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THE U.S. NAVY’S AVIATION SAFETY PROGRAM: A CRITICAL REVIEW.

Abstract

Safety research has shown that human error, as opposed to mechanical failure, is a major causal factor in accidents in high reliability organizations. In U.S. Naval aviation, human error accounts for more than 80% of mishaps. This paper represents the first attempt to summarize the elements of the U.S. Naval aviation safety program in a single document, and disseminate it to a non-military audience. The program is discussed in the context of safety research carried out in other military and high reliability organizations. The many areas in which the U.S. Navy has learned from other high reliability organizations are identified, and areas in which the elements of the Navy’s safety program could be adapted to mitigate the human factors causes of mishaps in commercial aviation delineated.
Introduction

Just as in commercial aviation, the mishap rate in U.S. Naval aviation has sharply declined since the 1950s (see Figure 1). Over the years there have been great advances in material technology, fuels and oils, aerodynamics, meteorology, radio communications, and navigation facilities which have all helped in reducing the number of aircraft accidents. Further advances in safety have been made through improvements in procedures and standards.

Figure 1. U.S. Naval major aviation mishap rate (Naval Safety Center, 2007).

Although the absolute mishap rate has decreased, the proportion of mishaps attributed to human error has not decreased at the same rate as the mishaps involving...
mechanical and environmental factors (Wiegmann & Shappell, 2003). In naval aviation, human error accounts for more than 80% of mishaps (Naval Safety Center, 2006). This finding is not unique to naval aviation, between 80% and 90% of all work related accidents and incidents can be attributed to human error (Health and Safety Executive, 2002; Hollnagel, 1993, Reason, 1990). Therefore, just as with other high reliability organizations (e.g. commercial aviation, nuclear power generation, offshore oil production, medicine), there is a recognition within naval aviation of the need to address the human causes of mishaps. Some of the techniques used to address the human factors causes of U.S. Naval aviation mishaps are adapted from other branches of the U.S. military and high reliability organizations (e.g. safety climate surveys, crew resource management). However, others are unique to U.S. Naval aviation (e.g. human factors reviews).

This paper represents the first attempt to summarize the elements of the U.S. Naval aviation safety program in a single document, and disseminate it to a non-military audience. The program will be discussed in the context of safety research carried out in military and other high reliability organizations. It will identify the many areas in which the U.S. Navy has learned from other high reliability organizations, and also delineate possible area in which elements of the Navy’s safety program could be adapted to mitigate the human factors causes of mishaps in commercial aviation.
U.S. Naval Aviation Safety Program

The goals of the U.S. Navy aviation safety program are to eliminate hazards and enhance the safety awareness of squadron personnel. The safety program’s “only purpose is to preserve human lives and material resources and, thereby, enhance readiness” (Chief of Naval Operations, 2001a: 2-1). The elements of the U.S. Navy’s aviation safety program can be divided into three categories: training, proactive hazard recognition, and safety performance evaluation (see Table 1). Each of these elements will be discussed below.

Table 1. Elements of the U.S. Navy’s Aviation Safety Program.

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Training

Learning is an important requirement for improving safety performance in high reliability organizations (Carroll, 1998). The U.S Naval aviation safety program includes safety training developed for specific personnel within the squadron, as well as safety training that is applicable to every member of an aviation squadron.

Aviation Safety Officer course

Every U.S Navy and Marine Corps squadron has an aviation safety officer (ASO). The ASO is a naval aviator whose primary roles are to advise the Commanding Officer (CO) on all aviation safety matters, assist the CO in establishing and managing the command aviation safety program, and maintain aviation safety records and squadron mishap statistics (Chief of Naval Operations, 2001a). The ASO is trained for this role at the Navy/Marine Corps School of Aviation Safety. The ASO course is 23 days of instruction in safety programs, human factors, aerospace medicine, mishap investigation, mishap reporting, aerodynamics, and structures.

