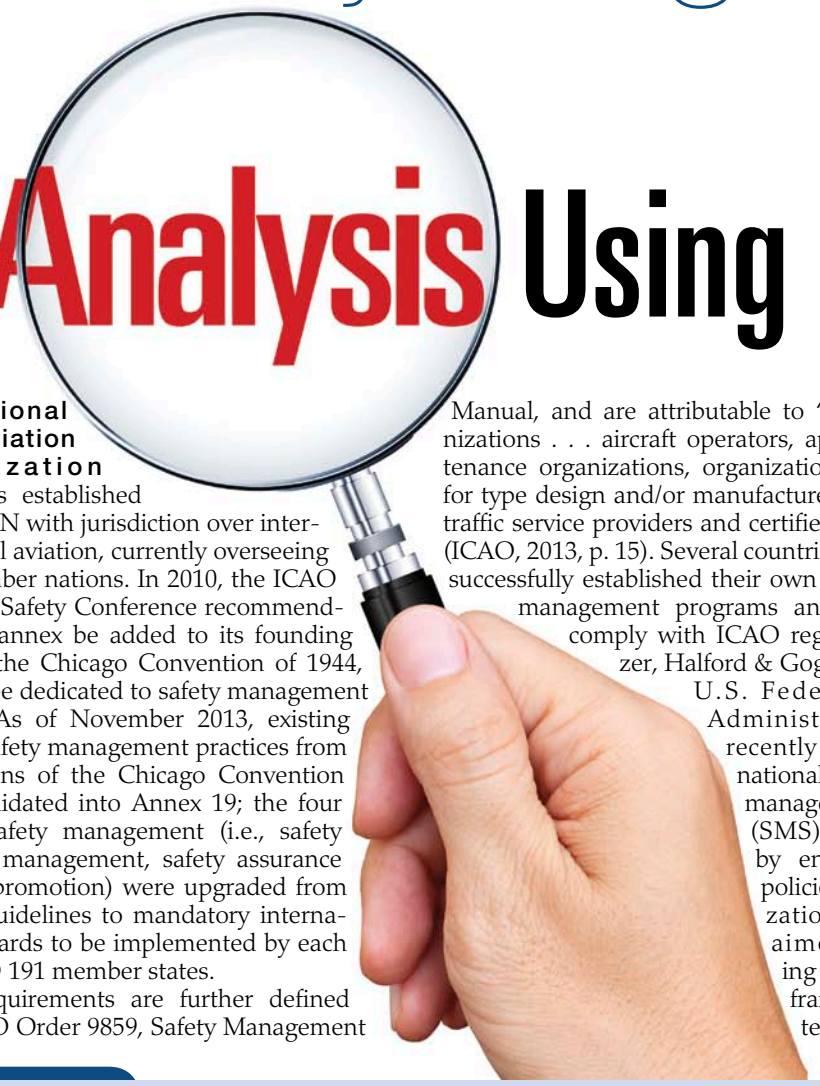
USAF Aviation Safety Program

Gap Analysis Using ICAO



International Civil Aviation Organization (ICAO) was established under the UN with jurisdiction over international civil aviation, currently overseeing its 191 member nations. In 2010, the ICAO High-Level Safety Conference recommended that an annex be added to its founding document, the Chicago Convention of 1944, and that it be dedicated to safety management principles. As of November 2013, existing voluntary safety management practices from other sections of the Chicago Convention were consolidated into Annex 19; the four pillars of safety management (i.e., safety policy, risk management, safety assurance and safety promotion) were upgraded from voluntary guidelines to mandatory international standards to be implemented by each of the ICAO 191 member states.

These requirements are further defined within ICAO Order 9859, Safety Management Manual, and are attributable to "training organizations . . . aircraft operators, approved maintenance organizations, organizations responsible for type design and/or manufacture of aircraft, air traffic service providers and certified aerodromes" (ICAO, 2013, p. 15). Several countries have already successfully established their own aviation safety management programs and continue to comply with ICAO regulations (Stolzer, Halford & Goglia, 2008).

U.S. Federal Aviation Administration (FAA) recently solidified its national aviation safety management system (SMS) commitment by enacting several policies and organizational directives aimed at defining the program framework for internal high-level

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Safety Management Guidance

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aviation safety offices and services. FAA (2010d) has not yet mandated SMS implementation by air carriers or operators but has released several documents, including Advisory Circular 120-92a, allowing operators to voluntarily comply and receive recognition for SMS implementation until mandatory guidance is provided. These efforts show a worldwide commitment to aviation SMS standards as they become the next evolution of safety doctrine.

