F-35 Lightning II

Throughout FY25, the F-35 development effort continued to face challenges in delivering reliable, fully functional software to the operational test (OT) teams. The development teams focused on two software variations, one each for the Technology Refresh (TR)-2 and TR-3 hardware configurations. In spite of the TR-3 capability being a rehost of TR-2, the latest iteration of TR-3 software (40R02) was unsuitable for dedicated OT. Similarly, the latest version of TR-2 software (30R08) – intended to be the last version of software fielded on the TR-2 aircraft – was predominantly unusable for additional OT events during most of FY25, due to stability problems, shortfalls in capability, and on-going discovery of deficiencies. Dedicated OT with 30R08 software began in September 2025 when the OT squadrons participated in a large test exercise, GRAY FLAG 2025 with the latest version of 30R08 software. As such, no new combat capability was fielded in FY25.

The F-35 Joint Program Office (JPO) planned for needed modifications to OT aircraft, but resource shortfalls have not enabled timely delivery of these modifications. Current aircraft forecasts show that there will not be enough OT aircraft available to accomplish dedicated OT in representative formations of aircraft. Concerning the resources necessary to evaluate F-35 capabilities in the Joint Simulation Environment (JSE), the program has only one F-35 In-a-Box (FIAB) delivery contracted for after the 40S03 release next year, which DOT&E considers to be unacceptable. The JPO plans to put more FIABs on contract as the Block 4 configuration plan matures.

SYSTEM DESCRIPTION

The F-35 Lightning II is a tri-Service, multinational, single seat, single-engine strike fighter aircraft. It is replacing legacy strike fighter aircraft in the U.S. Air Force, Marine Corps, and Navy and is being produced in three variants:

- F-35A Conventional Take-Off and Landing for the Air Force
- F-35B Short Take-Off/Vertical Landing for the Marine Corps
- F-35C Aircraft Carrier Variant for the Navy and the Marine Corps

The F-35 modernization plan, as defined in the Block 4 Modernization Capability Development Document, specifies required capabilities and associated capability gaps that drive incremental improvements under what is intended to be an agile acquisition framework.

MISSION

The missions of the F-35 aircraft include attacking fixed and mobile land targets, surface combatants at sea, and air threats, including advanced aircraft and cruise missiles, in joint operations during day and night, in all weather conditions, and in heavily defended areas.

PROGRAM

The F-35 Lightning II is an Acquisition Category ID program. IOT&E was completed in September 2023, and DOT&E published a combined IOT&E and LFT&E report in February 2024.

The USD(A&S) approved full-rate production in March 2024, and directed the program to designate two major subprograms within the overall acquisition program – one for the engine modernization effort and one for F-35 Block 4 development.

Block 4 FOT&E is governed by the F-35 Overarching Block 4 TEMP and associated annexes, which are updated incrementally and include developmental testing (DT) and OT with aircraft in the TR-2 and TR-3 configurations. The F-35 Block 4 TEMP Increment 3 annexes were approved in November 2024. They include software upgrades (versions 40R02, 40R03, and 41R01) that add capability, including new Electromagnetic Warfare capability enabled by upgraded hardware on TR-3 aircraft starting in production lot 19. To ensure the program office planned and funded for adequate OT, DOT&E required an addendum to Annex 3, detailing the capabilities and OT requirements for software version 41R01. DOT&E approved the addendum in October 2025.

The TR-3 avionics upgrade, which includes upgraded main mission computers (referred to as integrated core processors), aircraft memory system, and panoramic cockpit displays, is a key enabler for new Block 4 mission systems capabilities. The TR-3 upgrade replaces the corresponding TR-2 components that are currently fielded in nearly the entire fleet of F-35 aircraft.

Problems with the TR-3 hardware and software during DT forced the program to delay delivery of the Lot 15 production aircraft until performance improved, resulting in these aircraft being put into storage. In an effort to stabilize the performance on the new TR-3 hardware, the program developed a truncated version of software by disabling some of the combat capabilities that had already been fielded on the TR-2 aircraft. The JPO, Services, and Lockheed Martin reached an agreement to start accepting TR-3 aircraft with the truncated software. No combat-capable TR-3 aircraft have been delivered to the U.S. Services to date. As of the end of September 2025, 158 F-35s had been delivered in the TR-3 configuration and a total of 812 aircraft (any configuration) have been produced and delivered to the U.S. Services.

