F-35 Joint Strike Fighter (JSF)

In February 2024, DOT&E published a classified F-35 combined IOT&E and LFT&E report, supporting the Milestone C Defense Acquisition Board review in March. The report provides an independent assessment of the overall mission capability of the F-35 in the Block 3F configuration, in terms of its operational effectiveness, suitability, and survivability. The report included a separate annex that provided an assessment of F-35 Block 4 operational testing which occurred following IOT&E.

The program proceeded to full-rate production, based on an acquisition decision memorandum (ADM) signed by USD(A&S) in March 2024. The transition to full-rate production occurred in the middle of nearly a year-long pause in acceptance of production aircraft, as the program worked to achieve stability in the new hardware and software to the point where it met the acceptance standards of the Services, facilitating the aircraft's delivery. Although Lockheed Martin planned to deliver the Lot 15 aircraft – the first lot with the new Technology Refresh 3 (TR-3) mission systems architecture – starting in July 2023, they had to put the aircraft in long-term parking because the mission systems software did not satisfactorily function on the TR-3 hardware. As a result, the Services, in coordination with the program office, refused to take delivery of TR-3-equipped aircraft until July 2024.

The F-35 development effort too was facing challenges in delivering reliable, fully functional software to the operational test (OT) teams. In February 2024, the United Operational Test Team (UOTT) called for a "stop test" of the software they were testing (30R08) – intended as the last version of software fielded on the TR-2 aircraft – due to stability problems, shortfalls in capability, and deficiencies they discovered. Quality escapes from the manufacturing and production processes (i.e., problems that should have been identified and corrected during the check-out and acceptance process for new aircraft) are still being identified in the field.

The F-35 Joint Program Office (JPO) has not adequately planned for OT of the upgraded TR-3 hardware configuration to be completed prior to delivering multiple TR-3 aircraft to field units. DOT&E assesses that dedicated operational testing of these aircraft will not occur until mid to late FY26, approximately two years after the configuration began delivery to the field.

SYSTEM DESCRIPTION

The F-35 Joint Strike Fighter (JSF) 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 (CDD), specifies required capabilities and associated capability gaps that drive incremental improvements under 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 JSF is an Acquisition Category ID program. DOT&E approved the fourth revision of the System Development and Demonstration TEMP in March 2013, which directed and governed the conduct of IOT&E. IOT&E was completed in September 2023, and DOT&E published a combined IOT&E and LFT&E report in February 2024 for Block 3F with a separate annex on Block 4 testing to date. The report supported a subsequent Defense Acquisition Board, which resulted in the USD(A&S) approving full-rate production in a March 2024 ADM.

The full-rate production decision ADM 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. The Block 4 development subprogram will replace the former Continuous Capability Development and Delivery program for adding new capabilities – both hardware and software – to the F-35 aircraft. The TR-3 avionics upgrade is a key enabler for new Block 4 mission systems capabilities and includes upgraded integrated core processors, aircraft memory system, and panoramic cockpit displays. The TR-3 upgrade replaces the corresponding TR-2 components that are currently fielded. No combat-capable TR-3 aircraft have been delivered to the U.S. Services to date.

The program planned for the TR-3 upgrade to cut into the production line in time to deliver with the Lot 15 aircraft in 2023. As designed, the TR-3 architecture would host the capabilities from the 30R07 TR-2 software build with the new designation of 40R01. The capabilities added and delivered in the 30R08 TR-2 software would be added to the next software build, 40R02. However, problems with both the hardware and software during developmental testing (DT) forced the program to delay delivery of the Lot 15 production aircraft until performance improved. These aircraft were put into long-term

parking after production, to enable the production line to continue.

To stabilize the performance on the new TR-3 hardware, the program developed a truncated version of software by disabling combat capabilities that had already been fielded on the TR-2 aircraft. In July 2024, a year after the planned delivery, the JPO, Services, and Lockheed Martin reached an agreement to allow the Services to start accepting TR-3 aircraft with the truncated software lacking these TR-2 capabilities. The U.S. Air Force accepted the first two TR-3 Lot 15 aircraft later that month, with an interim test software build of the truncated version, designated 40R01.351, that would allow pilots in the field to use the aircraft for training. According to the JPO, as of the end of FY24, the program had delivered 41 TR-3 aircraft. The limitations in terms of combat capability of these aircraft are not known, nor is the timeline on which the previously fielded capabilities (on the TR-2 aircraft) will be tested and provided to the newly delivered TR-3 aircraft.

