



Breaking News: Lockheed Martin completes TR-3 upgrade to turn the F-35 into an even deadlier stealth fighter jet.

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Lockheed Martin has completed the Technology Refresh 3 (TR-3) upgrade for the **F-35 Lightning II** multirole fighter, stating that it has achieved a stable configuration capable of supporting combat capabilities. However, a single combat function still requires validation by the U.S. government before the configuration can be formally approved for operational use. Speaking at the 2025 Paris Air Show, Lockheed executives, including J.R. McDonald, Vice President of Business Development for the F-35 program, confirmed the company’s position that readiness has been reached.

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The TR-3 upgrade is considered essential because it provides the technical basis for Block 4, which Lockheed executives have characterized as “the most aggressive upgrade of any fighter in history.” (Picture source: US Marine Corps)

Despite this statement, Lockheed did not provide a specific timeline for final government approval. The F-35 Joint Program Office has not offered any indication of when certification might be granted. The TR-3 upgrade was originally planned for deployment in April 2023, but both hardware and software integration delays resulted in a year-long freeze on deliveries of F-35s equipped with the configuration, beginning in July 2023.

The TR-3 upgrade introduces 75 enhancements across hardware and software, including a new integrated core processor that provides 25 times the computing power of its TR-2 predecessor. This increase in processing capability supports a new cockpit display system, greater memory capacity, and faster mission system updates. It also enables compatibility with advanced artificial intelligence functions. These modifications are required to support future capabilities included in the Block 4 modernization program, which encompasses a new radar system, upgraded sensor suites, improved electronic warfare systems, and expanded weapons integration. TR-3 enables more rapid mission system updates and improved data fusion performance. These upgrades are not standalone; TR-3 serves as the computing and architectural foundation for Block 4, which is structured to be released incrementally during the second half of the 2020s. One combat capability remains unvalidated, though Lockheed has not disclosed its nature. Operational flight program updates are ready for deployment once final approval is granted.

The TR-3 upgrade is considered essential because it provides the technical basis for Block 4, which Lockheed executives have characterized as “the most aggressive upgrade of any fighter in history.” This phase of modernization includes the integration of the AN/APG-85 radar to replace the AN/APG-81, the AIM-260 Joint Advanced Tactical Missile (JATM), MBDA’s Meteor for European operators, the AGM-88G Advanced Anti-Radiation Guided Missile-Extended Range (AARGM-ER), and the Norwegian Joint Strike Missile (JSM). Block 4 will also feature updated low-observable coatings, a new Distributed Aperture System, and the ThNDR laser-based infrared countermeasure. Additional enhancements are expected in cross-domain connectivity and data fusion, expanding the F-35’s role as a node in U.S. and allied multi-domain networks. The Pratt & Whitney F135 Engine Core Upgrade (ECU) will address increased power and thermal demands, improving thrust and cooling efficiency by 50 percent. Although the XA100 adaptive cycle engine was examined under the Adaptive Engine Transition Program (AETP), it was not selected due to cost and integration concerns. These capabilities are scheduled for phased introduction through the late 2020s and early 2030s.

The delivery freeze that began in July 2023 was triggered by software instability in early TR-3 configurations. Following this delay, the U.S. Department of Defense (DoD) halted acceptance of F-35s equipped with TR-3. Lockheed Martin continued producing aircraft but was required to store a growing number of completed yet undelivered jets. The total reached as many as 120 aircraft, while Lockheed and the F-35 Joint Program Office (JPO) worked on a resolution. Deliveries resumed in July 2024 under a phased strategy based on an interim “truncated” TR-3 software version designed to support robust training capabilities. The first two F-35As delivered under this plan went to Dannelly Field, Alabama, and Nellis Air Force Base, Nevada. However, these aircraft were not combat-capable, and the full software release required for combat operations is not expected before late 2025 or early 2026. During the delivery halt, the Pentagon imposed financial penalties on Lockheed Martin, withholding between \$5 and \$7 million in final payments per aircraft, totaling approximately \$60 million in lost performance fees.