Aviation Safety Command course

The commitment of senior personnel to safety is crucial to maintaining a successful and sustainable safety program.Aviators that have been selected for command of a squadron attend a six day aviation safety command course at the Navy/Marine Corps School of Aviation Safety to prepare them for the role of a squadron CO. The Aviation Safety Command course can be regarded as an abbreviated version of the ASO course (see above) that has been specifically tailored for the role of senior leadership personnel.
Crew resource management training

The civil aviation industry was instrumental in developing Crew Resource Management (CRM), a training program designed to reduce error and increase flight crew effectiveness (Wiener, Kanki, & Helmreich, 1993). Due to the success of CRM training in civil aviation, it is now the most widely applied technique for providing team training to operations personnel in high reliability organizations (see Flin, O’Connor, & Mearns, 2002 for a review), and military aviation.

The goal of naval CRM training is to “improve mission effectiveness by minimizing crew preventable errors, maximizing crew coordination, and optimizing risk management” (Chief of Naval Operations, 2001b). Unlike commercial aviation, the U.S. Navy considers CRM training to be an operational training program, as opposed to a safety training course. However, if CRM’s goal of reducing preventable crew errors is achieved, improvements in safety would also be an inevitable outcome of CRM training.

The content of the U.S. Navy’s CRM training is driven by seven skill areas (decision making, assertiveness, mission analysis, communication, leadership, adaptability/flexibility, and situational awareness) and associated behaviors required for effective aircrew coordination (Prince & Salas, 1993). Every naval aviator must receive ground training and a CRM evaluation during an actual, or simulated flight, by a CRM instructor, or facilitator, once a year.

As has been the case with CRM in commercial aviation (see O’Connor, Flin & Fletcher, 2002; Salas, Wilson, Burke, Wightman & Howse, 2006; for a review), evaluations of the effectiveness of the U.S. Navy’s CRM training have been reported in the scientific literature. Course participants were found to be enthusiastic in their
reactions to the training (Baker, Bauman, & Zalensy, 1991; Salas, Fowlkes, Stout, Milanovich, & Prince, 1999; Stout, Salas, & Carson, 1994; Stout, Salas, & Kraiger, 1996) there was a positive shift in attitudes to the topics addressed in CRM training (Alkov, 1989; Alkov, 1991; Alkov & Gaynor, 1991; Baker et al., 1991; Salas et al., 1999; Stout et al., 1994) there was an increase in knowledge (Stout et al., 1996); and an improvement in CRM behavior of aircrew as a result of attending the training (Salas et al., 1999; Stout et al., 1994; Stout et al., 1996). Alkov (1989) and Alkov and Gaynor (1991) also reported a decrease in the mishap rate for three naval aircraft communities (helicopters, attack bombers, and multiplaced fighters) as a result of CRM training.

_Safety standdown_

A safety standdown is a dedicated period of safety training carried out by the squadron. The purpose is to provide a period of time, typically a morning or afternoon, in which the command focuses specifically on safety. During a safety standdown no flying is carried out. The training typically consists of a series of presentations concerned with safety issues that are of particular relevance to the squadron.

_Publications_

The Naval Safety Center publishes two monthly magazines that are devoted to aviation safety. The focus of _Approach_ is for aviators, and _Mech_ is for squadron maintenance personnel. Both magazines contain stories from naval aviators and maintainers regarding real-life situations in which a mishap was narrowly avoided, as well as information on the Navy’s safety programs. The Naval Safety Center’s website
(www.safetycenter.navy.mil) also has links to safety related instructions, presentations, articles, etc.

**Discussion: Safety training**

In terms of safety training, there is little commercial aviation can learn from the U.S. Navy’s safety program. Commercial aviation companies employ specially trained safety professionals, carry out recurrent safety and CRM training, and there are many different commercial aviation safety publications published by airlines, regulators, and aviation safety interest groups. However, there is much for the U.S. Navy to glean from commercial aviation in terms of integrating CRM training into technical training, developing CRM training for automated aircraft, and the use of behavioral markers to assess the CRM skills of aviators. Commercial aviation has made great strides in developing and utilizing behavioral marker systems such as the NASA/University of Texas Behavioral Markers (Federal Aviation Authority; FAA, 2004a, 2006a) and NOTECHS (see Flin et al, 2003 for more details). A behavioral marker system is a taxonomy or listing of key non-technical skills associated with effective and safe task performance in a given operational job position (Civil Aviation Authority; CAA, 2006). Behavioral marker systems have been developed for use by military aviation (e.g. TARGETS, Targeted Acceptable Responses to Generated Events or Tasks; Fowlkes, Lane, Salas, Franz, & Oser, 1994). However, unlike commercial aviation, as yet, behavioral markers have not been widely adopted by U.S. naval aviation.
**Proactive hazard identification**

The purpose of the proactive approach is to recognize and address hazards before they result in a mishap. The early identification of hazards reduces the need to wait for the system to fail in order to identify weaknesses and to take remedial actions (Flin, Mearns, O’Connor, & Bryden, 2000).