» MAJOR CONTRACTORS

- Lockheed Martin Aeronautics Company – Fort Worth, Texas
- Pratt & Whitney, a subsidiary of RTX – East Hartford, Connecticut

TEST ADEQUACY

» BLOCK 4 OPEN-AIR TESTING

DOT&E continues to have concerns about the ability of the United Operational Test Team (UOTT) – made up of members from the United States, the United Kingdom, and Australia – to conduct adequate testing of the Block 4 capabilities because of the reduced number of OT aircraft with the necessary hardware configurations and the required instrumentation to test mission systems and weapons integration. Effectively managing the multiple aircraft configurations is a challenge

that requires a single, integrated master schedule. The program maintains an integrated test aircraft flow that maps software builds to test aircraft configuration, modification schedules and flight test instrumentation, including Open-Air Battle Shaping (OABS). Funding and contracting delays have made it difficult for the OT teams to have eight fully capable aircraft available for dedicated OT trials during the OT periods. Given OT aircraft availability rates, this generally means a total of 12 OT aircraft must be planned and funded to ensure 8 OT aircraft are available for most missions.

Block 4, TR-2 Open-Air Testing

The UOTT 30R08 OT plan, the latest and last planned TR-2 software version, governs the open-air 30R08 OT for all units assigned to the UOTT. The plan covers the open-air test events that can be conducted with various increments or developmental versions of the software. Capability test events (CTEs) in the plan are events that may be conducted with early, less mature versions of the software and are designed to characterize the performance of new capabilities or verify corrections to deficiencies identified during previous testing. CTEs are flown as an extension of the development effort, particularly for this later build of 30-series software (30R08.XX) for the TR-2-configured aircraft, since most of the current DT fleet have been upgraded to the TR-3 configuration. Mission area trials (MATs) in the plan may also be flown with early versions of software and are normally conducted as a part of large force joint exercises to collect data from scenarios more operationally representative than the tightly controlled, smaller scenarios flown in the CTEs. MATs provide the added benefit of evaluating interoperability with other air warfare platforms. Dedicated OT missions are events that require full mission-level evaluations, assessing F-35 operational effectiveness in terms of lethality and survivability in mission scenarios, similar to those flown during IOT&E. They are generally flown with the final version of software in the series, which is the version that will be delivered to field units. Dedicated OT events include variations in operational conditions, such as the number of threat and friendly airborne forces or the number and type of ground threat systems. Finally, dedicated weapon employment events, both captive carry (weapon test article flown, but not released) and live fire events, are included in the 30R08 OT plan.

DOT&E approved the test plan incrementally from February 2023 through August 2025, as the UOTT was able to conduct some portions of the test plan with the version of software delivered to the OT fleet. The UOTT issued a stop test order for OT of the 30R08 software in February 2024, citing critical Category I deficiencies and overall poor software stability. The UOTT issued a limited resume test notification to the program office in October 2024, and completed a GBU-54 weapon employment event, pictured at the beginning of this article. For the remainder of FY25, the UOTT primarily focused on assisting the DT effort by flying CTEs with interim versions of software, identifying and characterizing deficiencies and anomalies, and providing feedback to the contractor software development team. Dedicated OT for the TR-2 configuration began in September 2025 when the OT squadrons participated in a large test exercise, GRAY FLAG 2025.

Block 4, TR-3 Open-Air Testing

The UOTT continues planning for OT of the first TR-3 production configuration, which is now planned to commence with software version 40R03. Although the program developed two earlier versions of software for delivery to the field – 40R01 and 40R02 – the program office designated them as not suitable for conducting OT. The program's DT effort with the TR-3 aircraft and associated software remained significantly behind schedule throughout FY25. Aircraft modifications, flight test instrumentation, OABS capabilities, and stable software will all be required before dedicated OT can begin on TR-3 aircraft. Additionally, program funding constraints will make it difficult to plan for and accomplish adequate weapons testing with 40R03.

» BLOCK 4 – JSE

Following the completion of F-35 IOT&E test trials in the JSE at Patuxent River Naval Air Station, Maryland, in late FY23, program management of the JSE evolved to a larger enterprise to support future OT and training requirements. The organization of the JSE enterprise and the process by which it originates, prioritizes, funds, and implements requirements continue to evolve.

The next iteration of OT of the F-35 in the JSE will be based on the capabilities fielded with 30R08 software. The corresponding aircraft model in the JSE is the 30S08 FIAB. The JPO and the Naval Air Warfare Center Aircraft Division started integration of the 30S08 FIAB in the JSE site at Patuxent River in August 2024. They plan to deliver an initial capability in 1QFY26 that has undergone limited regression testing, but not verification and validation (V&V) needed to accredit for OT. 30S08 V&V activities are planned to continue through FY26, culminating in formal accreditation in early FY27. The UOTT is developing a test plan for conducting 30S08 mission-level trials in the JSE once it is accredited for OT. The UOTT intends to conduct the trials at one or a combination of the JSE sites at Patuxent River and the new Digital Test and Training Range – Nellis (DTTR-N) in Nevada. The Air Force planned to deliver an initial operational capability at the DTTR-N by 1QFY26 with up to 12 F-35 cockpits in the 30S02 configuration (same as that used for IOT&E in FY23) and 4 F-22 cockpits. The Air Force plans to complete 30S08 integration at the DTTR-N in FY26, in parallel with V&V and accreditation (VV&A) activities at Patuxent River, leading to an accreditation at both sites in 4QFY27. After testing in the JSE with 30S08, the program currently has plans to fund only two more FIAB releases during the initial Block 4 contract effort. Additional releases of FIAB will require new funding and additional contracting actions.

