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Top Story

DoD Assesses Corrosion Potential on F-35 and F-22

GAO Audits Resulting Corrosion Study for Congress

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The DoD Corrosion Policy and Oversight Office, under Director Daniel J. Dunmire, submitted a full corrosion-related assessment of the F-35 Joint Strike Fighter (JSF) to Congress. As part of its study, the DoD Corrosion Office also analyzed a host of corrosion-related findings on the F-22A Raptor aircraft and the implications of those findings for the F-35 (also known as the F-35 Lightning II). Congress directed the Defense Department to perform the study as part of the 2010 National Defense Authorization Act.

AF-1 (rear) and AF-2, two F-35A Lightning II joint strike fighters, complete a test flight on May 11, 2010, from the Lockheed plant in Fort Worth, Texas. The crew prepared for a nonstop flight to Edwards Air Force Base, Calif., on May 17, as part of extended flight test operations. Photo by David Drais.

On December 16, 2010, the Government Accountability Office (GAO) released a performance audit of the DoD's F-35 corrosion study to the chairman and ranking members of the House and Senate Armed Services committees and the House and Senate Defense Appropriations subcommittees. (Click here for the full GAO report—*Defense Management: DoD Needs to Monitor and Assess Corrective Actions Resulting from Its Corrosion Study of the F-35 Joint Strike Fighter*.)

To carry out the evaluation, Dunmire assembled a team of experts from government and industry that was approved by the Honorable Ashton B. Carter, Under Secretary of Defense for Acquisition, Technology, and Logistics. Dunmire chose the team based on required areas of technical expertise and professional independence from the F-35 and F-22 program offices to avoid conflicts of interest. "To conduct the analysis, my team visited the F-35 and F-22 program offices, manufacturing and operating sites, service laboratories, and any other locations needed to collect the data required for our report," said Dunmire. In its report summary, GAO concluded: "The corrosion study was generally consistent with research standards that define a sound and complete study with regard to design, execution, and presentation." GAO also noted that the corrosion study's lack of formal recommendations, omitted by the Corrosion Office evaluation team to avoid delays in releasing their results, may make it "difficult for DoD and Congress to monitor and assess corrective actions…"

Dunmire commented on the evaluation process and results that were set forth in the publicly released GAO performance audit.

Here is some background to place the Corrosion Office evaluation in context. A few months after the F-22 was first fielded at Tyndall Air Force Base, Florida, in 2005, users found corrosion on the aluminum skin panels. During the following year, more than 200 corrosion findings were documented at 18 locations on the aircraft. Dunmire explained these findings: "The root cause of this problem lay within the galvanic couple between the conductive gap filler and aluminum skin panels. By October of 2007," Dunmire said, "a total of 534 corrosion findings were documented on the F-22, and substructure

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corrosion occurrences were becoming prevalent.” Realizing that this rate of corrosion damage could not continue indefinitely, the F-22 program office began developing, testing, and installing new materials and fixes on both fielded aircraft and aircraft in production.

Dunmire noted that the F-22 Raptor’s corrosion problems could have been anticipated. “For example, according to Military Standard 889, the galvanic dissimilarity of the materials used on the F-22 is at a high enough level to indicate extreme risk for corrosion. Fortunately, the F-35 program office benefited from the Air Force and Navy’s awareness of this and other problems on the F-22. The F-35 program office adopted more stringent corrosion testing and pushed for a more maintainable design.” He added that while the F-35 program has benefited from a greater awareness of corrosion issues, the program still faces problems involving the lack of material compatibility and competing design criteria, which require ongoing attention.

Issues Common to the F-22 and F-35

The evaluation team found two fundamental causes of corrosion issues that are common to both the F-22 and F-35 aircraft, Dunmire said. First, on neither aircraft is “corrosion resistance” defined as a requirement for the user, in spite of the fact that users operate and maintain both systems in severely corrosive desert and saltwater environments. Second, presently there are no tests for corrosion on either aircraft at the operational level. “Even though system specifications call for a design service life of 20 years for the F-22 and 30 years for the F-35, we have no method for verifying that tests on aircraft components will translate into these respective service lives,” he said. According to the GAO report, “No operational-level test for corrosion was conducted on the F-22 prior to initial operating capability, and none are currently planned for the F-35.”

