12.4_1 I work seven (7) consecutive duty days without 24 hours of rest.*
Q12.4_2 I feel stressed at work.*
Q12.4_3 I experience fatigue while on duty.*
Q12.4_4 Fatigue has affected my ability to perform the job effectively.*
Q12.4_5 I commit errors while on duty because of fatigue.*
Q12.4_6 Others in your work group exhibit fatigue while on duty.*

[7] Note that this item can be interpreted either 1) positively - Our organization considers fatigue as a key risk factor (to be controlled), or 2) negatively - Our organization currently has a fatigue risk. The researchers categorized it positively, but additional caution is needed when interpreting this result.

Strain and Fatigue

Q12.5 **Which of the following factors contributed to your fatigue while on duty?** *[mark all that apply]*

- ☐ Workload
- ☐ Work pace
- ☐ Rotating work schedule
- ☐ Work shift (i.e., early morning, night shift)
- ☐ Work environment (i.e. noise, temperature, air quality, lighting, etc.)
- ☐ Family demands
- ☐ Physical health
- ☐ Travel for work (distance and duration)
- ☐ On-call operations
- ☐ Other (please specify)

Q12.5txt **Other factors that contributed to your fatigue while on duty:** *[open-text]* [display if Q12.6 = Other (please specify)]

Q12.6 **Are there any operational changes that you would recommend to reduce your risk of fatigue?** *[Yes/No]*

Q12.6txt **Operational changes you recommend to reduce risk of fatigue:** *[open-text]* [display if Q12.7 = yes]

Q12txt **Please share any additional feedback regarding <u>Strain and Fatigue</u>:** *[open-text]*

Bullying[8]

This section assesses your work environment.

"Workplace bullying" is a persistent, unreasonable form of harassment. It can be defined as unwanted or unwelcome behavior that a reasonable person, having regard to all the circumstances, would consider offensive, insulting, humiliating, or intimidating. Workplace bullying does not include reasonable management action taken in a reasonable way.

Please indicate <u>how often</u> you encounter each of these challenges.

Bullying (3 months)

Q13.1	In the past three months, how often have you been subjected to workplace bullying?

Bullying (conditional questions)

[display if 13.1 = sometimes, frequently, most of the time, or all of the time]

Q13.2 The following behaviors are often seen as examples of negative behavior in the workplace. Please indicate <u>how often</u> you've encountered these negative acts in the <u>last 3 months</u>.

Over the <u>last 3 months</u> how often have you been subjected to the following...

Note: The response scale has changed. Please read carefully.

Bullying (3 months)

Q13.2_1	Someone withholding information which affects your performance.*
Q13.2_2	Being humiliated or ridiculed in connection with your work.*
Q13.2_3	Being ordered to do work below your level of competence.*
Q13.2_4	Having key areas of responsibility removed or replaced with more trivial or unpleasant tasks.*
Q13.2_5	Spreading of gossip and rumors about you.*
Q13.2_6	Being ignored, excluded or getting 'the cold shoulder'.*
Q13.2_7	Having insulting or offensive remarks made about your person (i.e., habits and background), your attitudes, or your private life.*
Q13.2_8	Being shouted at or being the target of spontaneous anger (or rage).*
Q13.3_1	Intimidating behavior, such as finger-pointing, invasion of personal space, shoving, blocking/barring the way.*
Q13.3_2	Hints or signals from others that you should quit your job.*
Q13.3_3	Repeated reminders of your error or mistakes.*
Q13.3_4	Being ignored or facing a hostile reaction when you approach others.*
Q13.3_5	Persistent criticism of your work and effort.*
Q13.3_6	Having your opinions and views ignored.*

[8] All 'Frequency' responses are measured on a 5-point Likert anchored at 'Never (1)', 'Now and then (2)', 'Monthly (3)', 'Weekly (4)', and 'Daily (5)', except for item 13.1 and open-text items.

Bullying (3 months)

Q13.3_7	Practical jokes carried out by people you don't get along with.*
Q13.3_8	Being given tasks with unreasonable or impossible targets or deadlines.*
Q13.4_1	Having unsubstantiated allegations made against you.*
Q13.4_2	Excessive monitoring of your work.*
Q13.4_3	Pressure not to claim something which by right you are entitled to (e.g., sick leave, holiday entitlement, travel expenses).*
Q13.4_4	Being the subject of excessive teasing and sarcasm.*
Q13.4_5	Being exposed to an unmanageable workload.*
Q13.4_6	Threats of violence or physical abuse or actual abuse.*
Q13txt	Please share any additional feedback regarding Bullying: *[open-text]*

System Usability and Workload

This section assesses the usability and workload that you experienced while completing the survey. Please be honest, as your responses will be used to improve the survey for future respondents.