ICAO and FAA offer slightly different definitions of SMS; however, Stolzer, et al. (2008), comprehensively define SMS as "a dynamic risk management system based on quality management system (QMS) principles in a structure scaled appropriately to the operational risk, applied in a safety culture environment" (p. 36). FAA (2010d) specifies that SMS is a formal, proactive approach to managing safety that includes organization-wide safety policy; formal methods for identifying, analyzing and mitigating hazards; and a total emphasis on promoting a robust safety culture within the organization. Historically, aviation safety analyzed past mishaps during a specified period to identify causal factors and anticipate future occurrences within a process commonly termed *reactive safety*.

While this type of analysis is still needed today, SMS emphasizes proactive and predictive safety processes to identify hazards before reactive safety techniques are necessary (FAA, 2010d). FAA (2010a) estimates it will cost U.S. Part 121 operators (i.e., major air carriers) $375.5 million (2011 value) to implement SMS over a 20-year period, but the benefits would exceed $500.8 million. The economic advantage, along with the incalculable benefit of preserving human life, suggests that FAA, other government agencies and aviation industry members should develop and implement SMS (FAA, 2010a). While these gains are mainly directed at civilian aviation, SMS is also applicable to military organizations (Panagopoulos & Bond, 2011).

U.S. Air Force (USAF) is responsible for directly overseeing and attending to the safety of its aircraft and people. Each year, USAF leadership maintains mission effectiveness, in part, by adherence to new and established aviation safety principles, some of which are adapted from civilian best practices. USAF has recognized SMS as a best practice and is currently preparing to create implementation policy for its use. Since SMS relies on a structure of reactive, proactive and predictive safety built on a strong foundation in quality processes and improvements, USAF will likely keep current safety practices consistent with the new program and develop new initiatives where omissions exist.

To identify areas of compliance and noncompliance, this research performed a longitudinal capability gap analysis in 2012 and again in 2013 on the state of the USAF aviation safety program as compared to ICAO SMS standards and operated under the premise that full adherence would enhance the safety program, save lives, and reduce injuries and costs.

The results of this research suggested that the 2012 USAF aviation safety program was 40.6% compliant, 22.8% partially compliant and 36.6% noncompliant with ICAO safety management reference criteria, while the 2013 program was 64.8% compliant, 25.3% partially compliant and 9.9% noncompliant.

IN BRIEF

- **A safety management system (SMS) approach to aviation safety is being implemented by member states of the International Civil Aviation Organization (ICAO).**
- **A longitudinal gap analysis compared the regulatory states of the U.S. Air Force aviation safety program in 2012 and 2013 after SMS adoption with ICAO safety management criteria.**
- **The results of this research suggested that the 2012 USAF aviation safety program was 40.6% compliant, 22.8% partially compliant and 36.6% noncompliant with ICAO safety management reference criteria, while the 2013 program was 64.8% compliant, 25.3% partially compliant and 9.9% noncompliant.**

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Literature Review

Publicly available USAF aviation safety-trend data and mishap-cost estimates were identified to reinforce the need for programmatic evolution from legacy safety program directives. While the review of literature did not reveal extensive peer-reviewed research specific to the USAF safety program, quality, nonpeer-reviewed information was available. According to USAF Safety Center (2012), USAF flew 35 different models of aircraft for a total of 11.9 million flight hours from FY2006 to FY2011. Regulations specific to flight operations dictate that an aviation safety mishap investigation take place whenever damage to Department of Defense (DOD) aircraft, injury to DOD military or civilian personnel, damage to public or private property, or injury or illness occurs to non-DOD personnel caused by USAF operations not related to combat (USAF, 2008). These mishap investigations are categorized by cost and injury severity and include:

- Class A = any unplanned occurrence in which the direct costs exceed $2 million, a fatality results or a permanent disability is sustained;
- Class B = direct costs of $500,000 but less than $2 million, or a permanent partial disability is sustained;
- Class C = direct costs of $50,000 but less than $500,000;
- Class E = nonreportable events, but are investigated for mishap prevention purposes (DOD, 2011; FAA, 2013b).