**Human factors review**

The Human Factors Council (HFC) and the Human Factors Board (HFB) are used by commanding officers to maintain an awareness of the physical conditions, the psychological well-being, the attitudes, and the motivation of their aircrews. The HFC is a regular (every month for Marine, and once per quarter for Navy squadrons; Chief of Naval Operations, 2001a), proactive, informal review of all officer and enlisted aircrew. The members of the HFC include at a minimum: the CO or Executive Officer (XO, second-in-command of the squadron), the ASO, the operations officer, the training officer, the Naval Air Training and Operating Procedures Standardization (NATOPS; the individual in the squadron responsible for flight safety training) officer, and the flight surgeon (Chief of Naval Operations, 2001a). The personal and professional characteristics of the aircrew are discussed in order to identify potential impacts on their flight performance. Information obtained from the HFC is confidential, and is not to be used for disciplinary or administrative reasons. The CO alone acts on this information, the sole purpose is for the enhancement of safety (Chief of Naval Operations, 2001a). If the HFC should identify a member of the aircrew who may be having some minor issues, then the HFC members will identify ways in which the member could be helped.
However, if the HFC identifies more serious issues that may interfere with a crew member’s ability to safely perform flight duties, then the CO could convene an HFB.

The HFB is a formal human factors review of a member of the aircrew. It focuses upon identifying and mitigating the concerns about the members ability to safely perform their flight duties. It is non-punitive, the focus is on helping the individual resume their responsibilities as an effective squadron member. The HFB should include, at a minimum: the ASO, flight surgeon, and any other officers of the CO’s choosing (Chief of Naval Operations, 2001a). Examples of situations in which a HFB would be appropriate are a single or sustained deficiency in performance, failure to achieve expected training goals, a preponderance of life stressors, and aeromedical problems (e.g. poor physical fitness, recurring airsickness; Commander Naval Air Forces, 1997).

Operational risk management

Operational risk management (ORM) is a decision making tool designed to increase operational effectiveness by anticipating hazards and reducing the potential for loss (Chief of Naval Operations, 2004). ORM is utilized Navy-wide, and is not specifically a naval aviation safety program. Nevertheless, given the dynamic nature of flight operations, the ORM concepts have particular relevance to naval aviation. The Navy’s ORM program grew out of ideas originally developed to improve safety in the development of new weapons, aircraft and space vehicles, and nuclear power. The U.S. Army was the first branch of the military to adopt the ORM principles, in 1991, to reduce training and combat losses. As a result of the success of ORM in the U.S. Army, it was adopted by the U.S. Navy in the late 1990s (Chief of Naval Operations, 2004).
ORM should be applied to all aspects of a command’s operations and activities. ORM consists of three elements: principles, steps, and levels (Naval Safety Center, 2006). The principles are concerned with risk assessment; steps involve hazard analysis, and methods to address the hazards; and levels describe time-related factors regarding the implementation of risk management. The principles of ORM are: (i) accept risk when benefits outweigh costs; (ii) accept no unnecessary risk; (iii) anticipate and manage risk through planning; and (iv) make risk decision at the proper level. The steps of ORM are: (i) identify controls; (ii) assess hazards; (iii) make risk decisions; (iv) implement controls; and (v) supervise. The three levels of ORM are: (i) time critical, an ‘on the run’ mental or oral review of the situation; (ii) deliberate, used in the planning phase of an operation; and (iii) in-depth, a very thorough and detailed risk assessment (see Chief of Naval Operations, 2004 for more details). Although not mandated, it is common practice for squadron COs to require aviators to complete a deliberate ORM worksheet prior to a flight. The aircrew identify potential hazards, and a numerical risk assessment code is applied to assess whether or not the they should go ahead with the mission.