Q14.1 Please indicate your level of agreement with each statement.

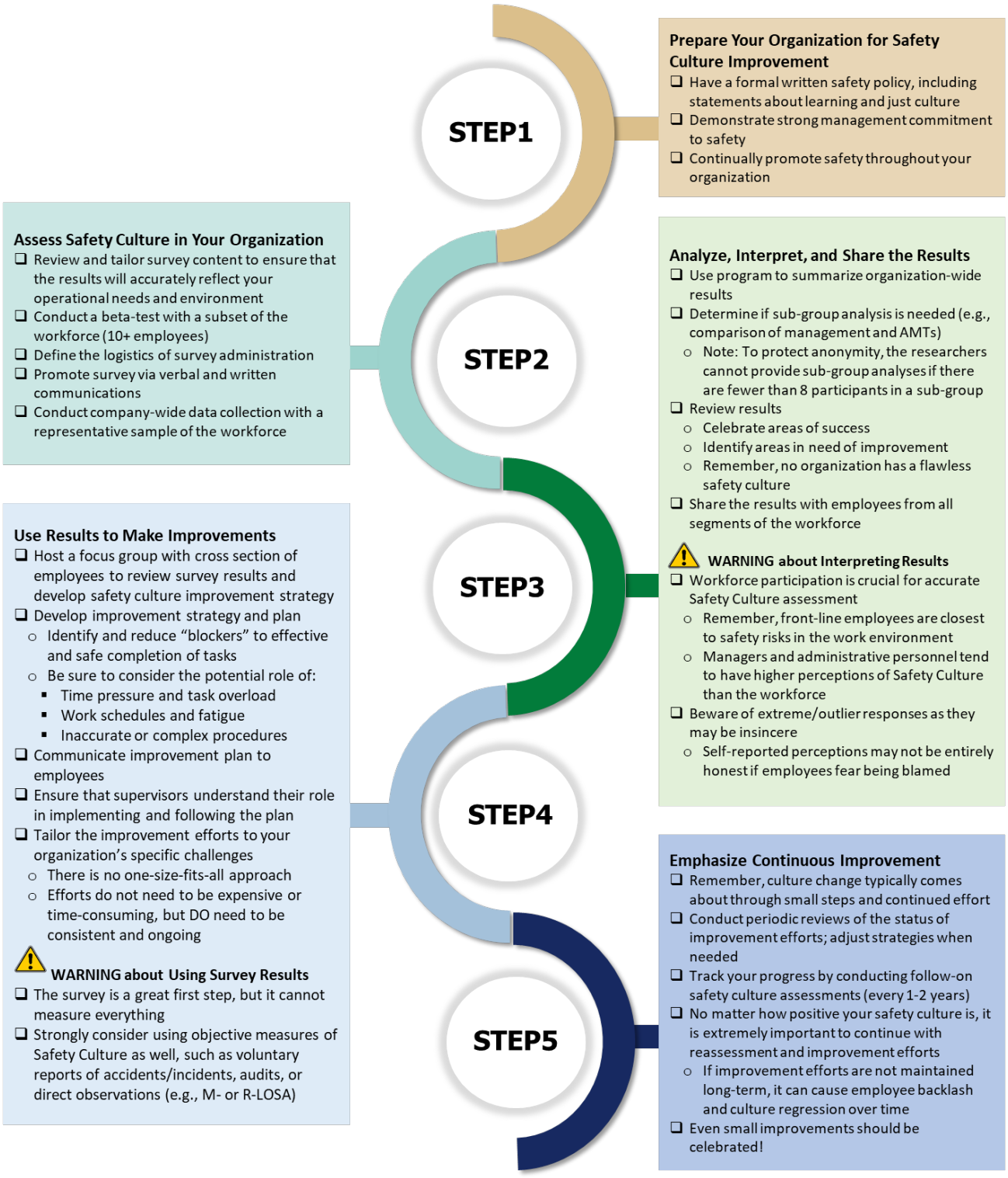
	Usability
Q14.1_1	The time required to complete this survey is appropriate for the value of the data collected.
Q14.1_2	The survey contains important items to assess an organization's safety culture.
Q14.1_3	The survey is user-friendly.
Q14.1_4	I would recommend this survey for industry use.
Q14.1_5	The survey results will be used by management to identify areas in need of improvement.
Q14.1_6	Managers will make meaningful improvements based on the survey results.
Q14.1_7	I thought there was too much inconsistency in the survey.*
Q14.1_8	I found the survey unnecessarily complex.*
Q14txt	Please share any additional feedback regarding Usability: *[open-text]*
Q15txt	**If you have feedback about how to improve the survey content, please provide it in the text box below.** *[open-text]*