USAF Mishap Data

From FY2006 to FY2011, USAF experienced 119 Class A mishaps and 441 Class B mishaps, which corresponded to rates of 1.00 and 3.70 mishaps per 100,000 flight hours, respectively (USAF Safety Center, 2012). Assuming minimum cost criteria were met, this number of mishaps equated to at least $458.5 million in financial loss, as well as the incalculable loss of 30 lives from noncombat operations. When considering the number of Class C mishaps and Class E events in USAF, financial costs for the referenced years likely exceeded $1 billion.

In 2006 and 2010, the USAF experienced its lowest ever Class A mishap rates of 0.90 and 0.71 per 100,000 flight hours, respectively (Kreisher, 2006; USAF Safety Center, 2012). While the Class A rates of fiscal year 2011 climbed slightly, two fatalities occurred, equating to approximately one death for every 1 million flight hours flown (USAF Safety Center, 2012). Zero mishaps and fatalities is an admirable goal, but entities such as ICAO suggest failures and operational errors will occur in aviation, and no activity incorporating humans can be "guaranteed to be absolutely free from operational errors and their consequences" (ICAO, 2013, para 1.1).

After they reanalyzed 124 USAF aviation mishaps from 1992 to 2005, Gibb and Olsen (2008) recommended a program change and improvements to the operational risk assessment process through quality assurance and line-oriented safety audits focusing on latent error mitigation strategies. Such strategies are inherent in an SMS-based program and are being implemented on a limited basis with USAF.

USAF Mishap Policy

USAF's mishap prevention program is outlined in Air Force Instruction (AFI) 91-202 (USAF, 2011). This document specifies the overall approach that USAF will take with regard to general mishap prevention and directly addresses aviation safety in 11 of its 154 pages. After 1998, the document was unchanged until revisions were incorporated in 2011, 2012 and 2013. With the 2013 update, the aviation safety section now includes several proactive safety initiatives and the document also introduced SMS structure. In addition to AFI 91-202, its source document, Air Force Policy Directive (AFPD) 91-2 was updated in 2012 from its 1993 version, collectively demonstrating a new commitment to safety after programmatic stagnation.

Several higher-level safety policies are currently being rewritten to include SMS principles within DOD, Air Force Mission Directive and AFPD guidance. Despite recent initiatives, the USAF aviation safety program has been deemed primarily reactive while concentrating its efforts on air operations, namely airborne aircraft, rather than the numerous internal processes that typically result in a successful or unsuccessful flight (Panagopoulos & Bond, 2011).

Safety Management Benefits

USAF places great emphasis on the resultant yearly mishap statistics, not unlike those mentioned previously. Liou, Yen and Tzeng (2008) recognize that this type of forensic data can provide useful insight, but caution organizations against relying solely on such data. One concern associated with an incident-rate-based safety system is that a mishap must occur before such a system can react (Liou, et al., 2008). Instead, safety professionals may choose to consider how an organization's safety process is applied since its variability may ultimately result in mishaps. An SMS reduces this variability by emphasizing safety risk and quality management in order to prevent mishaps before they can occur (Panagopoulos & Bond, 2011).

Shifting USAF's focus from a reactive, operationally focused safety program to one that reduces process variability will substantially enhance its safety culture and operational outcomes. Bottani, Monica and Vignali (2009) suggest that companies that incorporate an SMS exhibit higher performance in defining safety goals and communicating them to employees, updating risk data and risk analysis, as well as identifying risks and defining corrective actions, and employee training. These organizational safety changes may aid USAF in changing its established safety culture.

In 1994, a lack of organizational oversight allowed a pilot to perform dangerous aerial maneuvers resulting in four fatalities and the destruction of a B-52 aircraft (Trimble, 2010). Sixteen years later in 2010, a USAF C-17 crashed due to a similar lack of organizational oversight. These events suggest that simply changing regulations or firing culpable individuals is not enough to prevent similar mishaps from recurring (Trimble, 2010). A robust SMS seeks to ensure that quality safety processes are in place to