Both programs followed a performance-based acquisition approach during the contracting process. “The fact that both of these aircraft were designed and produced in a performance-based acquisition environment complicates any effort to prolong their life cycles,” Dunmire said. “In general, the current environment is a disincentive for contractors to meet performance baselines and write requirements that are well-defined. Also, neither program has a requirement that instills attention to life-cycle cost consideration such as corrosion mitigation. In this type of environment, the government assumes the risks and costs of failure, and has done so with both of these programs.”

An F-35 Lightning II Joint Strike Fighter (JSF) test aircraft banks over the flight line at Eglin Air Force Base, Florida, on April 23, 2010, sending contrails streaming off the wings. The aircraft is the first F-35 to visit the base, which is the future home of the JSF training facility. Photo by Senior Airman Julianne Showalter, U.S. Air Force.

In reviewing the consequences of the use of performance-based acquisition by the F-22 and F-35 program offices, the GAO report noted: “. . . neither aircraft had a corrosion prevention user requirement that would drive CPC [corrosion prevention and control] as a design requirement.” In addition, the expression “corrosion resistance” within system specifications for the F-22 and F-35 program offices is “a poorly defined and nonspecific term that is difficult to ensure incorporation into aircraft components and to verify,” the report states.

Only five years after the F-22 went into service, the government is paying multi-millions of dollars for repairs and retrofits related to corrosion, Dunmire said. “Our review team was concerned that life-cycle costs should be considered in design trades on either program. The government must have the authority to make decisions about corrosion performance, or there is risk that corrosion will affect life-cycle sustainment costs and readiness.”

As an example of this lack of accountability, Dunmire cited the instance in which a sub-tier supplier for the F-22 changed the configuration of a flight-critical avionics system mistakenly believed to be below the purview of government review. The F-22 program office was unaware that the supplier had made the change. “This situation resulted in increased field maintenance of the aircraft, putting it out of service, which drove up costs and reduced availability,” Dunmire said.

“Also, climatic testing was severely reduced for the F-22, reducing the ability to identify corrosion issues early in the program for the aircraft user,” Dunmire said. “These tests, if used correctly, can be critical ways in which DoD finds areas on the aircraft that are susceptible to corrosion,” Dunmire said.

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“The corrosion study concluded that if the F-22 program had accomplished testing earlier in the program, many of the corrosion problems could have been addressed at greatly reduced cost, and the associated readiness issues [could have been] avoided,” stated the GAO report.

Evaluation Results—F-22A Raptor

Dick Kinzie, DoD Corrosion Office Senior Analyst, discussed other findings during the team’s corrosion evaluation of three cases involving the F-22A Raptor. At some point the program initiated the use of a galvanically dissimilar gap filler and paint that were used in close proximity to the aluminum structure. “This combination constitutes a well-known corrosion risk,” Kinzie said.

Members of the 27th Expeditionary Aircraft Maintenance Unit completed the first accelerated packaged maintenance plan on an F-22 Raptor in a deployed environment on August 4, 2010, at Andersen Air Force Base, Guam. Photo by Master Sgt. Kevin J. Gruenwald, U.S. Air Force.

“The F-22 program is now aggressively implementing fixes in production and through retrofits to include the use of barrier materials and improved gap fillers,” Kinzie said. “Also, fixes to the drainage system are being investigated. Each of these continued risks is being mitigated through rigorous testing, planned aircraft inspections, and the identification of alternatives.”

The team also encountered the use of non-chromated primer, applied for environmental reasons, on the outer mold of the aircraft. “This did not provide the necessary corrosion protection,” Kinzie said. “So when Air Combat Command discovered severe corrosion problems during their operations, the program was directed to use the more corrosion-resistant hexavalent chromium to achieve the needed protection.”

As a result of the corrosion team evaluation, the F-22 program is applying a variety of fixes during production of new aircraft, as well as retrofitting old aircraft.

Evaluation Results—F-35 Lightning II

The F-35 has several technical performance metrics that are indirectly driving a more supportable and maintainable design for corrosion. “One of these, known as the sortie generation rate, is a key performance parameter for the program,” Kinzie explained. “In addition, our joint DoD requirements drove a more rigorous corrosion design for the F-35, which included more rigorous corrosion qualification tests.”