**Squadron Safety Councils**

For naval aviation squadrons there are two committees in place to address safety issues: the Aviation Safety Council (ASC) and the Enlisted Aviation Safety committee (EASC). These committees consider a range of safety issues involving the squadron’s current operations and personnel. These issues may include procedures, flight line hazards, or human factors causes of aviation mishaps. The purposes of the ASC are to “review command plans, policies, procedures, conditions, and instructions to ensure their
currency, correctness and responsiveness to safety recommendations” (Chief of Naval
Operations, 2001a: 2-4). The ASC consists of the ASO, ground safety officer (the
individual at the squadron who is responsible for non-aviation safety matters), and the
flight surgeon. The EASC includes an enlisted representative from every work center in
the command. The EASC meets monthly to discuss safety deficiencies, and provide
recommendations for improving safety practices and awareness.

‘Anymouse’ reporting

Every squadron shall provide a mechanism for anonymously reporting hazards
(Chief of Naval Operations, 2001a). In most squadrons, this consists of a locked box in
which squadron members can anonymously post any concerns. Generally, the box is
emptied by the ASO, and the information given to the CO for action. Although specific
processes may vary from squadron to squadron, the concept is the same: a mechanism for
anonymous reporting may facilitate a report of a safety issue that otherwise would go
unreported due to fear of retribution or embarrassment.

The FAA (2002) provided guidance to commercial aviation companies on setting
up an Aviation Safety Action Program (ASAP) to encourage employees to voluntarily
report safety information. U.S. Naval aviation has also begun fielding an anonymous
reporting system based upon NASA’s Aviation Safety Reporting System (ASRS) called
Pulse Plus. The ASRS database is a collection of incident reports that are voluntarily
submitted to NASA for use by aviation safety researchers. ASRS and other confidential
reporting systems such as the United Kingdom’s Confidential Human Factors Incident
Reporting Programme (CHIRP) have been invaluable in improving safety in commercial
aviation. For example data in the ASRS database has been used to study error types (Sarter & Alexander, 2000), situation awareness (Jones & Endsley, 1996), and alarm related accidents (Bliss, 2003). The information from confidential reporting systems has been used to redesign aircraft, air traffic control systems, airports, and pilot training to reduce the likelihood of human error (Tamuz, 1994). It is hoped that the Navy’s Pulse Plus system will also prove valuable in capturing safety related information that would otherwise be unreported by aviators.

The U.S. Navy has also started to field a flight data monitoring program called the military flight operational quality assurance (MFOQA). MFOQA is based upon civilian aviation’s voluntary flight operational quality assurance (FOQA) program. FOQA uses quick access recorders (QARs) to identify deviations for flight parameters specified in the standard operating procedures (Civil Aviation Authority; CAA, 2003). This information can be used to identify inadequate procedures, ineffective training and briefing, poor CRM skills, fuel inefficiency and environmental impact, aerodynamic inefficiency, powerplant deterioration, and systems deficiencies (Holtom, 2000). FOQA programs allow the early identification of safety trends, that could lead to accidents (FAA, 2004b).

Hazard report

A hazard report (HAZREP) is a method for highlighting hazards in naval aviation before they lead to a mishap (Chief of Naval Operations, 2001a). “A hazard is a potential cause of damage or injury that is under human control” (Naval Safety Center, 2001: 14). There are four purposes of HAZREPs: (i) to report a hazard and the remedial action taken
to address the hazard, so others can take similar action; (ii) to report a hazard and recommend corrective action for others; (iii) to report a hazard so some other organization can determine the appropriate corrective action; and (iv) to document a continuing hazard in order to establish risk severity (Naval Safety Center, 2001). A HAZREP is submitted by the squadron to the Naval Safety Center via mail, e-mail, or the web enabled safety system (WESS; a web based system for developing a HAZREP). It is also possible to submit an anonymous HAZREP in which only the Naval Safety Center knows the name of the individual who submitted the report. HAZREPs can be submitted to address non-human factors hazards. In fact, the vast majority of HAZREPs are not concerned with human factors issues. Reason (1997) comments that it is not an easy task to persuade people to file a report about a near miss, especially if this requires divulging their own errors. It is for these reasons that U.S. Naval aviation has started fielding Pulse Plus and MFOQA (see the earlier section on ‘anymouse’ reporting for a discussion).

