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## **QUALITY IN AIRLINE SAFETY: QUALITY METHODS AND TOOLS ARE NEEDED TO MANAGE NEW DIRECTIONS**

Alan Stolzer and Carl Halford

### **INTRODUCTION**

Approximately 650 million people fly on U.S. certificated air carriers annually (Department of Transportation: Federal Aviation Administration, 2003). Although statistically air transportation is one of the safest modes of travel, the few airline accidents that occur never fail to garner substantial media attention and concern of the public. The responsibility to seek ways to improve air transportation safety falls on all involved in aviation – practitioners and educators alike.

The purpose of this article is to provide, through a review of literature, a brief examination of the past, present, and future state of efforts to address airline safety, and to encourage educators to become involved in promoting the use of quality tools to improve safety.

#### **The Past**

Early airline safety departments functioned primarily in a reactive mode – investigating the most recent accident or incident and taking action to, hopefully, prevent a recurrence of the problem. Safety department staffs were generally small and personnel lacked specific training on how to do their jobs effectively. Often these departments were staffed with pilots who were no longer able to fly for medical reasons. Similar to the quality control function in the early days (Juran, 1994), the airline safety function was informal and tended to be distributed throughout the organization.

The result of this relatively low level of focus on accident prevention was predictable. In the 13-month period ending in January 1994 there were 13 airline accidents that resulted in 288 fatalities (National Transportation Safety Board, 2003). These accidents brought intense focus on airline safety and led to several regulatory changes designed to enhance safety.

#### **The Present**

To address the increasing accident rate in the early 1990s, the FAA convened an Aviation Safety Summit in January 1995, bringing together representatives from all aspects of aviation, especially airline operations. Several Federal Aviation Administration (FAA) regulations and initiatives were enacted as a consequence of this summit – all intended to strengthen safety and reduce accidents. For

example, in 1999 regulations were put in place requiring airlines to appoint a *trained* and qualified director of safety (Federal Aviation Administration, 1999). The FAA established very specific training requirements for the director, including training in corporate safety culture, safety data collection and analysis programs, risk management, incident/accident prevention and investigation, and others. As will be noted shortly, additional training was still needed for these individuals and their staffs.

Another dynamic that has changed is our technological capability to collect and analyze data. Data-intensive safety/quality programs such as Flight Operations Quality Assurance (FOQA), Aviation Safety Action Program (ASAP), Advanced Qualification Program (AQP), Air Transport Oversight System (ATOS), Global Aviation Information Network (GAIN), and others have been developed in the past five to ten years for the purpose of giving managers better information upon which to make decisions. To better understand the nature of the safety programs being developed and employed at airlines, a brief description of FOQA follows.

**Flight Operations Quality Assurance (FOQA).** One of the significant conclusions of the 1995 Aviation Safety Summit was that the voluntary implementation of FOQA might be the most promising initiative to reduce the number of accidents. As defined in 1993 by the Flight Safety Foundation, FOQA is, “a program for obtaining and

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analyzing data recorded in flight to improve flight-crew performance, air carrier training programs and operating procedures, air traffic control procedures, airport maintenance and design, and aircraft operations and design” (Flight Safety Foundation, 1998). Upon the recommendation of the conference attendees, the FAA sponsored a FOQA demonstration project with the following objectives: to develop hands-on experience with FOQA technology in a U.S. environment, document the cost-benefits of voluntary implementation of FOQA programs, and initiate the development of organizational strategies for FOQA information management and use. The three-year, FAA-funded, \$5.5 million demonstration project was begun in July 1995, and more than ten U.S. airlines have approved programs today.

Depending upon the capabilities of the airplane involved, FOQA collects parameters from hundreds of sensors and data sources on the airplane. On a typical Boeing 757 manufactured 15 years ago, for example, FOQA records and stores 200 to 300 parameters per second. Sophisticated airplanes produced today are capable of capturing over 2,000 parameters per second (Phillips, 2002). Parameters recorded include: altitude, airspeed, heading, control surface position, engine and system condition information, cockpit switch positions, information from navigation equipment, and so on. Many FOQA systems are capable of indicating such things as whether the cabin seat belt light is illuminated, the amount of turbulence the airplane is in (using g-load/accelerometer sensors), and the wind drift angle. Using expert software tools, these data are explored to detect single events or exceedances (i.e., deviations from defined expectations) that may have occurred, and the data are aggregated to learn about trends that may indicate areas that need further attention.