The decision to proceed into full-rate production occurred after nearly thirteen years and fifteen lots of aircraft production at the prime contractor facility. Over that time span, the program office monitored key production and manufacturing metrics, including the scrap, rework, and repair hours per aircraft for each lot (due to problems identified during manufacturing and assembly) and quality escapes (i.e., problems that should have been identified and corrected during the check-out and acceptance process for new aircraft). According to JPO reports, efforts to improve production quality resulted in a 47 percent reduction in the time associated with scrap, rework, and repair and a 63 percent reduction in the observed number of quality escapes from the production line, between 2016 and 2023. While these efforts continue, quality escapes from the production line are still being discovered in the field. In one example, a U.S. Marine Corps fighter squadron in California discovered a series of quality escapes with a number of F-35C aircraft delivered to the unit in FY24.

A separate F-35 Overarching Block 4 TEMP and associated annexes govern the conduct of Block 4 FOT&E. Block 4 includes DT and OT with aircraft in the TR-2 configuration. For these aircraft, the program has designated flight software using a 30-series designation (i.e., 30RXX for development and flight testing software iterations, and 30PXX for final production and fielding). Block 4 also includes DT and OT with aircraft in the TR-3 configuration. The software for these aircraft is designated with a 40-series nomenclature (i.e., 40RXX or 40PXX). DOT&E approved the F-35 Overarching Block 4 TEMP and Increment 1 Annex in May 2020. The Increment 1 Annex covered the Block 4 DT and OT of software versions 30P03 through 30P06, which were completed in FY21. Increment 2 Annexes, which cover Block 4 software versions 30P07, 30P08, and 40P01, and their associated hardware enablers, including the transition from TR-2- to TR-3-equipped aircraft in the production line, were approved in October and December 2022. The Increment 3 Annexes, which cover Block 4 software versions 40P02, 40P03, and 41P01, and their associated hardware enablers were approved by DOT&E in November 2024.

At the time of this report, the program is undergoing a major review of sequencing and prioritizing the series of additional new capabilities through the establishment of the Block 4 subprogram. DOT&E expects the results of this effort will likely affect schedules and resources for the OT activities covered by the F-35 Overarching Block 4 TEMP and its annexes. The program office must adjust timelines that support OT of the capabilities as they become defined within the Block 4 subprogram. These timelines must prioritize aircraft capability, modifications, and instrumentation — to include Open-Air Battle Shaping (OABS) — so eight fully capable aircraft are available for dedicated operational test trials during the OT periods.

» 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

During FY24, the U.S. Operational Test Team transitioned from being a U.S.-only team to the United Operational Test Team (UOTT), absorbing test teams from the United Kingdom and Australia to the F-35 OT enterprise.

Block 4, TR-2, 30-Series Open-Air Testing

In February 2023, DOT&E approved only four weapon events in the UOTT's 30R08 test plan, due to the lack of readiness of key requirements, such as the final version of software, flight test instrumentation, aircraft modifications, and OABS, the latter being required to complete dedicated operational test (DOT) scenarios. By October 2023, readiness requirements improved, allowing DOT&E to approve some additional test events in the plan. These included four Close Air Support and four Defensive Counter Air DOTs, along with seven additional weapons events (three bomb and four missile events). The remaining test events will be approved by DOT&E when readiness requirements are met.

The UOTT 30R08 OT plan, signed in January 2023, governs the open-air OT for all units assigned to the UOTT. The plan includes a spectrum of open-air test events that can be conducted with the incremental versions of the software. Capability test events (CTEs) 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 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) 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. DOT missions are events that require full mission-level evaluations, assessing F-35 operational effectiveness in terms of lethality and survivability in mission scenarios, like 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.

DOTs include variations in operational conditions, such as the number of red and blue airborne forces or the number and type of ground threat systems. Finally, dedicated weapon events, both captive carry (weapon test article flown, but not released) and live-fire events, are included in the test plan. The UOTT can complete CTE and MAT events from the test plan without DOT&E approval, but the weapons events and DOTs must be approved by DOT&E, to ensure test readiness and adequacy.

Prior to February 2024, the UOTT completed four DOT&E-approved Close Air Support DOT events, which DOT&E did not observe. The UOTT conducted AIM-120 and AIM-9X weapons events, which DOT&E observed. In February 2024, the UOTT issued a "stop test" of the 30R08 software, citing two critical Category I deficiencies and overall poor software stability performance, which prevented additional test events from being approved. The UOTT also conducted regression testing of previously approved AIM-120 events after the stop test was issued. The UOTT was not able to complete any additional weapons events or DOT events due to poor software stability.