**Commanding Officer’s safety policy**

A CO should establish a written set of aviation safety goals and safety policy that defines how squadron personnel should attain these goals (Chief of Naval Operations, 2001a).

**Discussion: Proactive hazard reporting.**

The use of FOQA and ASRS, as used in commercial aviation, have served as good models for proactive hazard reporting in U.S. Naval aviation. Another commercial aviation safety program that may have benefits for U.S. naval aviation is the Line
Operations Safety Audit (LOSA). LOSA involves specially trained observers collecting safety related information on environmental conditions, operational complexity, and flight crew performance during normal flight operations (FAA, 2006a). These observations are non-punitive and the findings are aggregated to identify trends in error prevalence and flight crew management, crew performance strengths and weaknesses, and threat and error linkages with undesired aircraft states (Klinec, Murray, Merritt, & Helmreich, 2003).

The elements of proactive hazard reporting used by U.S. Naval aviation that may have applications for improving safety in commercial aviation are human factors reviews and operational risk management. Alkov, Borowsky, and Gaynor (1982) and Alkov, Gaynor, Borowsky (1985) evaluated the life style changes and personality characteristics of U.S. naval aviators who had been involved in a mishap. They compared the responses of the aviators who had made an error that contributed to the mishap, to those aviators who were involved in a mishap, but did not make an error. It was found that that when compared to the ‘not at fault’ aviators, the ‘at fault’ aviators were significantly more likely to have had pre-existing major life stressors such as marital problems, problems with interpersonal relationships, recent trouble with supervisors, and recent trouble with peers. Other research with military aviators has shown that acute stress (e.g. Otsuka, Onozaw, & Miyamoto, 2006), personality (e.g. Parsa & Kapadia, 1997), fatigue (e.g. Hardaway & Gregory, 2005), or aspects of national culture (Soeters & Boer, 2000) can have a detrimental effect on the safety performance of aviators.

Similarly, in commercial aviation there are many studies that have identified the detrimental effects of personal factors such as stress (e.g. Loewenthal, Eysenck, Lubitsh,
Gortin, & Bicknell, 2000), fatigue (e.g. Goode, 2003), and hazardous thought patterns (e.g. FAA, 1991; Hunter, 2005, 1995) on aviator performance, Taken together, these studies suggest the identification of aviators engaged in these types of behavior through an intervention program such as human factors reviews should be considered an important technique for mishap prevention.

The ORM process may also have utility for commercial aviation, especially considering that 37% of commercial mishaps can be attributed to decision errors (Shappell, Detwiler, Holcomb, Hackworth, Boquet, & Wiegmann, 2007). The importance of risk management is recognized by the FAA. “A formal system of hazard identification and safety risk management... is essential in controlling risk to acceptable levels” (FAA, 2006b: 9). Further, the risk management strategy proposed by the FAA, is based upon the same steps as the U.S. military’s ORM program (FAA, 2006b). Therefore, basing a risk management strategy on a system that is already developed, and applied, may serve as a useful model for commercial aviation companies.

**Safety performance evaluation**

Evaluating the safety program is crucial to ensure that it is achieving the goal of improving safety. Traditionally, safety performance in high risk organizations has been assessed solely on the basis of ‘lagging indicators’ of safety such as fatalities, or mishap rates. However, more recently, high risk organizations (and U.S. Naval aviation) have also started to examine ‘leading indicators’ of safety such as safety audits or measures of safety climate (Flin et al., 2000). Examples of leading indicators that are used in commercial aviation that were discussed earlier are FOQA, ASRS, and LOSA. The use of
leading indicators of safety allows issues to be addressed before they result in a mishap.
The reason for the shift in focus is that in the last 20 years the severe aviation mishaps rate has decreased to such low levels (see figure 1), that it ceases to be a useful measure of safety performance. Therefore, there is a need to utilize other metrics of safety performance. The U.S. Naval aviation’s leading and lagging metrics of safety performance are described below.