The data collected in a FOQA system is virtually the same as that collected in the digital flight data recorder system – the so-called ‘black box’ – that investigators use to determine the cause of aircraft accidents. In the case of the flight data recorder, data from the last 25 hours of flight are stored in a crash resistant container, typically in the tail section of the aircraft. The data are almost always retrievable in the event of a crash, but otherwise the data are difficult to access. FOQA, on the other hand, is designed to use the data for purposes other than crash investigation, so the data medium, such as an optical storage device or PCMCIA card, is readily accessible during routine maintenance events.

Several examples of safety and operational problems for which FOQA provided objective information

are cited by the Flight Safety Foundation (1998).

- An airline discovered through its FOQA program that the number of exceedances was greater during flight in visual conditions than in instrument conditions. This finding caused the airline’s training managers to change the training program to emphasize flight in visual conditions. This is a demonstrable quality and safety benefit that was enabled by the FOQA program.
- Another airline’s FOQA analysis determined that the incidence of descent-rate exceedances was unusually high at one particular runway at a specific airport. The cause was determined to be a poorly designed instrument approach procedure that required flight crews to descend steeply during the final approach segment. When these findings were shared with the FAA, the approach was redesigned to correct the problem.
- FOQA has provided a number of airlines objective, quantitative information that can be used to evaluate approach procedures that are unusual with respect to rate of descent or excessive maneuvering at low altitude.
- Airlines have reported that they have used FOQA information to identify and correct a variety of safety problems through changes or renewed emphasis in standard operating procedures, retraining, and repair of faulty equipment.

The Federal Aviation Administration’s preliminary estimates of costs versus benefits of FOQA programs were encouraging to advocates of FOQA. Although difficult to quantify (e.g., the savings from *not* having a crash), the FAA estimated that the annual cost of a FOQA program with 50 aircraft would be approximately \$760,000 per year. Savings from reduced expenditures for fuel, engine maintenance, and accident costs were estimated at \$1.65 million per year, resulting in a net annual savings of \$892,000 (Flight Safety Foundation, 1998). In an industry where profit margins are small and every dollar counts, these projected savings coupled with the desire to improve safety have been sufficient to fuel the airlines’ interest in FOQA.

Aviation Performance Measuring System. With the advent of FOQA and other programs that generate vast amounts of data (e.g., GAIN, ASAP, radar and air traffic control data, risk analysis), it is apparent that sophisticated tools must be available to derive meaningful information from the data.

Recognizing the potential for system-wide safety improvements, the FAA and NASA began an FAA-funded collaborative program in 1993 to develop a set of tools and methodologies to process data in a highly automated manner. The objectives of the Aviation Performance Measuring System (APMS) are to: establish a sound scientific and technological basis for analyzing flight data; to define an open and flexible architecture for data analysis systems; and to develop and promulgate guidelines for a standardized database structure for future analysis extensions. While current vendor-provided FOQA analysis tools exist, APMS seeks to provide more, advanced data analysis and analytical tools coupled with a means of interchanging data across competing software programs.

While standard FOQA tools focus primarily (but not exclusively) on exceedance detection, APMS is intended to expand the scope of FOQA by using all available data for safety and efficiency. Examples of tools in testing or various stages of development by NASA and contractor-partners are (Chidester, 2003):

- Event processing system
- Graphical viewer with links to animation and performance envelopes
- Exceedances report generator
- Pattern search – enables analyst to search the entire database, or a portion thereof, for a specified portion of flight parameters
- Routine events – documents the distribution of key parameters relevant to standard operating procedures at points during a flight
- Phase of flight reports – presents key descriptive statistics for various user-determined parameters
- Data integration – enables the linkage of flight data to other data streams, such as weather and traffic
- Atypicality analysis – uses multivariate cluster-analysis to group flights based on similarities of flight signatures, and calculates an atypicality score for each flight.

#### Managers Lack Training

In spite of the availability of both internal and external sources of information coupled with increasingly sophisticated computer technology, many flight safety managers (FSMs) lack knowledge and training in the use of quality and statistical tools necessary to reap the maximum advantage from these potent sources of information. According to a recent report by a GAIN working group, FSMs have received no specific guidance about the analytical procedures to follow to carry out their responsibilities, and their approach to the job lacks a well-

defined process – with specific objectives and priorities – to identify safety problems. The report concludes that the FSMs gain most of their knowledge from experience they accrue on the job, and that there is a need for enhancing FSM skills and knowledge (Global Aviation Information Network, 2001).