» SUITABILITY TESTING

DOT&E approved the latest iteration of the UOTT's F-35 Modernization Block 4 Suitability Test Plan in February 2025, with the caveat that the UOTT address shortfalls in the plan. The UOTT submitted an amendment to the plan in May 2025 to address the shortfalls, which DOT&E approved in July 2025. However, DOT&E remains concerned that no additional dynamic RCS measurement testing has been done on any variant by any of the Services since IOT&E. These measurements are necessary to assess the long-term health and performance of the low observable properties of the aircraft.

In 2026, the program plans to field a ground-based support system that would allow dynamic RCS measurements of operational aircraft by linking with ground station monitors. Without the ground station linkage, only a relatively small number of aircraft equipped with appropriate instrumentation can be measured.

» SURVIVABILITY TESTING

The F-35 Block 4 Cybersecurity Operational Test Plan (COTP) for FY25 included nine scheduled test events, of which only three were conducted. Planned FY25 test events slipped primarily due to attrition of the UOTT cyber survivability test team, which experienced a significant reduction of personnel in FY25. Additionally, funding priorities within the JPO limited testing opportunities. The deferred FY25 test events are being planned for FY26.

In FY25, the UOTT cyber team delivered the report for the FY24 cyber survivability assessment of line-replaceable unit supply chain refurbishment practices, a high interest area for the DoW and the F-35 program. All cyber survivability test activities were conducted in accordance with DOT&E-approved plans, and key events were observed by DOT&E.

Aircraft made available for cyber survivability testing have been permanently grounded assets. These assets are used for software development and thus limit the scope of cyber testing because of the potentially disruptive nature of cyber tests. More robust and representative aircraft cyber tests are needed, which will require Service and JPO investment in hardware- and software-in-the-loop capabilities. To address this need, the JPO designated a retired TR-2 mission systems DT aircraft (AF-3) to be available for dedicated cyber survivability testing. Transfer of the aircraft experienced delays in FY25 and is expected to be available for cyber testing in 1QFY26.

Candidates for cyber survivability testing are continually assessed for inclusion in updates to the COTP. Additionally, once cyber effects are characterized, emulation during mission rehearsals in the JSE, or as appropriate in open-air exercises, will be key to assessing potential mission consequences from cyber exploits.

PERFORMANCE

» EFFECTIVENESS

Block 4, TR-2 Development

The F-35 program continues to show no improvement in meeting schedule and performance timelines for developing and testing software, failing to deliver on the expectations of its agile development framework. The process of addressing deficiencies and adding new capabilities has stagnated as the current 30-series block of software has been undergoing a fly-fix-fly iterative development cycle for nearly four years, delivering a test-ready version of 30R08 to the UOTT at the end of FY25. Additional challenges added with the TR-3 avionics upgrades, both in development and testing, have caused continued delays to the planned schedules for delivering capabilities in Block 4 for the aircraft in the TR-2 configuration. Table 1 below compares the development-to-fielding timelines for the latest three versions of 30-series software, as well as the number of software iterations and whether each software version delivered with the full capabilities initially planned for it. Both 30R06 and 30R08 development took longer than planned and more iterations of software to address discoveries and deficiencies. Both 30R07 and 30R08 have delivered or will deliver with less than their planned capabilities. The program has not decided whether it will add another 30-series software version beyond 30R08. The overall result has been no significant 30-series (TR-2) capability improvement through the latest software versions, and the 40-series (TR-3) software getting further behind and amassing new deficiencies.

Block 4, TR-2 Open-Air OT

Due to the lack of adequate testing on the 30R08 software, DOT&E is unable to assess its operational effectiveness. The UOTT has flown with immature versions of the 30R08 software to support DT assessments of capabilities and has participated in large force joint exercises to assess integration and interoperability with other aircraft. However, these tests are not adequate to evaluate effectiveness of the 30R08 capabilities in terms of combat lethality and survivability, in mission-level scenarios. The testing that the UOTT has been able to accomplish continues to lead to discovery of deficiencies. During FY25, the UOTT wrote 17 deficiency reports against