Data Scoring and Analysis Guide

- To protect confidentiality of the participants, only analyses and reports of aggregated data (i.e., where $n \geq 8$) should be produced and reported.
- The survey items and response options can be standardized for analysis. This allows easier interpretation of the results, where higher values always reflect more positive perceptions of the safety culture regardless of meaning of all subscales. To calculate a simple average within each subscale, all average scores can be mathematically standardized from a 6-point Likert scale to a 10-point score for ease of interpretation (see ***Equation 1***). When standardizing, keep in mind:
    - Items marked by an asterisk (*) are reversely worded; therefore, the scores should be reversed before standardizing and analyzing the data.
    - The 'Not Applicable' (N/A) responses can be excluded for score averaging.
- Standardizing scores may not be appropriate for some data types, such as yes-no response options and comment responses. Instead, consider:
    - Calculating percentage of yes responses.
    - Identifying themes in comment responses, such as: strengths, opportunities, recommendations for improvement.

Appendix A.
Safety Culture Improvement Roadmap

To assist with the process of assessing and promoting safety culture, we created a roadmap for safety culture improvement efforts.



Appendix A. Supplemental Results

This appendix presents supplemental results of the safety culture survey comparing demographic characteristics of interest.

Job Role

We assigned participant job positions into three Job Role categories based on similarities in responsibilities. These categories are (a) Maintainers, (b) Front-line Leadership, and (c) Upper Management. See Table 9, Table 10, and Figure 9 for details. Job roles and responsibilities are defined differently by different organizations (e.g., Non-Management Leadership can be categorized as a Maintainer or as Front-line Leadership due to differences in job duties and hierarchical structure across organizations). Therefore, the reader should not presume that the job roles within a category are identical across organizations, and it is possible the results would differ if other categories were used.

Table 1
Participant Job Role Categories

Job Category	Org.	Job Roles
Maintainers	1	Non-management/Maintainer/Aviation Technician
	2	Maintainer/Technician/A&P Mechanic/Technician/Painter/Aircraft Cleaner (Non-management)
	3	1 Skill Level (e.g., Helper); 3 Skill Level (e.g., Apprentice); 5 Skill Level (e.g., Journeyman)
	4	Non-management/Maintainer (e.g., Inspector, Certificated Tech, Non-certificated Tech); Non-management/Non-maintainer (e.g., Training, Planning, Tool Room, Materials, etc.)
	5	Non-management technical staff (e.g., Technicians, Inspectors, or other technical certifying staff); Non-management technical support staff (e.g., Tooling, Calibration, Facilities Technician); Non-management non-technical staff (e.g., Stores, Utility workers)
Front-line Leadership	1	Front-line Management (e.g., Project Manager); Non-management Leadership (e.g., Lead, Alt. Lead Technician, Inspector)
	2	Front-line Management (e.g., Supervisor); Non-management Leadership (e.g., Senior Base AMT)
	3	7 Skill Level (e.g., Craftsman, Supervisor)
	4	Front-line Management (e.g., Mod/Hangar/Site Manager, Inspection Manager); Non-management Leadership (e.g., Supervisor, Lead, Airworthiness Specialist)
	5	Front-line management (e.g., Supervisor, Shift, or Department Manager)
Upper Management	1	Mid-level Management (e.g., Program Manager); Senior management (e.g., Director, V. P.); Non-management/Non-maintainer (Support department such as HR, PC, QA, Finance)

2	Mid-level Management (e.g., Regional Manager); Other Non-management/Non-maintainer (e.g., Administrative or Support Role/Tool Room/Production Control)
3	9 Skill Level or higher (e.g., Superintendent, Chief, Officer, Commander, Management)
4	Mid-level Management (e.g., Accountable Manager, Department Manager); Senior Management (e.g., Director, V. P.); Other Functional Areas (e.g., Safety, Product Assurance, Program Management, etc.)
5	Senior management (e.g., Sr. Manager or above); Other management and admin (e.g., Staff representative, Engineer, Analyst)

Note. *Language for job roles in this table are exactly as provided by the participating organizations.*