In a survey question regarding the company's safety management strategy, it was determined that only one airline out of the 15 surveyed has a clearly defined safety strategy that includes practices for the use of tools and processes. The use of tools by the respondents to achieve desired safety levels is minimal at best. Some of the tools used include Microsoft Excel, Microsoft Access, Aviation Quality Database, various aviation safety reports, and others. Regarding the use of more sophisticated tools and processes, one airline reported using a tool called Procedural Event Analysis Tool, another reported employing Reason's model and root cause analysis, and several airlines perform flight data analysis and trending using internal databases (Global Aviation Information Network, 2001). What may be most noteworthy regarding the list of tools used is the absence of well-established quality tools and processes such as control charts, Pareto charts, scatter diagrams, cause and effect diagrams, and many of the quality management tools.

#### **The Future**

There has been a gradual movement in the air transportation industry to embrace quality principles. For example, numerous air transportation companies and organizations have, in whole or in part, achieved ISO 9000 series registration, such as China Airlines, The Boeing Company, Federal Aviation Administration, Honeywell, Jeppesen Sanderson, Raytheon Aerospace Company, Rockwell Collins, and others. AS 9100 has been created as an aviation-specific variation of the general ISO 9000 standards. Groups, such as the International Aerospace Quality Group and the American Society for Quality's Aviation/Space & Defense Division, have been formed to promote various aspects of quality in aviation (Brong, 2002).

Herein lies the opportunity, and the stage is set. Quality has proven its worth in a host of industries, perhaps most notably in the automotive and electronics industries. The gains other industries have made using proven quality processes have been well documented (e.g., Kondo, 2001; Eriksson and Hansson, 2003; Miller and Morris, 2000; "Q-100 Stock Index", 2002), yet there may be no more imperative place to incorporate sound quality principles than in an airline safety environment, where the consequence of poor quality inevitably results in loss of life.

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Each organization has different purposes and goals as well as workforce capability and training, so it is not possible to prescribe which quality programs and tools should be used. The process should begin with the development of a comprehensive quality management system, which will lead to a disciplined approach to developing the airline's safety strategy and methods. Hand-in-hand with the development of this system should be the identification of the knowledge and skills needed to manage the quality system, and the creation of training programs that assure qualified people are available to manage the system.

Most would agree that the airline safety department of the future will have the following characteristics:

- A customer focus
- Leadership – operationally independent and focused on safety
- A process approach to all operations
- A systems approach to management
- Fact-based decision making
- A system for continuous improvement
- Eagerness and capacity to implement the 'best' safety tools, e.g., FOQA, ASAP
- An audit and improvement system (e.g., Air Transport Oversight System) markedly superior to FAA regulatory oversight
- A proactive rather than reactive approach to safety management (Walters, 2002)

As stated by the Flight Safety Foundation (1997), an effective airline safety program is one that: enjoys the support of top management; is viewed as a partner rather than an adversary; has access to the appropriate internal and external data and information from various safety initiatives;

makes safety information readily available to all who need it; and has the staff, tools and training necessary to achieve its purpose.

### CONCLUSION

Airline safety is at an important crossroad. Despite a commendable safety record, public apprehension of airline safety is high, modern aircraft and systems are becoming increasingly complex, and airspace is very congested in many parts of the country. Many experts believe that these advances and others have outpaced the industry's safety infrastructure.

Similarly, technology has enabled the development of more sophisticated tools for managing safety than ever before. Data collection and storage systems are robust, computer processing power is abundant, and the industry's safety culture is maturing.

But what is lacking is a disciplined quality approach to improving safety. Airlines must increasingly embrace and employ quality principles in designing, implementing, and managing safety programs. The expertise necessary to do this may be obtained through quality training for flight safety managers, employment of quality professionals in the safety departments, or extensive consultation with quality experts. Regardless of which method or combination of methods the airlines choose to employ, quality in airline safety must be the goal.

Finally, educators must take a proactive role in providing the training necessary to improve airline safety through quality. Faculty and administrators must realize the value of the quality approach to safety through examination of the literature, and incorporate these principles into relevant coursework for all those involved in the safety function. →

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