



U.S. Air Force

PROCESS ROADMAP: DETERMINING THE CAUSE OF F-22 UNEXPLAINED PHYSIOLOGICAL INCIDENTS

The Air Force Scientific Advisory Board's (AFSAB) Quicklook Study on Aircraft Oxygen Generation Systems (OBOGS) has been completed and released. While this study did not determine the root cause(s) for a disproportionately larger rate of unexplained physiological incidents in the F-22 than other fighter type aircraft in the U.S. inventory, it provided processes and procedures to be used in determining the root cause(s) for those incidents. The AFSAB study was the third tier of four in the Air Force's deliberate effort to find the cause(s) for the F-22's unexplained physiological incidents.

TIERED APPROACH

TIER 1: ROOT CAUSE AND CORRECTION ANALYSIS PROCESS

The first tier was initiated in April of 2008 with the first reported F-22 physiological incident. Engineers from the F-22 System Program Office, the prime contractor for the F-22, Lockheed Martin, and its two primary subcontractors responsible for the F-22's Life Support System, Boeing and Honeywell, initiated the Root Cause and Correction Analysis process which worked in collaboration with the Air Force safety investigation process to determine the root cause(s) behind reported incidents. Ultimately, causes were determined for two of the 14 incidents reported between April of 2008 and May of 2011. The remaining twelve cases represented a rate of more than ten times the Air Force average for other aircraft systems.

After the tragic loss of pilot Capt Jeff Haney and his F-22 in Alaska in November 2010, the initial mishap investigation suggested that hypoxia, a lack of oxygen available to the pilot, may have been causal to the accident. Ultimately, the Air Force's Accident Investigation Board concluded that Haney failed to recognize and initiate a timely dive recovery due to channelized attention. Based on the fatal mishap and previously unexplained physiological incidents, Air Combat Command established a comprehensive Class E Safety Investigation Board, chaired by an Air Force major general, to expand the scope of investigation.

TIER 2: CLASS E SAFETY INVESTIGATION BOARD

This investigation became the second tier level of effort in determining the cause(s) for the F-22's unexplained physiological incidents. The effort proceeded for nearly six months, and in addition to continuing to build on the Root Cause and Corrective Action analysis effort, it initiated a massive number of ground system tests on every component related to the F-22's life support system. In order to minimize the potential for further physiological incidents in the F-22, crews were instructed to remain below 25,000 feet and to use the MAX mode of the On-Board Oxygen Generation Systems (OBOGS) to ensure delivery of the maximum amount of oxygen to the pilot. Both actions were designed to put the pilot in an environment least likely to result in any further physiological incidents. Despite these actions, the rate of physiological incidents increased and in early May 2011, after two more troubling incidents, the Air Force grounded the F-22 fleet.

Based on the data and analysis of the incidents, the Safety Investigation Board concluded that:

- The Air Force would need to specially instrument test aircraft in order to perform a prescribed series of flight test profiles to better understand the F-22 life support systems performance in specific flight environments; and

- Because of decisions made early in the F-22's Engineering, Manufacturing and Development (EMD) phase, a broader area review of the Air Force's acquisition decision policies, processes and procedures needed to be accomplished.

TIER 3: AIR FORCE SCIENTIFIC ADVISORY BOARD

In June 2011, the Air Force Secretary and the Chief of Staff tasked the Air Force Scientific Advisory Board to form a study panel to continue efforts to determine the root cause(s) for the unexplained physiological incidents as well as to review other oxygen generation and life support systems to determine if commonalities, key assumptions, design limitations and characteristics of the acquisition process might have contributed to a less robust life support system in the F-22. The Air Force Scientific Advisory Board study panel was also to make recommendations to the Secretary and the Chief of Staff regarding the dynamic flight testing profiles designed by the Safety Investigation Board and provide an appropriate path ahead to eventually return the F-22 safely to its full operational flight environment.

The AFSAB brought together some of the nation's most recognized aviation engineering, physiological and toxicological experts. The study panel synchronized efforts of the Safety Investigation Board, the System Program Office and the contractors, and developed a comprehensive data gathering and analysis effort to not only fully review and assess the work of the previous two tiers of effort but also to analyze the new data gathered as a result of the specifically designed flight test profiles.