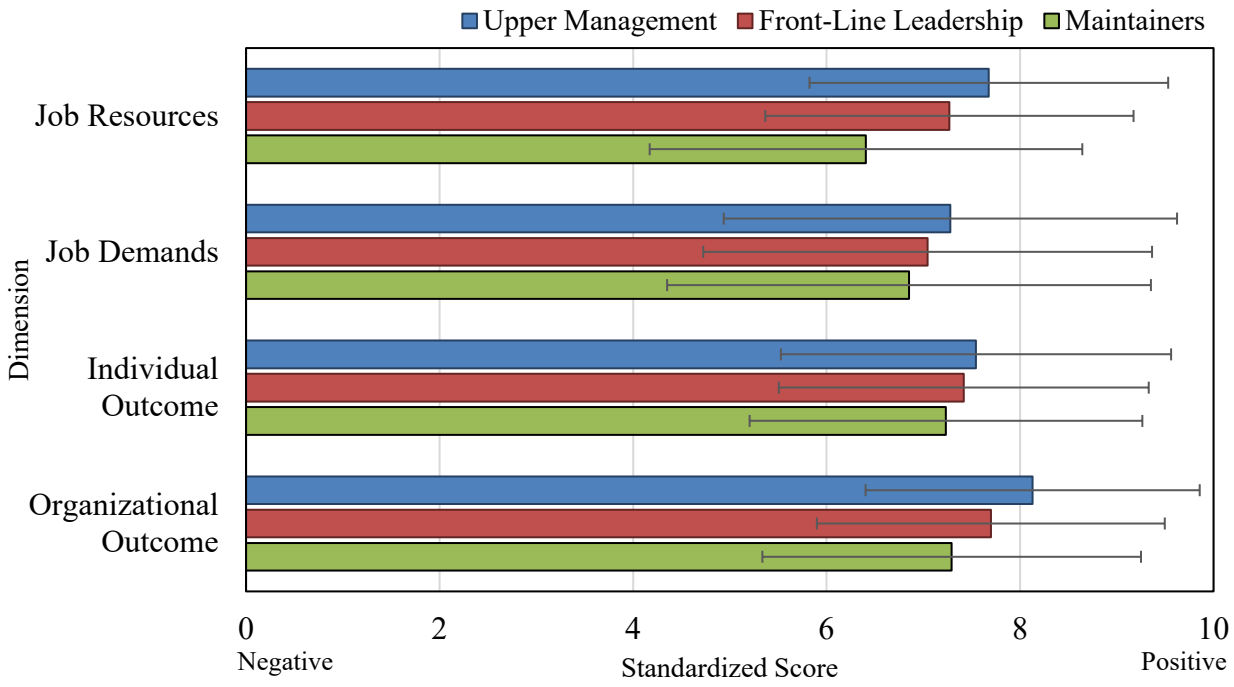
Table 2

Participant Job Categories by Organization

Job Category	Org. 1 (Part 145)	Org. 2 (Part 135)	Org. 3 (Military, Part 145)	Org. 4 (Part 145)	Org. 5 (Part 121)	Overall
Maintainers	22.3%	71.8%	45.8%	14.3%	60.0%	49.6%
Front-line Leadership	49.8%	19.7%	50.0%	42.9%	21.9%	31.8%
Upper Management	27.9%	8.5%	4.2%	42.9%	18.1%	18.5%

