

Development of MIL-STD-3050, OBOGS

Award Winner: Air Force Team



A 36-month project developed MIL-STD-3050, “Aircraft Crew Breathing Systems Using On-Board Oxygen Generating System (OBOGS),” in response to a recommendation by the U.S. Air Force (USAF) Scientific Advisory Board Quicklook Study of Aircraft Oxygen Generation involving F-22 system safety issues. The full coordination design criteria standard covers the design, integration, certification, and sustainment/maintenance requirements for aircraft crew breathing systems using an OBOGS. It provides a minimum set of criteria for future acquisitions to correct technical and management weaknesses and ensure the safety and effectiveness of these flight critical systems. MIL-STD-3050 is a standardization management benchmark for the successful development of a fully coordinated military standard among Department of Defense equities, prime aircraft manufacturers, and life support subsystem suppliers to meet a high-visibility need.

Background

Many aircraft make use of an on-board oxygen generation system to provide breathing oxygen for the aircrew. Compared to historical experience through early 2012, there had been an increasing number of hypoxia-like incidents in the F-22 Raptor aircraft that may have been related to the OBOGS or its installation. Following the loss of an F-22 in Alaska in November 2010 and several hypoxia-like incidents at Elmendorf Air Force Base in May 2011 that led to grounding of the F-22 aircraft fleet, the USAF Scientific Advisory Board (SAB) was tasked in June 2011 to conduct a Quicklook Study of system safety issues involving OBOGS to help ensure that the appropriate steps were being taken to enhance flight safety of these aircraft. One of three areas for investigation was to “review the policies, processes, and procedural changes that occurred during the F-22’s development and fielding, and evaluate the implications with respect to design limitations, risk analysis, program execution, and acquisition workforce.” The Quicklook Study report was published in February 2012.¹

Problem/Opportunity

The need for a standardization solution was underscored by SAB findings in the review and evaluation of policies, processes, and procedures. The findings included the following:²

- The F-22 was developed during the period of acquisition reform when significant development and sustainment activities were transitioned to major defense contractors and contract-usable military specifications and standards were cancelled or converted to guidance-only handbooks.

¹ This paragraph is from the Foreword of the *USAF Scientific Advisory Board Report on Aircraft Oxygen Generation*, February 1, 2012.

² These findings are from the *USAF Scientific Advisory Board Report on Aircraft Oxygen Generation*, February 1, 2012.

- An applicable multi-national standardization document from the Air and Space Interoperability Council (ASIC; formerly Air Standardization Coordinating Committee)—currently ASIC Advisory Publication 4060, “The Minimum Quality Criteria for On-Board Generated Oxygen”—was called out as advisory guidance for the F-22.
- The Air Force substantially diminished its application of systems engineering and reduced its acquisition core competencies (e.g., systems engineering, human systems integration, aviation physiology, cost estimation, contracting, and program and configuration management). Lost capabilities and expertise to perform the critical function of human systems integration led to atrophy of policies/standards and research and development expertise with respect to the integrity of the life support system.
- Three life support system-critical subsystems (OBOGS, Back-up Oxygen System [BOS], and Emergency Oxygen Subsystem [EOS]) were not classified as “safety-critical items” and were integrated or eliminated without sufficient analysis.
- Modeling, simulation, and integrated hardware-in-the-loop testing to support the development of the F-22 life support system and the thermal management system were insufficient to provide an “end-to-end” assessment of the range of conditions likely to be experienced by the F-22.
- The OBOGS was developed as a “fly-to-warn/fail” system with no requirement for initial or periodic end-to-end certification of the breathing air or periodic maintenance and inspection of key components.

Approach

The SAB recommendations³ drove the action for and content of a standardization solution:

- Develop and implement a comprehensive Aviation Breathing Air Standard to be used in developing, certifying, fielding, and maintaining all aircraft oxygen breathing systems.
- Develop and install an automatic BOS in the F-22 life support system.
- Reenergize the emphasis on human systems integration throughout a weapon system’s life cycle, with much greater emphasis during Pre-Milestone A and during the engineering and manufacturing development phases. Develop the capability to research manned high-altitude flight environments and equipment, develop appropriate standards, oversee contractor development, and independently certify critical, safety-of-flight elements.
- Improve the ease of activating the EOS and provide positive indication to the pilot of successful activation.
- Develop and implement appropriate inspection and maintenance criteria for the OBOGS and life support system to ensure that breathing air standards are maintained.

³ These recommendations are from the USAF Scientific Advisory Board Report on Aircraft Oxygen Generation, February 1, 2012.

- Clearly define the “inherent governmental roles and responsibilities” related to acquisition processes and identify the core competencies necessary to execute those responsibilities.

The Air Force formed a team in June 2012 with primary membership from the Air Force Research Laboratory’s 711 Human Performance Wing/Warfighter Interface Division and the Air Force Life Cycle Management Center’s Flight Systems Division and Systems Engineering Services Division. The team was supported by contractor staff from the F-22 Program Element Monitor’s (PEM’s) office (SAF/AQPF) and the Air Force Departmental Standardization Office (DepSO–SAF/AQRE).