*Mishap investigating and reporting*

The collection and accurate analysis of accident data is essential for improving workplace safety (Dismukes, Berman, & Loukopoulous, 2007; Kayten, 1993; Wiegmann & Shappell, 2001). However, this is not an easy goal to achieve. For example, Gordon, Flin, & Mearns (2005) argued that many accident reporting systems used by the offshore oil industry in the UK lacked a firm theoretical framework for identifying the human factors causes of accidents.

Unlike commercial aviation, an independent body does not investigate a U.S. Naval aviation mishap. Should a squadron have an aviation mishap, an aviation mishap board (AMB) will be formed to investigate. At a minimum, the AMB will consist of: an ASO, a flight surgeon, an officer knowledgeable about aircraft maintenance, an officer knowledgeable about aircraft operations, and a senior member who is in-charge of the board (Chief of Naval Operations, 2001a). All of the members of the AMB are in the U.S. Navy. Marine Corps, and only the senior member is from a different squadron. The AMB is responsible for investigating and reporting the cause(s) of the mishap up the military chain-of-command in a standard form to the Naval Safety Center. The flight surgeon
assigned to the AMB is the individual primarily concerned with the investigation of the human factors causes of a mishap. The flight surgeon uses the Human Factors Analysis Classification System (HFACS) to delineate the human factors causes of the mishap. HFACS has been used to investigate and classify human error in military, commercial, and general aviation (Shappell et al, 2007).

Safety survey

The purpose of a safety survey is to provide a periodical assessment of a squadron’s safety program (Chief of Naval Operations, 2001a). An informal survey can be conducted by squadron personnel, or by staff from a sister squadron. However, a squadron must request a formal safety survey from the Naval Safety Center biennially, regardless of whether an informal survey was carried out. The safety surveys ensure that a squadron is effectively utilizing the safety programs described in this paper.

Safety climate/culture assessment

Widely accepted definitions of safety climate and culture do not exist. Zohar (1980) defined safety climate as a summary of perceptions that employees share about their work environment. Safety climate describes employees' perceptions, attitudes, and beliefs about risk and safety (Mearns & Flin, 1999). It is a "snapshot" of the current state of safety in a squadron. Safety culture is a more complex and enduring trait reflecting fundamental values, norms, assumptions and expectations, which to some extent reside in societal culture (Mearns & Flin, 1999). Measurement of safety culture requires in-depth investigation including an analysis of how organizational members interact to form a
shared view of safety. A squadron CO can obtain quantitative information on the unit’s safety climate using the Naval Aviation Command Safety Assessment Survey (CSAS), and qualitative information on the unit’s safety culture through a safety culture workshop.

The CSAS was developed by the U.S Naval Postgraduate School to assess the safety climate of Naval aviation squadrons (Desai, Roberts, & Ciavarelli, 2006; it has also been adapted for use with medical personnel, see Gaba, Singer, Sinaiko, Bowen, & Ciavarelli, 2003). The CSAS is a 61-item attitude questionnaire based upon research in high reliability organizations (see Desai et al, 2006 for more details). Attitude questionnaires have been widely used to assess the safety climate of an organization (see Flin et al 2000 for a review). The CSAS is an online survey completed periodically by all members of the squadron. The results of a squadron’s survey are only available to the CO. However, aggregated data is made available to all COs for comparison of their squadron’s performance with their peers. Desai et al (2006) examined the responses of 6,361 individuals in U.S. Navy squadrons and found a positive association between the responses on the CSAS and minor or intermediate severity mishaps, but no association between the responses and major mishaps.

The safety culture workshop identifies potential hazards that might interfere with mission accomplishment. They also identify command strengths. A safety culture workshop is facilitated by specially trained senior naval aviators. The facilitators spend time looking around the squadron, watching people working, and having informal conversations with a cross section of squadron personnel. Following the informal phase of the workshop, the facilitators carry out focus group discussions with squadron personnel. The information gleaned from the workshop is then summarized and given
back to the squadron’s CO. The CO should use this information to focus on areas that require better risk assessment and risk controls.

Discussion: Safety performance evaluation.