Figure 1

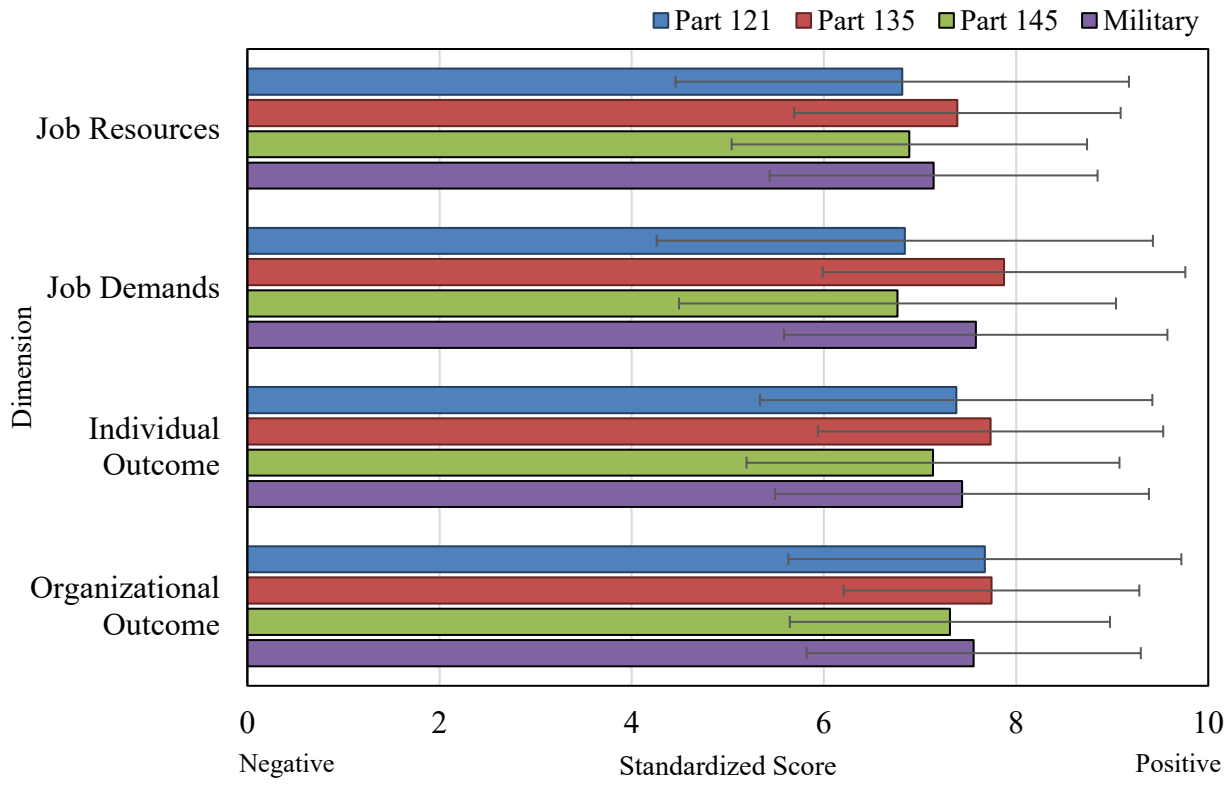
Measured Dimensions by Job Role



Operation Type

We assigned organizations into Operation Type categories based on similarities in their operation. These categories are (a) Part 145 (Organizations #1 and #4), (b) Part 135 (Organization #2), (c) Military (Organization #3), and (d) Part 121 (Organization #5) as shown in Figure 10.

Figure 2
Measured Dimensions by Operation Type



Shift Schedule

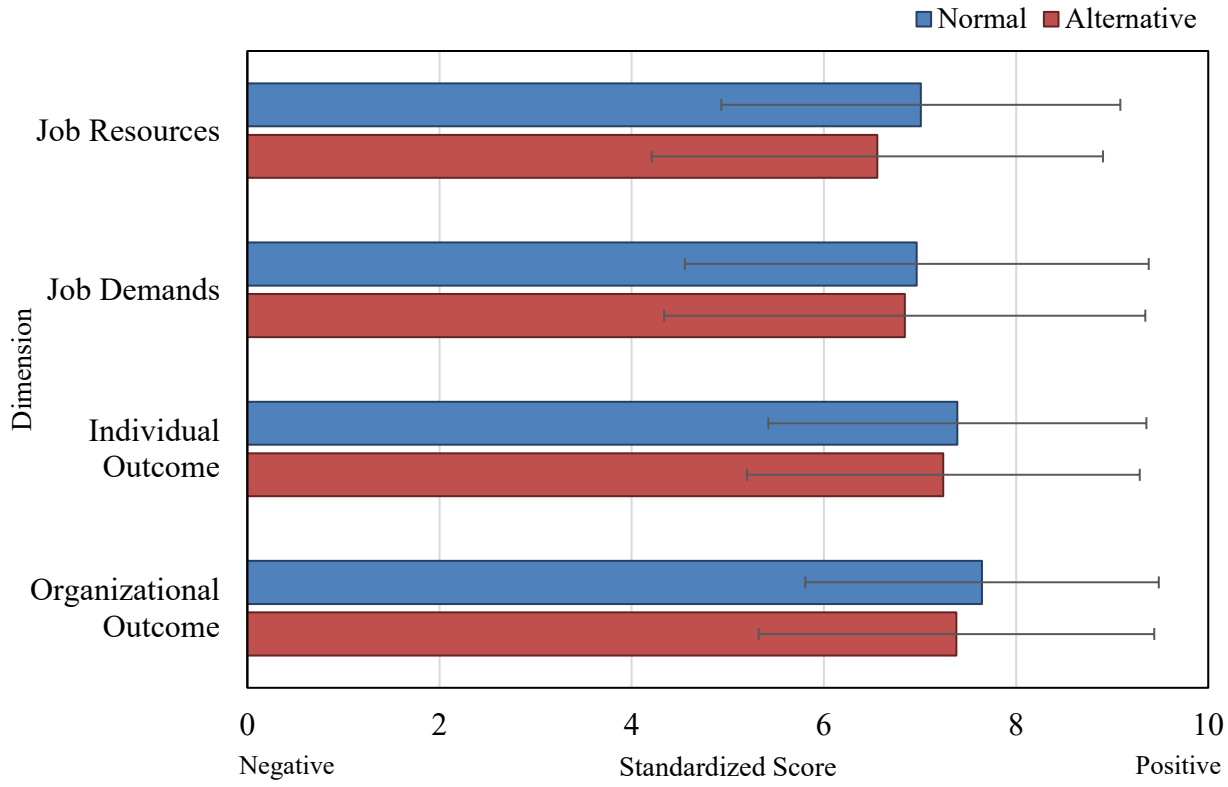
Participants were considered as having a "Normal" shift schedule if they responded "1st Shift" or "5 days on, 2 days off". Participants were considered as having an "Alternative" shift if they responded "2nd Shift", "3rd Shift", "7 days on, 7 days off", or "On-Call".