Table 1

USAF Aviation Safety Program SMS Compliance Based on Policy Review

	2012 results				2013 results			
	No.	*Compliant*	*Partial*	*Noncompliant*	*No.*	*Compliant*	*Partial*	*Noncompliant*
Component 1	44	24 (54.5%)	6 (13.7%)	14 (31.8%)	33	24 (72.8%)	6 (18.2%)	3 (9.0%)
Element 1.1	12	6	0	6	7	5	2	0
Element 1.2	9	9	0	0	8	5	1	2
Element 1.3	3	3	0	0	4	4	0	0
Element 1.4	3	3	0	0	7	7	0	0
Element 1.5	17	3	6	8	7	3	3	1
Component 2	21	8 (38.1%)	3 (14.3%)	10 (47.6%)	13	11 (84.6%)	2 (15.4%)	0 (0.0%)
Element 2.1	16	7	2	7	7	6	1	0
Element 2.2	5	1	1	3	6	5	1	0
Component 3	26	5 (19.2%)	10 (38.5%)	11 (42.3%)	18	8 (44.4%)	9 (50%)	1 (5.6%)
Element 3.1	17	4	10	3	8	3	4	1
Element 3.2	4	0	0	4	4	1	3	0
Element 3.3	5	1	0	4	6	4	2	0
Component 4	10	4 (40%)	4 (40%)	2 (20%)	7	3 (42.9%)	1 (14.2%)	3 (42.9%)
Element 4.1	5	3	1	1	4	1	0	3
Element 4.2	5	1	3	1	3	2	1	0
Total	**101**	**41 (40.6%)**	**23 (22.8%)**	**37 (36.6%)**	**71**	**46 (64.8%)**	**18 (25.3%)**	**7 (9.9%)**

continue risk management and feedback processes to reduce the likelihood of preventable mishaps. Without the quality tools and feedback processes inherent within an SMS, a traditional safety program is more likely to repeat past mistakes.

Research Questions

- As of March 2012, what regulatory gaps exist in USAF's aviation safety program as compared to international civil aviation safety management criteria?
- As of October 2013, what regulatory gaps exist in USAF's aviation safety program as compared to international civil aviation safety management criteria?
- Based on longitudinal research, is the USAF aviation safety program progressing toward an SMS as defined by international civil aviation?

Methods

ICAO and FAA recommend that organizations perform a gap analysis comparing the current state of the safety program to established guidance to identify areas of improvement and formulate a plan of action to become fully compliant (FAA, 2010c; ICAO, 2013). Since FAA has not yet established formal national guidance regarding safety management, the authors elected to perform the recommended gap analysis utilizing ICAO international guidance intended to be incorporated within the U.S., and possibly its military forces as well.

A gap analysis is inherently subjective; however, this research attempted to minimize these effects by incorporating three researchers, each performing independent analyses, then collaborating afterward on disagreements. USAF was not asked to endorse this preliminary research; therefore, no official resources were provided to the research team other than documentation freely available to the public. The documentation, however, includes the same regulations and policies USAF uses to enforce its initiatives and is considered an accurate assessment of safety management regulatory implementation.

USAF did not allow access to its personnel or facilities; therefore, practical field implementation of USAF safety management regulations was not assessed within the body of this research. This type of research would require official USAF endorsement and acceptance of public disclosure within a non-USAF-controlled study. This type of research would be beneficial to safety management implementation and is recommended later in this article. Safety management, its processes and implementation are applicable to a wide range of disciplines and are not exclusive to aviation or USAF. While there are certainly limitations in generalizing gap analysis results, the authors believe the difficulties of large-scale safety management limitations may be generalized to other large organizations regardless of discipline.

This research compared the regulatory state of the USAF aviation safety program, as of March 2012, to SMS gap analysis criteria included within the second edition of ICAO 9859 (2009); the analysis was performed again in October 2013 during USAF SMS formal implementation. During the course of this study, updated SMS gap analysis criteria were released within the third edition of ICAO Order 9859 (2013). The research team elected to perform the second analysis utilizing these new criteria. At the time each analysis was conducted, the regulatory state of the USAF aviation safety program was defined by the guidance publically available at the Air Force e-Publishing website (**www.e-publishing.af.mil**).

This research considered regulatory policy, procedures and safety oversight functions applicable

to USAF organizations directly responsible for implementing and conducting flying operations. Each gap analysis question was individually evaluated by the research team members by reviewing applicable supporting information from ICAO references and USAF regulations. This process resulted in ratings of compliant, partially compliant or noncompliant.

Once individual analyses were complete, inconsistent ratings were discussed, researched and reevaluated until unanimous resolution was attained. Between the two ICAO gap analysis versions, the overall structure of four major components and 12 elements remained the same and allowed for descriptive statistics and direct high-level comparison of the two USAF program states.