Table 1. Comparison of Development Parameters of the Latest Software Versions

Comparison Parameters	Production Software Version		
	30R06	30R07	30R08
Software iterations planned	Four: 30R06.01, .02, .03, .04	Three: 30R07.01, .02, .03	Three: 30R08.01, .02, .03
Software iterations needed	Seven: 30R06.01, .02, .03, .031, .04, .041, .042	Eight: 30R07.01, .02, .03, .031, .033, .04, .041, .045	Thirteen (at least): 30R08.01, .02, .03, .04, .041, .051, .061, .062, .063, .064, .065, .066, .900
First DT flight	August 2020	April 2021	December 2021
First OT flight	October 2020	January 2022	March 2022
Planned release to the field	April 2021	May 2022	March 2023
Actual release to the field	September 2021	May 2022	TBD
Span from 1st DT flight to field release	13 months	13 months	> 45 months
All planned capabilities delivered?	Yes	No	No

the performance of capabilities in the 30R08 software, many of which were against capabilities that were working in previous versions of software, an indication of inadequate integration and regression testing. Six of these reports were designated as Category I – the most severe level of deficiency. The program continues to face software stability issues that delay delivery of software needed to accomplish dedicated OT. The OT teams have observed improved stability in the most recent software version provided for testing.

Block 4, TR-3 Development

Although the program and Services have been accepting aircraft off the production line for over a year, including those that were placed in storage waiting for an acceptable version of software, no dedicated OT (i.e., in accordance with a DOT&E approved test plan) had been completed through the end of FY25 on the TR-3 aircraft in a production-representative configuration. DOT&E anticipates that the first iteration of TR-3 software that will undergo dedicated OT missions and weapons testing is 40R03.

» SUITABILITY

The operational suitability of the F-35 fleet continues to fall short of Service expectations and the requirements defined in F-35 Block 4 Modernization Capability Development Document. Historical data show that sustaining improvement in aircraft suitability metrics is difficult, despite reliability improvements initiated by the program. (See the FY24 Annual Report for details on the historical data.) The program continues to prioritize aircraft availability improvement initiatives in order to meet U.S. and partner nation expectations.

F-35 aircraft mission systems instabilities can degrade mission performance and may require a pilot-initiated reset of mission systems in-flight, which could have severe consequences during combat. These resets are poorly recorded – the Autonomic Logistics Information System (ALIS), used to track and manage maintenance issues, does not have the capability to automatically log these events, and pilots have historically underreported the occurrences in post-flight debriefs. As such, mission systems instability is not accurately reflected in reliability metrics. To improve F-35 aircraft mission systems stability, DOT&E recommends that the Operational Data Integrated Network (ODIN) – the system replacing ALIS – include the capability to automatically record and document pilot-initiated resets of mission systems.

» SURVIVABILITY

While the program has made strides to fix many cyber deficiencies and has stated that fixing cyber issues is a priority, additional deficiencies were found during the test events in FY25.

Further insights into prioritizing components of the aircraft for cyber survivability will be forthcoming from the imminent completion of a first-phase Mission-Based Cyber Risk Assessment that commenced in 4QFY22, and from the follow-on second phase that started in 4QFY24.

RECOMMENDATIONS

The F-35 JPO and the Services, as appropriate, should:

1. Continue preparations for required F-35 FOT&E in the JSE beginning with the 30R08 capability release, and fund a FIAB for each capability release through the Block 4 program.
2. Ensure programming, funding, and contracting are in place to modify all OT aircraft with the appropriate capabilities, life limit, and instrumentation, including OABS requirements, in time to accomplish dedicated OT of mission and weapons events in the associated OT plans.
3. Conduct more in-depth cyber survivability testing of the air vehicle, ALIS/ODIN, training systems, and eventually JSE; complete the plans for hardware- and software-in-the-loop air vehicle cyber test assets that can be used for the full extent of cyber testing; introduce the ability for JSE to emulate cyber effects during mission rehearsals, as recommended in the FY22 – 24 Annual Reports.
4. Continue to correct program-wide deficiencies identified during cyber survivability testing in a timely manner and verify corrections within ALIS prior to rehosting ALIS software on ODIN, as recommended in the FY22 – 24 Annual Reports.
5. Develop and routinely report software sustainment and

stability metrics that show how well the program's overall software development capability for the air vehicle and logistics sustainment system is progressing. In particular, incorporate the ability of the aircraft's prognostics health management to detect and record pilot-initiated resets of mission critical systems in flight and produce records in the Computerized Maintenance Management System to more accurately track air vehicle system stability, as recommended in the FY22 – 24 Annual Reports.

6. Pursue funding and asset requirements to support testing of weapons being integrated in the 40R03 release, particularly long-range air-to-surface weapons.

The UOTT should:

1. Work with the U.S. Services to resume dynamic RCS measurements of two OT aircraft per variant, in accordance with the TEMP, as recommended in the FY24 Annual Report.