After those actions and after a thorough review of the data related to the test flight profiles, the AFSAB study panel developed a prudent "Return to Fly" program for the Air Force. That Return to Fly program included: a complete assessment of the each aircraft's life support and oxygen delivery systems; a thorough training regimen for the F-22 pilots and maintenance crews; equipping the pilots with pulse oximeters and man rated chemical filters; and developing specific response protocols to gather and collect appropriate data for each flight, including a detailed response profile should a physiological incident occur in the air or on the ground. Because flight safety was of paramount concern, the Return to Flight phase was designed to protect the crews while continuing to gather important data and providing the nation with critical combat capability. From the time the F-22 resumed flight operations in September 2011 until the AFSAB completed its study in January of 2012, the F-22 fleet flew more than 7,500 sorties.

When the AFSAB study panel presented its findings and recommendations to the Secretary and Chief of Staff of the Air Force in January 2012, it had not identified the root cause(s) for the unexplained incidents, but it did have an effective process for ensuring safe flight operations while continuing to gather the data necessary to determine the root cause(s). At that point, among its recommendations was the establishment of a Task Force, to be led by Air Combat Command, to both oversee the Return to Fly protocols as well as develop and manage the implementation plans and schedules for completing the remainder of the recommendations.

TIER 4: F-22 LIFE SUPPORT SYSTEM TASK FORCE

The Secretary of the Air Force established an F-22 life support system task force in January 2012 to continue the efforts of the AFSAB Quicklook Study group. The task force leveraged the results of previous F-22 safety investigation boards and the SAB study group's findings, recommendations and conclusions; then continued research, analysis and testing to determine the significant contributing factors to previously unexplained F-22 physiological incidents. The Task Force consists of a collaborative multi-Service, cross-functional team. This integrated government/industry/academia team approach, built on the efforts of the SAB study group and permitted an increased breadth of experience, enhanced scope of knowledge, and provided additional impartial expert analysis.

The task force is confident that data derived from the SAB study group's Hypothesis 1 (oxygen quantity) describes the major contributors to the previously unexplained physiological incidents reported by F-22 pilots over the past few years. This determination was possible following continued analysis of the flight data and thousands of centrifuge and altitude chamber test events with F-22 pilots. The task force, based on extensive ground and flight test data collection and analysis by independent laboratories led by a team of scientists and engineers, including members of the National Academy of Engineering and the Air Force Scientific Advisory Board, is confident that Hypothesis 2 (oxygen quality) is not the root cause of previously unexplained physiological symptoms reported by F-22 pilots and ground crew.

Systemic factors in the life support system, such as: the Combat Edge upper pressure garment and C2A1 filter functionalities have been identified, removed, and corrective action is underway. These actions have reduced the potential negative effects created by high oxygen concentration levels produced by the OBOGS through cockpit selectable oxygen concentration settings. Human factors at two F-22 operating locations were also determined to be contributory factors. The task force has communicated findings and corrective actions to the F-22 community, and this communication has reduced the ambiguity and uncertainty while increasing pilot and ground crew confidence in the F-22's life support systems.

The task force has closed seven of the SAB study group's eight near-term actions and collection of incident data. The remaining SAB action is fielding the Helmet Mounted Pulse Oximeter (HMPO). The Air Force has equipped Elmendorf AFB F-22 pilots with HMPOs and is on track to equip the remainder of the F-22 pilots by November 2012.

More work lies ahead as the Air Force transitions to normal F-22 flight operations. The path to resuming normal flight operations hinges on the successful development, testing and fielding of the modified Combat Edge upper pressure garment valve. This modification will successfully integrate the key components of the F-22 life support system to ensure adequate oxygen flow to the pilot while providing protection in the high altitude and high-G environments where the F-22 operates. This modification is expected to be fielded by the end of 2012.

The fielding of the automatic backup oxygen system will provide additional protection to F-22 pilots while flying at high altitude and under the most demanding oxygen-delivery system scenarios that can be envisioned for the F-22 life cycle. The first operational aircraft is expected to be modified in January 2013; the first operational squadron should be complete by spring 2013 and fleet completion is planned by mid-2014.

The Task Force is certain the F-22 cockpit and surrounding work space is a safe, effective place to operate.

There will be physiological incidents in the future. Flight safety is always of paramount concern, but the harsh high altitude/high-G environment is extremely demanding and Air Force pilots are aware of those demands. Physiological incidents occur in all high-performance aircraft due to the demands placed on the aircrew. The measures taken by the Air Force are designed to reduce the incident rate significantly and over time bring the F-22 incident rates in line with comparable high performance fighter aircraft. The Air Force is committed to implementing these changes to return the F-22 to normal operations; thus significantly contributing to our nation's vital interests by providing Air Dominance, when and where ordered, to protect and enable the joint U.S. military force. The Air Force will continue to leverage lessons learned throughout this investigative process and will invest in characterizing and understanding the high performance aircraft environment to optimize pilot performance, not only in the F-22, but in all current and future weapon systems.