Researchers appear to agree that a combination of quantitative (safety climate) and qualitative (safety culture workshops) techniques provides a comprehensive evaluation of the safety culture of an organization (Wiegmann, et al., 2004). Despite a recognition that a positive safety climate is important in preventing accidents (FAA, 2006b), there are few documented examples of the use of safety climate questionnaires in commercial aviation (Wiegmann, Zhang, von Thaden, Sharma, & Gibbons, 2004). Further, where safety climate questionnaires have been used in other high reliability organizations, they generally represent a single research effort rather than a continuous effort to track safety climate over time. Particular examples of the use of safety climate tools in commercial aviation include: the commercial aviation safety survey (Gibbons, von Thaden, & Wiegmann, 2006), organizational safety culture questionnaire (Patankar, 2003; Block, Sabin & Patankar, 2007), and the maintenance resource management technical operations questionnaire (Taylor & Thomas, 2003).

The U.S. Navy has taken the CSAS beyond a research tool and is using it as a mechanism for providing periodic feedback on command safety climate to COs. The combination of a web-based system for obtaining responses from participants, and providing feedback to COs, is an efficient system for data collection and reporting. Further, it allows a squadron’s responses to be compared over time, and be judged against other squadrons, is an effective safety culture tracking method for senior personnel.
Therefore, it is suggested that the method of implementation of the CSAS by the U.S. Navy represents a framework for commercial aviation to allow senior management to obtain feedback regarding the state of safety within the organization.

The other element that would benefit safety in commercial aviation is the safety culture workshop. The information obtained from the safety culture workshop complements the findings from the safety climate questionnaire. The safety culture workshop provides the opportunity for personnel to voice concerns that may not have been addressed in the climate questionnaire, or that required more in-depth discussion.

**Conclusion**

Commercial aviation has generally provided the model for the vast majority of the elements of the U.S. Navy’s safety program. However, the U.S. Naval aviation’s experience in implementing operational risk management, human factors councils, and safety climate/culture assessment, may be worthy of consideration in improving safety in commercial aviation, as well as other high-reliability organizations.

The main weakness with the U.S. Navy’s aviation safety program is that, apart from CRM training, the individual elements of the program have not been scrutinized to evaluate their impact on safety. The regulators of commercial aviation such as the FAA, CAA, and Joint Aviation Authority (JAA) are arguably more rigorous in their demands for identifying the effectiveness of a safety program prior to recommending it’s implementation. However, the failure to adequately assess the effectiveness of safety training programs is a weakness that is not confined to naval aviation; many of the safety programs used in high reliability organizations have not been subjected to detailed
scrutiny. In high reliability organizations with low numbers of accidents and multiple safety programs, evaluating the effectiveness of a particular safety program is challenging. To illustrate, in a review of the methods 113 UK aviation companies use to evaluate the effectiveness of CRM training, only 60% of companies carried out an evaluation of reactions, 21% an evaluation of attitudes, 36% a knowledge assessment, 53% an assessment of the effect on behavior, and 33% evaluated the effect of CRM training on the organization (O’Connor, Flin, Fletcher & Hemsley, 2002b). Oftentimes political or economic pressure result in the necessity for a safety program to be implemented without a proper evaluation of it’s effectiveness. Nevertheless, researchers must continue to attempt to conduct robust research on the effectiveness of safety programs to ensure that organizations are getting a good return on investment.

For the airline industry, improving safety makes financial sense. Rose (1990) found the lower profitability in the airline industry is correlated with higher accident and incident rate, particularly for smaller carriers. The same is true of naval aviation. In a climate of shrinking budgets, the accidental destruction of in excess of 700 aircraft per year as occurred in the 1950s is simply unacceptable. Fleming (2001) outlines a number of indicators of a high level of safety culture maturity: a sustained period without a recordable accident or high potential incident; no complacency in the organization, coupled with a constant paranoia that the next accident is just around the corner; a range of measures to monitor performance; and confidence in the safety processes. If naval aviation is to meet the U.S. Secretary of Defense’s goal of zero preventable accidents and achieve a 75% accident reduction in 2008 (as compared to the 2002 mishap rate; U.S.
Secretary of Defense, 2007); and if commercial aviation is to improve upon, it’s safety performance, this is the level of safety culture to which they must strive.

Endnotes

All opinions stated in this paper are those of the author and do not necessarily represent the opinion or position of the U.S. Navy, Naval Aviation Schools Command, or the Navy/Marine Corps School of Aviation Safety.
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