LONGITUDINAL SAFETY CLIMATE ANALYSIS: MODELING FOR ENHANCED ORGANIZATIONAL RESPONSE

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Much of the safety climate research captures only a transient state in the aviation environment, by extension limiting organizational responses to transactional approaches. The limits of the transient annual safety climate audit traps safety attitudinal/behavioral research in a static or reactive cycle. The present study takes advantage of a collegiate aviation environment with multiple training locations (each with its own culture), participating in regular safety climate audits across flight operations, to develop an enhanced safety culture model. Using longitudinal climate data collected from the organization, the authors present a mixed-methods trend analysis of safety climate changes to date, incorporating organizational structure and resource variables. The longitudinal model creates a more comprehensive evaluation of the long-term safety culture of the organization at all training locations and creates a new format for a more enhanced organizational response. The study utilizes the new longitudinal model as a framework for developing systems-based responses to climate concerns, and in turn documenting the impact of the organizational changes made in result. This paper presents initial findings based on the primary training location; final results are presented at the ISAP meeting and available after the presentation. Application across multiple aviation operation settings are discussed, including characteristics and strategies for improving organizational response to safety climate and culture evaluations.

Safety climate and safety culture have become nearly ubiquitous constructs in current discussions of both accident prevention and organizational performance (e.g., Block, et al, 2007; Gibbons et al, 2006; Karanikas, 2016). The ubiquity, rather than being a sign of a topic that has been over-researched, points to the criticality of these constructs and the acknowledgement that no research has yet completely tackled or resolved all of the challenges in the organizational safety climate field. The evolution of research into human error in aviation has continued to evolve from focus on the individual's error (e.g., Hunter, 2005) to crew/group level factors (e.g., Taylor & Thomas, 2003), and then to larger organizational influences (Mjos, 2004; Block, et al, 2007). This in turn has led to attempts to capture aspects of the the climate and/or culture within the organization that contribute to or impede 'safety' with regard to attitudes, policies, and behaviors (e.g., Bowen, et al 2011; Bowen, 2013).

Research conducted by Von Thaden, Wiegmann, and Shappell (2006) identified ten categories of organizational factors that appeared associated with commercial airline accidents investigated by the National Transportation Safety Board (NTSB). These factors included: training, surveillance, procedures/directives, standards, information, supervision, documentation, pressure, substantiation, and facilities. Their research indicated that inadequate procedures and directives were most commonly linked with aviation accidents. Both facets of their investigation provide strong evidence in favor of a systems theory approach to aviation safety. While the work of von Thaden, et al. and others (e.g., Soeters & Boer, 2000) in reviewing accident data for safety culture and organizational systems trends is extremely valuable for the creation of failure models of safety climate and culture, most aviation practitioners prefer to identify factors that will support safety in advance of incidents or accidents, rather than being forced to review and attempt to *post facto* address these failures.

One strategy to pre-emptively identify weaknesses or risk factors within an aviation organization is the implementation of an annual or semi-annual "safety climate audit". Employees at multiple levels of the organization may be asked to complete a written or oral questionnaire documenting their beliefs, behaviors, observations, or opinions regarding various categories of organizational factors and structure. Some of these questionnaires have been created by commercial designers and provided to the aviation organization, but many are self-created by a safety manager or other technical expert with safety responsibility. Many of these designing the questionnaires, however, lack any training on survey methodology, design, implementation, or analysis, leaving the organization with potentially incorrect or misleading data, or results that have been under-analyzed due to a lack of comprehension.

Unfortunately, the nature of organizational safety climate as residing heavily within the perceptions and beliefs of its members makes understanding of climate as anything more than a transient organizational state a challenge, particularly to the safety practitioner. Many practitioners as well as researchers focus on single-year findings or, at most, year-to-year changes in attitude or action as indicators of the health of the organization's safety climate, and by extension, its long-term culture (Schein, 2004). However, little work has been done to examine multi-year trends in safety climate audit data, nor to use such multi-year trends to begin an evaluation of the longer-term safety culture of the organization. The current research is an attempt to begin to fill this gap as well as provide insight into other scientist-practitioners faced with organizational questions and concerns about safety climate.

Methodology

In an attempt to begin to address the lack of multi-year data analysis within aviation organizations, the authors collected 4 years' worth of data (2012-2016) from the annual safety climate audit questionnaire at a U.S. university's collegiate aviation program, collected in the fall of each year. Flight instructors, dispatchers, office workers, and supervisors throughout the flight operation were requested to complete the audit survey each year; the organization has a nearly 100% response rate each year the survey was administered.

The safety climate audit questionnaire was created by the collegiate aviation program to evaluate potential safety concerns occurring at the individual, team, or organizational level. The 74-item questionnaire was designed by the organization and has been in use in various iterations since 2003. The most recent revision occurred in 2012; the present data set contains responses from 2013 to the present.

Respondent Demographics

Demographic data on respondents over the past 4 years can be seen in Table 1; as is apparent in the tables, respondents are primarily young (69.4% are age 30 or younger) instructors (88.1%) who are relatively new to the organization (77.7% have five or fewers years with the operation). A total of 175 respondents completed the audit questionnaire over the past four years.