For all dimensions, participants working "Normal" shift expressed more positive perceptions towards safety culture (see Table 11 and Figure 11). This was expected, as rotating or alternative shift schedules often affect work-life balance, and there are challenges associated with gaining sufficient sleep during daylight hours.

Table 3
Participant Shift Schedule by Organization

Shift Type	Org. 1 (Part 145)	Org. 2 (Part 135)	Org. 3 (Military, Part 145)	Org. 4 (Part 145)	Org. 5 (Part 121)	Overall
Normal	82.8%	85.9%	40.8%	89.3%	64.6%	67.9%
Alternative	17.2%	14.1%	0.0%	10.7%	35.4%	24.9%
No Response	0.0%	0.0%	59.2%	0.0%	0.0%	7.2%

Figure 3
Measured Dimensions by Shift Schedule



Level of Experience

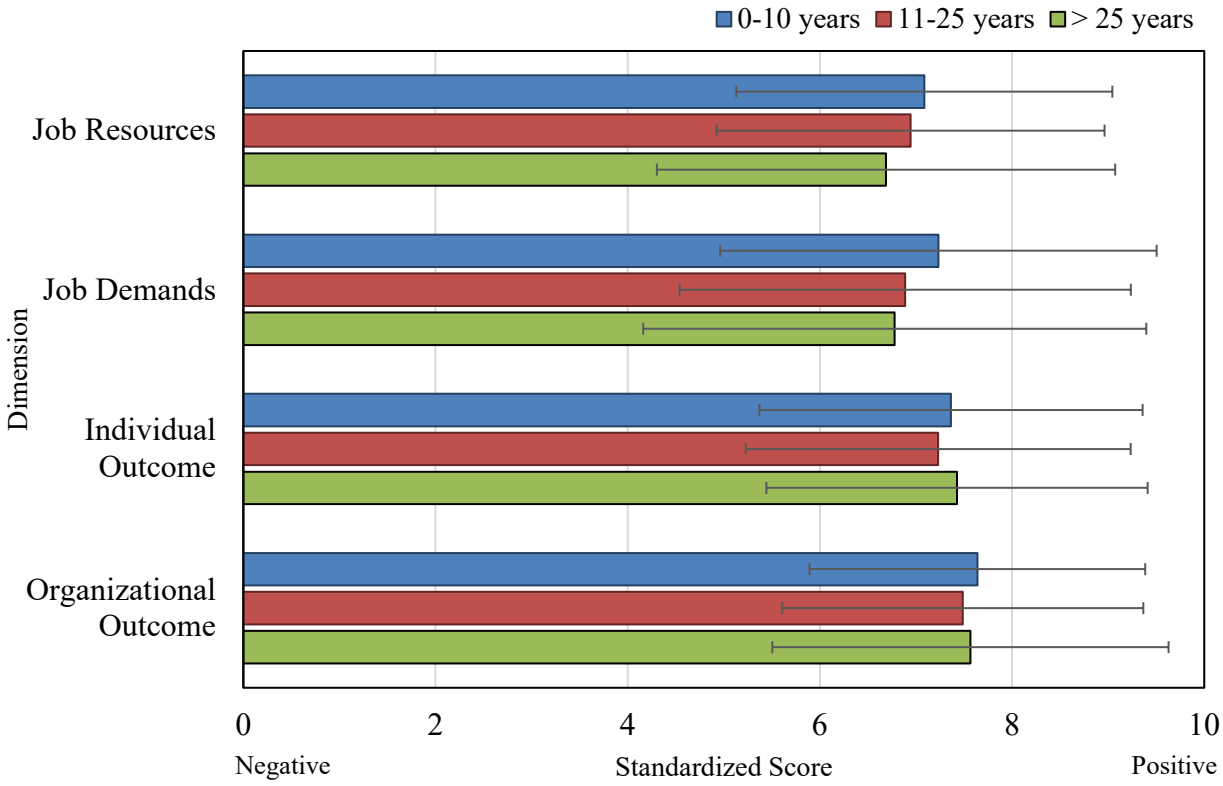
When analyzed by years in organization, the newest (0-10 years) and most senior (>25 years) employees had the highest scores for each subscale, while participants in between demonstrated the lowest scores (see Table 12 and Figure 12). This is consistent with the research indicating a curvilinear relationship between tenure and some subscales of safety climate/culture (e.g., supervisory trust; Taylor, 2002) as well as job satisfaction (Ethridge, 2016; Gyekye, 2006). There are a number of factors that may contribute to this result: sense-making, increase in job responsibilities and skills over time, shared norms and greater organizational knowledge for older workers, and sensitivity to hazardous situations. Employment challenges associated with