Results

A gap analysis of 101 ICAO (2009) criteria was used to evaluate the USAF aviation safety program, based on regulatory review in March 2012; a subsequent analysis of 71 ICAO (2013) criteria was used to reevaluate the USAF program in October 2013. No assumptions or determinations were made based on actual inspection of safety practices or program implementation. A summary of the gap analysis results is presented in Table 1, (p. 29). Compliance, partial compliance and noncompliance estimates were made for each of the four main SMS components, each element within the components, as well as overall program compliance. In accordance with ICAO Order 9859 (2009; 2013), SMS components were defined as:

- Component 1: Safety policy and objectives;
- Component 2: Safety risk management;
- Component 3: Safety assurance;
- Component 4: Safety program.

Analysis & Discussion

This research suggests that while USAF is not attempting to specifically adhere to ICAO criteria, many of its current written initiatives demonstrate an estimated 40.6% ($n = 41$) compliance as of 2012 and a 64.8% ($n = 46$) compliance as of 2013. Perhaps more important, the noncompliance decreased from 36.6% ($n = 37$) to 9.9% ($n = 7$) during the same time frame. During the course of this research, ICAO decreased its total criteria from 101 to 71 items; however, the organization appears to have generally accomplished this task by combining similar criteria, then reframing the questions, or by placing the detailed information as compliance reference material to broad-based questions. USAF's aviation safety program appears to be maturing toward compliance with accepted international safety management principles.

The SMS compliance rates of private industry are not readily known since FAA has not communicated final regulatory guidance to its industry. In 2011, FAA published interim SMS guidance based on ICAO guidelines and allowed aviation service providers the opportunity to voluntarily comply with anticipated standards. The benefits of such a pilot program include establishing realistic timelines for phased implementation; identifying the most challenging areas to implement; recognizing what guidance is most beneficial; and establishing the pros and cons of phased departmental implementation, as opposed to implementation across all departments of a company simultaneously (FAA). While this program is only voluntary, it helps to create a medium for sharing best practices and lessons learned. FAA SMS regulatory guidance is still pending; therefore, it still may be enhanced by lessons learned within its own industry, including the related practices of USAF.

Component 1: Safety Policy & Objectives

Individual elements within Component 1 included management commitment and responsibility, safety accountabilities, appointment of key safety personnel, coordination of emergency response planning and SMS documentation. From 2012 to 2013, the USAF aviation safety program strengthened its commitment to safety management principles; several areas of Component 1 were strengthened, but areas of possible future improvement remain. In the 2011 analysis, USAF regulations did not link aviation safety goals to safety performance indicators, targets or action plans; however, the 2013 analysis revealed that the Air Force Safety Management System (AFSMS) now included those links within its framework and newly established proactive safety programs.

Most areas rated in partial compliance only required relatively small changes to be in full compliance. For example, ICAO SMS standards include multiple requirements to be communicated within organization-wide safety policy. While USAF commanders are required to communicate their safety expectations, no minimum requirements are established. This provides commanders with great latitude to implement safety policy; however, it also allows for safety generalities and oversights to permeate throughout the organization in cases where leaders are not well-versed on current safety methods.

The most notable area of noncompliance was the omission of an organization-wide AFSMS implementation policy, as recommended in ICAO guidance and currently employed by FAA organizations. This is especially critical, as an aviation safety management program may be estabished within the existing infrastructure, but is distinctly different in its methodology and execution. Without clear implementation guidance, upper-level intent may not translate to operational-level personnel, or worse, may be viewed as a new safety program in title only.

From 2012 to 2013, the USAF aviation safety program experienced considerable growth by releasing guidance directing an AFSMS. A program that was once based on reactive safety principles now includes proactive safety techniques, similar to those adopted by international civil aviation. Minor regulatory changes would bring the USAF program closer to full SMS compliance; however, an overall implementation strategy should first be addressed.

Component 2: Safety Risk Management

Individual elements within Component 2 included hazard identification and safety risk assessment and mitigation. This component showed the most regulatory improvement over the course of this study, from 52.4% fully or partially compliant in 2012 to 100% in 2013. In 2012, the USAF risk management program was managed by the safety directorates, arguably with more emphasis on ground-based safety as opposed to aviation safety. At the time, USAF aviation safety staff members were formally trained in courses emphasizing incident investigation, rather than proactive hazard and risk mitigation.

In 2013, the USAF risk management program transitioned from one that was somewhat outdated and governed by safety-based regulations to one that includes industry-accepted best practices and is governed by special management regulations. The act of placing the risk management program within the special management regulations clearly placed hazard identification, risk assessment and mitigation as a process fully integrated into all personnel duties.

