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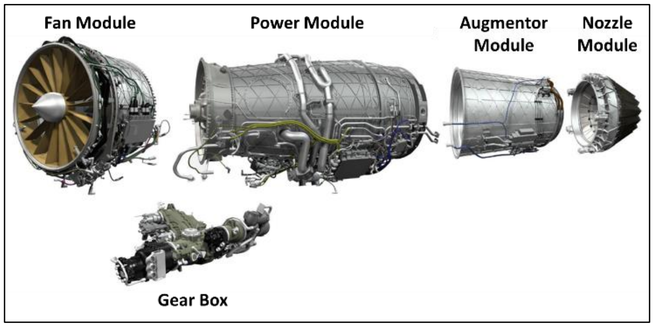
F-35 Joint Strike Fighter (JSF) Engine Options

The Department of Defense (DOD) is considering whether to upgrade the F-35 Joint Strike Fighter's (JSF's) existing F135 engine—the Engine Enhancement Package (EEP)—or to develop and procure a new engine for the aircraft—the Adaptive Engine Technology Program (AETP). Congress has long expressed interest in issues relating to the F-35's engine. Section 242 of the FY2022 National Defense Authorization Act (P.L. 117-81) required DOD to develop an acquisition strategy for transitioning the engine of the Air Force version of the JSF (the F-35A) to the AETP. Section 243 required DOD to develop a separate acquisition strategy for transitioning the Marine Corps and Navy versions (the F-35B and F-35C, respectively) to some form of advanced propulsion.

History of F135 Engine

The F135 (see **Figure 1**)—designed and built by Pratt & Whitney (P&W) of Middletown, CT—is the only engine that currently powers the F-35. (For more on the F-35 program, see CRS Report RL30563, *F-35 Joint Strike Fighter (JSF) Program*, by John R. Hoehn.) DOD awarded P&W the F135 contract in 2001. P&W decided to derive the F135 from the F119 engine, which powers the Air Force's F-22 fighter, to speed up the F135's development.

Figure 1. Diagram of F135 Engine



Source: CRS adapted graphic from GAO report GAO-22-104678, July 2022, p. 6, at https://www.gao.gov/assets/730/721771.pdf.

General Electric (GE) and Rolls Royce (RR), alternatively, collaborated to develop an engine for the JSF called the F136, and the F-35 program initially planned to use both engines. The Navy ended its participation in the F136 program. Following DOD's F135 contract award in 2001, GE and RR continued to develop the F136. In FY2011, Congress ended development funding for the F136, and GE and RR announced in December 2011 that they would no longer continue developing the F136.

P&W has experienced design challenges with the F135 engine, such as bleed air requirements and sustainability issues. Air Force Lieutenant General Eric Fick, the Program Executive Officer for the JSF program, testified in April 2022 that DOD originally defined the F135's requirements for bleed air (compressed air taken from within the engine) during early development. However, engine capability design modifications and new requirements emerged during the F-35 Continuous Capability Development Delivery (C2D2) program. The F-35 C2D2 program provides "incremental ... improvements to maintain joint air dominance against evolving threats." He stated that "[t]o provide the necessary bleed air, the engine was required to run hotter, and early engineering assessments suggest that this increase in operating temperature could decrease engine life, driving earlier depot inductions and an increase in life cycle cost."

A July 2021 Government Accountability Office (GAO) report (GAO-21-39) stated that "[a]ccording to multiple service and program officials, challenges related to F-35 engine sustainment are currently affecting the program and may pose its greatest sustainment risk over the next 10 years." The report described two issues affecting the engine:

- The need to "[remove] engines for unscheduled maintenance more often than expected, primarily to repair the power module—a key component of the engine that generates thrust for the aircraft to fly"; and
- DOD's ability "to repair only 43 percent of removed power modules in 2020, thereby resulting in a backlog of power modules needing repair."

The report stated that these issues resulted in not meeting goals for engine repair turnaround times, and that "DOD recognizes that it lacks the capacity to make both unscheduled and scheduled engine power module repairs at the levels needed to support the F-35 program."

An updated July 2022 report (GAO-22-104678) stated that the "number of power modules needing repair was largely due to coating distress of the high-pressure turbine blades. F-35 aircraft operations in dusty or sandy environments, as well as the higher running temperatures, have caused accelerated coating distress on the blades." The report further stated:

> Annual engine sustainment costs, a portion of total sustainment costs, have increased from $79 million in fiscal year 2016 to $315 million in fiscal year 2020.... By fiscal year 2028, maintenance costs for the F-35 aircraft engine are projected to be over $1 billion annually. According to Pratt & Whitney officials, scheduled maintenance has the potential to be over 70 percent of total engine maintenance costs by 2030.

The report added that to address these F135 sustainment issues, DOD is assessing two potential options: the EEP and the AETP, reviewed below.