the COVID-19 pandemic may have also influenced overall job satisfaction and safety climate/culture.

Table 4
Years of Experience at Current Organization

Years of Experience	Org. 1 (Part 145)	Org. 2 (Part 135)	Org. 3 (Military, Part 145)	Org. 4 (Part 145)	Org. 5 (Part 121)	Overall
0-10 years	55.3%	71.4%	67.5%	71.4%	22.8%	40.2%
11-25 years	39.5%	28.6%	28.3%	28.6%	19.7%	26.0%
>25 years	5.1%	0.0%	4.2%	0.0%	57.5%	33.9%

Figure 4
Measured Dimensions by Level of Experience (in Years) at Current Organization



Workday and Workweek

Participants' average workday and workweek (in hours) are reported in Table 13 and Table 14, respectively. As displayed in Figure 13, safety culture perceptions decrease with increased hours per workweek.

Table 5
Participant Workday

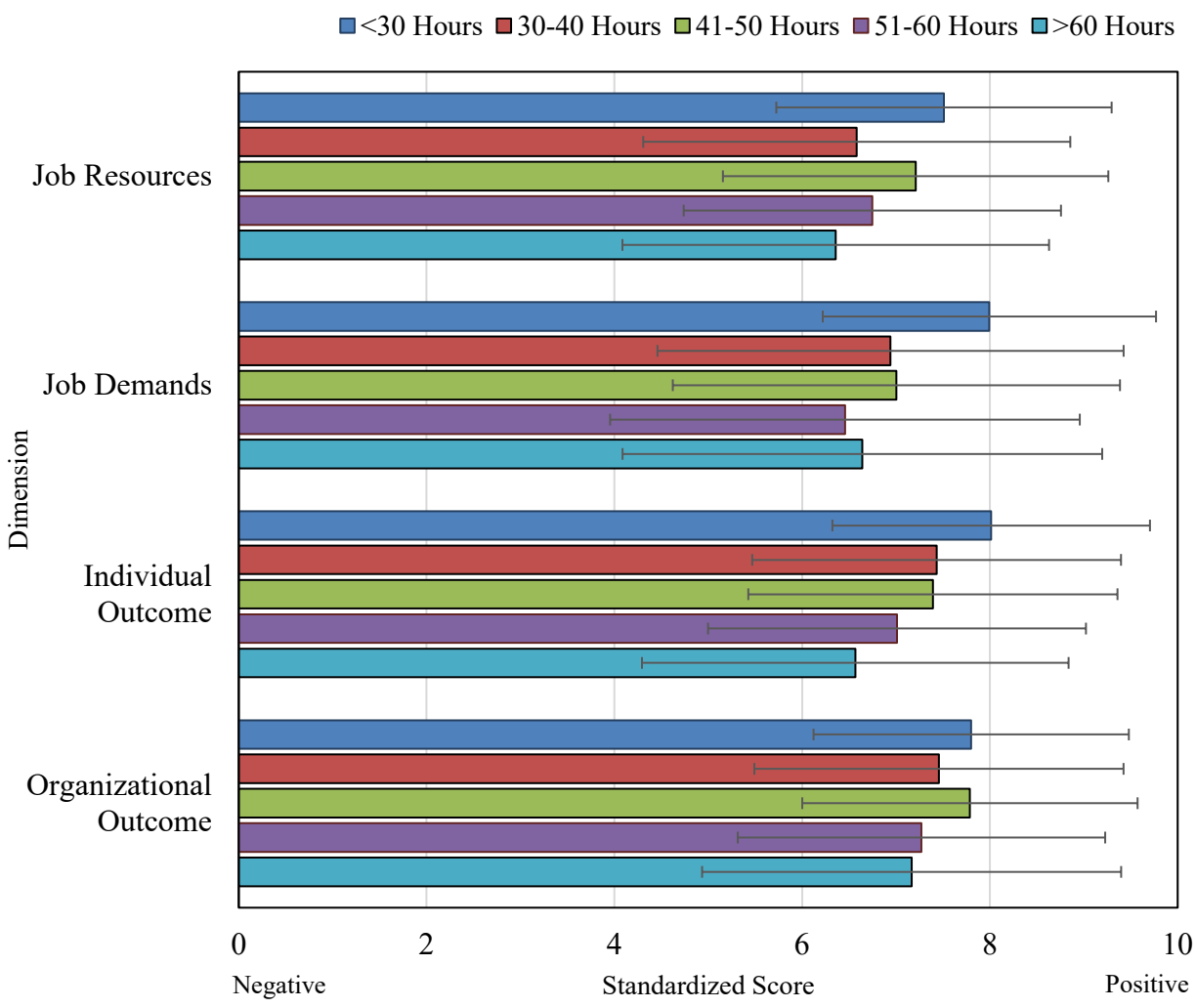
Workday	Org. 1 (Part 145)	Org. 2 (Part 135)	Org. 3 (Military, Part 145)	Org. 4 (Part 145)	Org. 5 (Part 121)	Overall
1-4 hours	0.0%	29.6%	25.8%	0.0%	0.2%	5.4%
5-8 hours	25.1%	50.7%	49.2%	35.7%	44.3%	40.9%
9-12 hours	68.8%	19.7%	19.2%	57.1%	43.9%	45.0%
13-16 hours	0.5%	0.0%	5.8%	3.6%	6.3%	4.5%
>20 hours	5.6%	0.0%	0.0%	3.6%	5.2%	4.3%