Table 1: Respondent Demographics

Respondent Reported Age Ranges

20-30	118
31-40	36
41-50	5
51-60	0
60	11

Primary Job Responsibility

Flight Instructor	148
Supervisor/Manager	20

	Years in Organization	Years at Current Job
<1	38	68
1-5	94	76
6-10	19	16
11-15	14	5
16-20	3	3
20+	2	2

Certificates/Ratings Possessed

CFI	6
CFII	84
MEI	59
ATP	13
Other	3

The relative youth and short tenure of the majority of organization employees would suggest a safety climate that would be more likely to be transient from year to year based on turnover and developmental factors. To evaluate this, year over year comparisons for the safety climate audit were analyzed using univariate analysis of variance with Bonferroni correction. Results found that, of the 74 items on the safety climate questionnaire, only ten showed significant change in the past four years. These items can be seen in Table 2.

Table 2: Questionnaire Items with Significant Longitudinal Change

Safety Climate Item	F value	Pairwise Comparison Mean Scores (Significant)	
The Assistant Aviation Safety Program Manager has the power to make changes.	$F_{(3,169)}$ =3.613, p=.015	4.2766, s=1.28 5.1166, s=1.16	Year 1 Year 4
The Assistant Aviation Safety Program Manager has little or no authority compared to operations personnel.	$F_{(3,169)}$ =3.032, p=.031	3.978, s=1.39 3.113, s=1.29	Year 1 Year 4
Flight department management shows favoritism to certain pilots.	$F_{(3,170)}$ =4.635, p=.004	4.500, s=1.709 3.204, s=1.678	Year 3 Year 4
Pilots who call in fatigued fear being scrutinized by the chief pilot.	$F_{(3,171)}$ =4.164, p=.007	3.707, s=1.887 2.477, s=1.355	Year 3 Year 4
The chief pilot does not hesitate to contact instructor pilots to discuss safety issues.	$F_{(3,171)}$ =4.212, p=.007	4.553, s=1.47 5.302, s=1.26 4.553, s=1.47	Year 1 Year 2 Year 1

		5.463, s=1.24	Year 3
As long as there is no accident or incident, the chief pilot does not care how flight operations are performed.	$F_{(3,171)}$ =2.761, p=044	2.425, s=1.39 1.772, s=0.773	Year 1 Year 4
The chief pilot has a clear understanding of risks associated with flight operations.	$F_{(3,171)}$ =3.513, p=.017	5.872, s=1.11 6.418, s=0.663 5.872, s=1.11 6.454, s=0.588	Year 1 Year 2 Year 1 Year 4
Pilots often report safety concerns to their chief pilot rather than the safety department.	$F_{(3,169)}$ =2.952, p=.034	2.617, s=1.189 3.348, s=1.325	2013-2014
The flight supervisor consistently emphasizes information or details (e.g., weather requirements, NOTAMs) that affect flight safety.	$F_{(3,171)}$ =2.927, p=.035	4.634, s=1.71 5.545, s=1.021	Year 3 Year 4
The flight supervisor is responsive to pilots' concerns about safety.	$F_{(3,171)}$ =3.142, p=.027	5.439, s=1.449 6.09, s=0.603)	Year 3 Year 4

Factor Analysis

The survey was designed with items clustered around 14 theoretical constructs; however, no confirmatory analyses had been conducted to evaluate the extent to which questions actually mapped to the organizational factors. Given the high turnover rate of the primary respondent group (flight instructors), as well as the gap in time between each administration of the audit questionnaire, the decision was made for the purpose of preliminary analyses to treat the annual samples as independent for the purpose of evaluating the proposed factors. Even taking this liberty, principal components analysis (PCA) failed to provide a stable factor structure. PCA was attempted in order to reduce the number of survey items in use for subsequent analyses and provide recommendations to the flight training program for ways in which to reduce the length of the questionnaire. This failure is in part likely due to the questionnaire length (74 items) and relative overall sample size (N=175).

Table 3: Intended Factors of Safety Climate Audit

Reporting System
Aviation Safety Program Manager
Assistant Aviation Safety Program Manager
Accountability
Pilot Authority
Professionalism
Chief Flight Instructor
Training Managers
Flight Supervisor
Ramp Operations
Instructors
Safety Values
Going Beyond Compliance
Institution Safety Record

Discussion

The present study sought to increase understanding of longitudinal trends in organizational safety climate, in order to identify stronger leverage points for organizational change and enhanced safety performance. In addition, the study sought to evaluate the quality and utility of the annual safety climate audit questionnaire in use in a large-scale collegiate aviation training organization. Data presented here are based upon analysis of the initial training location under investigation; final results based upon multi-site comparison are presented at the International Symposium on Aviation Psychology and available after that meeting.

One of the key concerns to be discussed in final presentation of the data is the utilization of disparate safety climate audits at each flight training location within the institution. The authors strongly recommend that the institution identifies a single set of safety climate items for use at all training locations in order to facilitate future cross-analyses and the impact of larger institutional trends.

Data from Site 1 suggest that employee attitudes regarding the majority of safety climate components have remained consistent over the past four years. Only ten of the 74 items in the climate questionnaire showed significant differences in comparing data over time. This, when coupled with the high rate of turnover among front line flight instructor employees, suggests a remarkably consistent culture in existence within the training operation. This may be due in part to the highly-regulated structure of the FAA Part 141 training program, or due to other organizational factors. This finding may be one of the most significant of the study, as it indicates areas in which change may be initially occurring within the organization, with regard to employee attitudes. These ten items may be the indices of leverage points within the organization; future research to explore and clarify these results is planned.

The authors propose substantially reducing the number of items in the safety climate audit using a more theory-based factor structure. The current structure, with 74 items attempting to encompass 14 factors, contains a large degree of conceptual overlap and a lack of question clarity. This can be seen in the failure of the principal components analysis to provide a consistent factor structure.

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