As opposed to safety personnel assessing hazards and supplementing the process with voluntary methods, the entire process is managed by all personnel and validated by safety specialists. Computer-based risk management courses are required for all personnel, and program managers must attend classroom instruction.

USAF could strengthen this program further by establishing a refresher training frequency or, at minimum, retracting its grandfather clause requiring personnel to take the course only once. The USAF risk management program is almost fully compliant with ICAO SMS standards, only requiring minor regulatory changes to clearly establish applicability to USAF mission-essential task listing creation and subsequent change management.

Component 3: Safety Assurance

Individual elements within Component 3 included safety performance monitoring and measurement, management of change and continuous SMS improvement. The overall section was assessed as 19.2% compliant in 2012 and 44.4% compliant in 2013; however, during the same time frame, items rated as noncompliant dropped from 42.3% to 5.6%.

Within the 2012 assessment, no formal aviation safety guidance was available to establish proactive criteria for safety process change. At the same time, USAF had not established proactive processes to evaluate how well its safety program was working and instead focused on reactive safety incident rates.

The newly established 2013 AFSMS and overhauled risk management program set forth principles to discover aviation safety program performance flaws before necessitating reactive safety. The challenge, however, will be to design an implementation strategy and audit process to allow for the collection and meaningful interpretation of vast amounts of hazard, risk assessment and risk controls data not previously captured to this degree. This facet reemphasizes the importance of a strategic AFSMS implementation plan as mentioned in Component 1.

Several items in the safety performance monitoring and measurement section were rated as partially compliant. Proactive safety monitoring could be bolstered by including Class E event review processes and further refining AFSMS performance indicators. Targets associated with performance indicators should be frequently reviewed to ensure relevant metrics in a dynamic environment. Partially compliant items were also assessed within the change management section. USAF clearly established how change management applied to aircraft and material but did not formally implement a process to manage the hazards and risk inherent in headquarters-level operational aviation planning as it relates to change management.

Component 4: Safety Program

Individual elements within Component 4 included training, education and safety communication. An SMS is substantially different from a traditional aviation safety program, as it is data-centric and relies heavily on an informed safety culture. According to regulatory guidance and a review of all available USAF safety course syllabi, USAF has not established AFSMS education for its leaders and personnel involved with the implementation of the AFSMS, nor is there evidence of organization-wide awareness strategies. To foster AFSMS awareness and integration into daily activities, USAF should consider developing educational programs for all levels of personnel, likely as part of its implementation guidance. As such guidance is established, USAF would also benefit from creating a medium for sharing SMS information from related activities in other branches of the military that choose to adopt a safety management program for their aviation as well as ground-based activities.

Conclusion

USAF is not mandated to employ international civil aviation safety management standards; however, these same standards may be useful in identifying new areas for improvement. The USAF aviation safety program was measured against ICAO SMS criteria in March 2012 and again in October 2013. The results of this research suggest that the 2012 USAF aviation safety program was 40.6% compliant, 22.8% partially compliant and 36.6% noncompliant with ICAO safety management criteria, while the 2013 program was 64.8% compliant, 25.3% partially compliant and 9.9% noncompliant.

As of 2012, USAF had not formally adopted safety management principles into its aviation safety program, and this was evident within the first part of this analysis and possibly the historic USAF aviation mishap rates. As of 2013, USAF began its own

SMS emphasizes proactive and predictive safety processes to identify hazards before reactive safety techniques are necessary.

AFSMS; this effort is greatly reflected within the second analysis and shows a strengthening regulatory commitment to international practices. The introduction of the AFSMS marked a substantial change in USAF aviation safety philosophy. This research made no attempt to evaluate the practical implementation of USAF safety measures, but rather was limited to a regulatory policy and document review.

While this analysis indicated that the 2013 USAF aviation safety program was more compliant with ICAO SMS criteria as compared to its program in 2012, several obstacles must be overcome before this program is realized. The AFSMS program will mature over the coming years, and it may not be feasible for public entities to research the practical implementation of this effort; however, it may be possible to observe long-term USAF aviation mishap safety trends and note 2013 as a changing point in preventable mishaps. If made possible by USAF, subsequent studies could compare mishap rates against actual AFSMS implementation criteria, as assessed by field research, to verify that the initiative enhances the overall safety program, saves lives to a greater extent, and reduces injuries and costs. **PS**

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