As of June 2025, Lockheed Martin has delivered 200 F-35s equipped with the TR-3 configuration. These jets remain restricted to training missions. The company expects to deliver between 170 and 190 F-35s over the course of 2025. Deliveries include aircraft for international customers under Foreign Military Sales agreements and cooperative production arrangements. In November 2024, the U.S. Department of Defense awarded Lockheed Martin a \$869.9 million contract for long-lead components related to Lot 20 production, which includes TR-3 hardware and initial Block 4 capabilities. Lot 20 covers aircraft for the U.S. Air Force, Navy, Marine Corps, and several allied air forces. Lockheed has resumed manufacturing at a rate of approximately 20 aircraft per month. During the delivery freeze, the company used \$700 million of internal funding to sustain production and avoid disruption to its supply chain. Full-rate production, enabled by the achievement of Milestone C in March 2024, allows for the execution of multiyear procurement contracts.

Lockheed Martin is also supplying retrofit kits to upgrade earlier TR-2 standard aircraft to the TR-3 configuration. These kits are being installed at operational bases by contract field teams. The TR-3 architecture is based on a modular and open-systems design, which Lockheed says will allow more rapid and cost-effective future software updates. The first flight test of a TR-3-configured F-35 took place on January 6, 2023, from Edwards Air Force Base. During the 50-minute test, the aircraft reached 35,000 feet and near-supersonic speed. TR-3 has also been tested in networked operations, including one scenario in which a Dutch F-35 used a multi-domain gateway to transfer classified data to a command-and-control system, which then relayed firing-quality data to a ground-based rocket artillery unit. These tests were conducted to assess the system’s effectiveness as a data node in a multi-domain combat environment.

European participation in the F-35 program continues to expand. By June 2025, more than 1,185 F-35s had been delivered globally, and 20 countries had joined the program. European industry contributes key components, with Rheinmetall in Germany producing center fuselages, Patria in Finland manufacturing forward fuselages, Leonardo in Italy building wings, and Belgian suppliers producing horizontal tail sections. Aircraft assembled in Cameri, Italy, may include elements from all four countries. Poland is the most recent European nation to receive TR-3 F-35s, which are currently based at Ebbing Air National Guard Base in Arkansas, where the first Polish pilots have begun training. Other recent buyers include the Czech Republic, Greece, and Romania. The U.S. European Command anticipates that over 700 F-35s will be operating across Europe by 2035. Belgium took delivery of its first aircraft in December 2024, stationed at Luke Air Force Base in Arizona. The planned delivery of 34 Belgian aircraft is now expected to conclude by mid-2025. The revised timeline, delayed due to production issues, has led to parliamentary scrutiny and financial penalties applied to Lockheed.

Lockheed Martin has discussed further developments for the **F-35** that would incorporate technologies from the U.S. Air Force’s Next Generation Air Dominance (NGAD) program. These prospective upgrades include advanced sensors, updated stealth coatings, and optionally unmanned operation. Lockheed CEO Jim Taiclet stated that such a configuration, referred to as “fifth-generation plus”, could provide 80 percent of the capability expected from a sixth-generation fighter at roughly half the cost. Proposals under consideration include a twin-engine variant designated “F-55,” although aerospace analysts have expressed skepticism regarding the feasibility of such designs. The Block 4 modernization effort is expected to proceed through successive updates and may eventually be followed by a Block 5. Potential additions under evaluation include infrared search and track systems and low-drag external fuel tanks developed for the F-22. Despite losing the NGAD manned aircraft competition to Boeing, Lockheed Martin has indicated it will apply NGAD-derived technologies to both the F-35 and F-22 platforms. These plans are intended to maintain the operational relevance of existing fifth-generation aircraft into the 2030s and beyond.

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