Table 6
Participant Workweek

Workweek	Org. 1 (Part 145)	Org. 2 (Part 135)	Org. 3 (Military, Part 145)	Org. 4 (Part 145)	Org. 5 (Part 121)	Overall
<30 hours	0.0%	28.2%	0.8%	0.0%	1.3%	2.8%
30-40 hours	18.1%	39.4%	23.3%	32.1%	45.6%	36.1%
41-50 hours	55.8%	12.7%	15.0%	53.6%	41.2%	39.5%
51-60 hours	25.1%	7.0%	1.7%	7.1%	7.6%	10.6%
>60 hours	0.9%	12.7%	0.0%	7.1%	4.3%	3.8%
No Response	0.0%	0.0%	59.2%	0.0%	0.0%	7.2%

Note. *The large percentage of 'No Response' observed in Organization 3 is attributable to the question not being asked for part-time, drill status guardsmen.*

Figure 5
Measured Dimensions by Workweek



Overtime and Travel Frequency

Overtime and travel frequency are reported in Table 15 and Table 16, respectively.

Table 7
Participant Overtime Frequency

Overtime Frequency	Org. 1 (Part 145)	Org. 2 (Part 135)	Org. 3 (Military, Part 145)	Org. 4 (Part 145)	Org. 5 (Part 121)	Overall
<1 per month	15.8%	57.7%	23.3%	32.1%	57.7%	43.7%
1-2 per month	16.7%	32.4%	7.5%	17.9%	22.8%	20.2%
1-2 per week	25.6%	4.2%	5.8%	14.3%	10.7%	13.0%

>2 per week	41.4%	5.6%	4.2%	35.7%	8.9%	15.9%
No Response	0.5%	0.0%	59.2%	0.0%	0.0%	7.3%

Table 8
Participant Travel Frequency

Travel Frequency	**Org. 1 (Part 145)**	**Org. 2 (Part 135)**	**Org. 3 (Military, Part 145)**	**Org. 4 (Part 145)**	**Org. 5 (Part 121)**	**Overall**
Never	66.5%	5.6%	2.5%	10.7%	46.7%	41.6%
A few times per year	30.7%	26.8%	36.7%	75.0%	43.0%	39.3%
One time or more per month	2.8%	38.0%	1.7%	10.7%	8.1%	8.4%
No Response	0.0%	29.6%	59.2%	3.6%	2.2%	10.6%