The F-35 program has adopted the many “lessons learned” related to corrosion from the F-22 program in the areas of materials, according to the GAO report’s analysis of the DoD corrosion study. The GAO report also states, “The F-35 program is mitigating corrosion risk associated with conductive gap filler—the sealant between exterior panels?and paint by using a gap filler that is less galvanically dissimilar [to] aluminum, an alternative to the conductive paint, a design with fewer seams that require gap filler, and more representative verification and qualification testing.” As Dunmire stated above, the GAO report noted, “Many of the F-22’s corrosion problems were linked to problems with gap filler materials and paint.”

Dunmire said, “The F-35 program has launched several mitigation actions to deal with the risk, including plans to conduct additional and more representative verification and qualification tests. Organizational changes that integrate personnel working with corrosion materials and processes with stealth or low-observable technology are also resulting in more integration of signature corrosion materials and processes to functional areas.”

“For example, the F-35 drainage design is significantly improved compared to that of the F-22,” Dunmire said. “Most drain holes are adequately sized and complete drain paths have been analyzed to account for and prevent fluid entrapment. It will be important during climatic testing to verify the drain paths.” The GAO report also noted: “Drain holes in the F-22 were found to be too small to enable good water drainage.”

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"Second, the choice of primer coating on the F-35 airframe represents a significant corrosion risk," Dunmire said. "In the judgment of the evaluation team, non-chromated primers may pose a larger corrosion risk than primers that contain chromates." In its section on "potential future corrosion issues for the F-35," the GAO report stated: "The F-35 has also chosen to use a non-chromated primer that has never been tested on an aircraft in a corrosive operating environment."

An F-22 Raptor soars through the air on July 1, 2010, on its way home to Joint Base Pearl Harbor-Hickam, Hawaii. Photo by Senior Airman Gustavo Gonzalez, U.S. Air Force.

And third, Dunmire said, magnesium components on the F-35 engine gearbox also present a corrosion risk. Furthermore, components that have been qualified by similarity rather than test have an increased corrosion risk. In addition, the aluminum gearbox components that are not protected with a primer and topcoat, in contrast with those traditionally used in such military systems, represent increased risk.

Conclusions

"Overall, the team found that both the F-35 and F-22 programs are currently at risk for corrosion, even though that risk is not as great for the F-35," Dunmire said. "Much work remains to be done, but it is certainly possible for the F-35 program to identify future corrosion risks through adequate planning and mitigation methods. However, this evaluation has concluded that the fixes being used by the Air Force on the F-22 carry further risk for corrosion. It is incumbent upon the Air Force to aggressively mitigate these additional risks in order to prevent further damage."

According to the GAO report, "the study also names a number of new weapon systems that could benefit from CPC lessons learned from both the F-22 and F-35. These systems include the Expeditionary Fighting Vehicle, CH-53K helicopter, Joint High Speed Vessel, Broad Area Maritime Surveillance Unmanned Aircraft System, and the Joint Light Tactical Vehicle."

Dunmire's office is in the process of addressing what all the services can do to manage the issues raised by the corrosion evaluation. "While we will assess our findings more in the coming weeks, our review of the F-35 and F-22 programs has pinpointed a number of areas for improvement that should be executed by all DoD weapon system program offices," he said.

Dunmire added, "With respect to corrosion prevention, all DoD program offices, including the F-35 and F-22, need independent, credible evaluation and clear requirements that can be traced through sub-tier documents. We also need design guidelines and trade studies that are balanced, as well as verification and validation through testing that represents how the weapon system performs in service. Most important, during testing and evaluation these systems should be exposed to corrosive locations similar to the areas where the system could be deployed."

Evaluation Team Focus Areas

To perform the evaluation, core members of Dunmire's evaluation team were joined by contracted subject-matter experts who support the Office of Corrosion Policy and Oversight. There were 10 team members who evaluated existing corrosion-related requirements for both the F-35 and F-22 programs, along with issues related to corrosion verification, validation, and testing, noted Kinzie. "Our 10-member team was broken down into five areas of focus," Kinzie explained. The focus areas included science and technology, systems engineering and program management, materials and processing, structures, and manufacturing."

In a concluding section, noting that the corrosion study was "well-executed," the GAO report stated: "The study team gathered and reviewed program documents; conducted site visits to program offices, service laboratories, manufacturing facilities, and major depots; and analyzed the information it obtained for contributing causes, lessons learned, and applications of best or accepted practices."

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