Overview of F135 EEP

P&W contends that the EEP would provide "an affordable, low risk, and agile pathway to fielding meaningful propulsion capability for all F-35 customers." More specifically, P&W states that the EEP would mitigate current sustainment issues with the F135, meet the needs of the Block 4 version of the F-35, and provide $40 billion in lifecycle savings. GAO's July 2022 report notes the EEP "would result in an increase in capability, such as improved range and thrust." P&W states that if the EEP is required to work with all three F-35 variants, "some degradation in performance would be experienced to accommodate the lift fan that is part of the engine for the [the Marine Corps'] F-35B [variant]." DOD has not provided an estimate for how much the EEP would cost to develop. Some analysts estimate the EEP's development cost at about $2 billion.

Overview of AETP

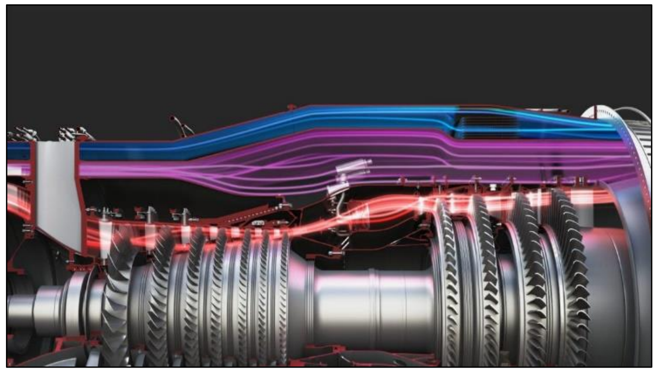
AETP is the Air Force's next-generation engine research and development program, intended for use with the service's envisioned Next Generation Air Dominance (NGAD) aircraft. As mentioned above, DOD is also assessing the potential for using AETP with the F-35. Typically, designers optimize jet engines for either fuel economy (as in airliners and military cargo aircraft) or high thrust (as in fighters). By permitting changes to the bypass ratio (the amount of air that goes around the engine core compared with the amount that goes through the engine core), adaptive engine technology allows jet engines to switch between fuel-efficient and high-thrust modes, as needed. Adaptive engines can also improve thermal management, which can permit increased power generation. Two companies are developing adaptive-engine technologies: GE (which is developing the XA100; see **Figure 2**) and P&W (which is developing the XA101). A September 13, 2022, trade press report states that both the GE and P&W engines "are expected to increase the F-35's range by at least 25 percent, increase its thrust by 10 percent and double the power management compared to the F135."

Secretary of the Air Force Frank Kendall testified in April 2022 that he anticipated AETP offering a cost savings and an increase in capability (e.g., range and power generation) compared with the current F135. He testified that he anticipated that it would cost about $6 billion to transition the AETP into production. Kendall has said that the Air Force could make a decision on whether to pursue AETP in the FY2024 budget.

GE's Version of AETP—the XA100

General Electric advertises the XA100 engine as increasing the F-35 aircraft's range by 30%—achieving 25% from improved fuel economy and 10% from increased thrust. According to defense press reporting, the XA100 engine completed testing at Arnold Engineering Development Complex in September 2022. In addition, testing for the XA100 engine reportedly demonstrated that the engine could potentially be modified to power the F-35B aircraft. GE contends that the XA100 can support both the F-35 and NGAD programs.

Figure 2. GE XA100 Engine



Source: Photograph accompanying GE Aerospace, "Testing on GE's First XA100 Adaptive Cycle Engine Concludes, Proves Out Transformational Capabilities," May 20, 2021, at https://blog.geaerospace.com/technology/testing-on-ges-first-xa100-adaptive-cycle-engine-concludes-proves-out-transformational-capabilities/.

P&W's Version of AETP—the XA101

The XA101 reportedly is in testing as of September 2022. P&W stated that "XA101 testing remains on track and aligned with the U.S. Air Force's AETP development timeline.... P&W is committed to the continued maturation of the technology suite in AETP, as it is foundational for the sixth-gen [sixth-generation] capabilities needed for NGAD family of systems in the 2030s."

Potential Issues for Congress

Congress may consider whether or not it should authorize and fund an upgrade to the F135 engine and consider the potential impact current F135 sustainment issues have on F-35 readiness. In addition, Congress may also consider whether

- it would be more cost-effective for the Air Force to pursue EEP or AETP;
- Congress has sufficient information on potential costs (including development, procurement, and life-cycle operation and support costs), development risks, and performance improvements of EEP and AETP to adequately compare and assess these two options for upgrading the F135;
- it might be more cost effective if the AETP were pursued to only apply it to the F-35A, or to also apply it to the F-35B and/or the F-35C as well; and
- there are potential secondary impacts for other Air Force aircraft if the AETP were pursued as an upgrade to the F135. For example, AETP engines might reduce the requirements for aerial refueling capacity.

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