The team’s plan for addressing the SAB recommendations was to convert the ASIC Advisory Publication 4060 guidance on minimum quality criteria for on-board generated oxygen to a formal military standard and to expand its scope to include the other recommendations involving life support subsystem identification/management as safety critical items and specification of the certain functional requirements, physiological operational conditions, and verification requirements for new designs. The initial approach was to use two steps: first, to develop and issue a limited coordination USAF-only standard in June 2013 to meet emerging Air Force needs; and second, to expand coordination to formally include the Navy and industry.

As development of the USAF-only standard proceeded with the Navy included for information, the team recognized that incorporating and harmonizing Navy requirements would have a substantial impact on the standard. After consultation with the PEM and DepSO staffs, the team changed the approach and decided to develop a single, full-coordination standard with extensive industry participation.

This shift in approach extended the development time an additional 24 months from June 2013 to May 2015. Navy and prime airframe contractor comments and coordination began with Air Force organizations in June 2012 and completed in June 2014. Non-airframe industry comments and coordination began serially in June 2014 and completed in March 2015. Industry participants included prime airframe contractors (Lockheed-Martin, Boeing, Airbus), OBOGS suppliers (Honeywell, Cobham), ejection seat suppliers (Martin Baker, UTAS), and physiological testing contractors (Wyle Labs).

Outcome

Three years of effort to develop and publish MIL-STD-3050 has resulted in the following:

- Acceptance by Air Force executive leadership that action has been completed to prevent acquisition reform-based engineering and management process deficiencies in the F-22 from occurring in future procurement and sustainment of life support system safety-critical items, including an OBOGS.

- Demonstration that with due diligence, the Defense Standardization Program (DSP) is able to produce a consensus military standard among DoD and a diverse group of industry suppliers for use in acquiring a military unique capability.

Current Status

MIL-STD 3050 was published on May 11, 2015. It is already being hailed as a must-read document for anyone working in this domain.

Challenges

Several significant technical and cultural barriers were overcome in the development of this standard: the resolution of differences in the OBOGS input air interface and in human system testing requirements between Air Force and Navy systems, and compromises with industry on OBOGS performance requirements and design constraints.

Lengthy but collaborative discussions were required to establish common OBOGS air input requirements between Air Force aircraft with an environmental control system and Navy aircraft with a direct engine bleed air supply. Similarly, standard requirements for the Air Force approach to man-rating its life support systems were reconciled with the Navy's approach of system testing without a man-in-the-loop.

Compromises with industry to reach common requirements included industry acceptance of an increased OBOGS output flow rate and constraints on the type of OBOGS molecular sieve material used (without requiring additional safety qualification/certification) and government acceptance of a reduced number of required OBOGS monitoring, recording, and warning parameters.

About the Award Winner

The team consisted of George W. Miller, Jose L. Ubinas, and Madeleine M. Istvan.

George Miller is a 711 HPW/RHCP technical expert, the MIL-STD-3050 development team lead, and responsible engineer for the published document. His involvement began in November 2011 as a subject matter expert presenter to the SAB Quicklook Panel on the ASIC Advisory Publication 4060, other related multi-national standards, and planning for what was then called a “USAF Air Standard Directive” but later identified as a DoD military standard. As the lead, Mr. Miller managed all team activities and coordinated actions of the other members. He planned and led all technical actions with the Navy, prime airframe contractors, and OBOGS suppliers; performed the technical adjudication of all reviewer comments; and prepared them for discussions among team members. Administratively, he accurately developed and maintained version control of the initial and all subsequent working drafts of MIL-STD-3050 and related comment resolution matrixes, and he distributed all incremental versions among team members and reviewers, including industry reviewers who reviewed and commented sequentially.

Jose Ubinas is an AFLCMC/EZFC crew systems engineer and MIL-STD-3050 development team member. His involvement began with formation of the team in June 2012 and continued through final coordination for approval in April 2015. Mr. Ubinas was responsible for ensuring that the life support system/OBOGS requirements were technically and contractually compatible with crew systems performance specifications, including the applicable Joint Service Specification Guides. He had a strong influence on the military standard’s adherence to establishing design criteria in performance and functional terms to the greatest extent possible. Mr. Ubinas managed the coordination of the evolving draft standard within his office, with F-22 and F-35 Program Office staffs, and with the ejection seat suppliers who had or may have an interface with OBOGS. He actively participated in all team coordination meetings and technical interchange telecons with Navy and industry representatives.

Madeleine Istvan is an AFLCMC/EZSS lead technical editor and MIL-STD-3050 development team member. Her involvement also began with formation of the team in June 2012 and continued through submittal of the standard for publication in May 2015. Ms. Istvan was responsible for all DSP standardization management/preparing activity actions for document development and publishing, including project initiation/approval, formatting the initial draft development document to MIL-STD-962 requirements and iterating subsequent versions to accommodate major changes in scope and content, managing the final formal DSP document coordination via the Acquisition Streamlining and Standardization Information System, and editing the final version for approval by the Air Force standardization executive. Her expertise was invaluable in properly crafting and securing full Navy coordination on a coherent design criteria standard for OBOGS in highly diverse life support subsystem architectures.