Block 4, TR-3, 40-Series Open-Air Testing

The UOTT began making plans for OT of the first TR-3 production configuration, with software version 40R02, but the program's DT effort with the TR-3 aircraft and associated software remained significantly behind schedule throughout FY24. Aircraft modifications, flight test instrumentation, OABS capabilities, and stable software will all be required before dedicated operational testing can begin on the TR-3 aircraft with the capabilities already fielded on the TR-2 aircraft. Given the program constraints on contracting and

associated timelines, DOT&E estimates that DOTs of TR-3 aircraft will likely not begin in earnest until mid to late FY26, two years after the aircraft began being delivered to field units. If readiness criteria involving modifications, instrumentation, OABS and software that is adequately mature and stable are met sooner, operational testing may be able to start earlier.

» BLOCK 4 –JOINT SIMULATION ENVIRONMENT (JSE)

Following the completion of F-35 IOT&E test trials in the JSE at Patuxent River Naval Air Station, Maryland, program management of the JSE moved to an organization outside of the JPO. A joint U.S. Air Force and Navy JSE enterprise now manages the JSE environment, services, and threat models. The F-35 JPO continues to manage the F-35 model updates that run inside the environment – referred to as the F-35-in-a-box (FIAB). The next iteration of OT of the F-35 in the JSE will be based on the capabilities fielded with 30R08 software, in TR-2 aircraft.

To support these OT events, the JPO began early 30S08 software integration (the 30S08 is 30R08-equivalent software for the FIAB) in the JSE at Patuxent River in August 2024, with the goal of having a working (i.e., usable for training) 30S08 FIAB late in FY25. Development and integration of 30S08 is planned to continue through FY25, and the verification, validation, and accreditation process leading to formal accreditation is planned for completion in FY26. The UOTT plans to conduct 30R08 mission-level test trials once the JSE has been accredited for OT, likely no earlier than mid to late FY26.

» SUITABILITY TESTING

DOT&E approved the latest iteration of the UOTT's Annual F-35 Modernization Block 4 Suitability Test Plan in October 2023. Since the plan did not comply with TEMP requirements, DOT&E directed the UOTT to continue dynamic radar cross-section measurements of two OT aircraft per variant, in accordance with the TEMP. To date, no additional dynamic measurement testing has been done on any variant, in violation of TEMP requirements and DOT&E direction.

In late July and early August 2024, the UOTT conducted the remaining events to complete testing of Autonomic Logistics Information System (ALIS) disconnected contingency operations, under a test plan approved by DOT&E in August 2023. DOT&E observed the events. This was a limited test wherein ALIS components were disconnected for a period of time under different contingency operating scenarios. The purpose of the testing was to assess overall effects on flight operations when connections within the ALIS architecture become unavailable, whether through intended actions or other incident that results in denial of service. The UOTT conducted the first scenarios in August 2023, where the Standard Operating Unit (SOU) was disconnected from flight line operations. The scenarios tested in July through early August 2024 included operations where the SOU was disconnected from the Central Point of Entry (CPE). The CPE is the hub that provides connectivity to the higher-level Autonomic Logistics Operating Unit, which interfaces with Lockheed Martin's global sustainment system.

ALIS and Operational Data Integrated Network (ODIN)

The transition from ALIS to ODIN continues to undergo changes in process and in capability. The JPO originally expected to fully containerize ALIS software in a single update referred to as "lift and shift," without adding capability, to transfer it to the new ODIN hardware. Instead, the program is now planning to gradually containerize ALIS software features over many smaller updates on a six-month release cadence, while concurrently adding new capabilities long demanded by operators.

While developing this first six-month software release for ODIN, designated Mx-P.01, the program is concurrently fielding a new version of ALIS and deploying updated ODIN hardware. The current (and planned-to-be final) version of ALIS, called 22.Q4, started fielding in June 2024. It is a major release that includes modernized operating systems and infrastructure applications such as database management software.

It is designed to address critical obsolescence and cybersecurity issues. Given the unusual size of the upgrade, the program projects ALIS 22.Q4 roll-out will not complete to all fielded units until between July and November 2025.

The JPO plans to freeze the content for Mx-P.01 in October 2024, followed by contractor and government-led DT, to support a release in 4QFY25. Each subsequent six-month release is expected to have an 18-month development timeframe, leading to multiple, serial versions in development simultaneously. The second expected six-month release, Mx-P.02, started development in 4QFY24 for fielding in 2QFY26. Mx-P.02 is planned to have improved disconnected operations performance, and cybersecurity hardening of the hypervisors used to host virtualized operating systems. The third release, Mx-P.03, is planned for fielding in 4QFY26. The program expects it to feature a significant expansion of containerized features, as well as additional cybersecurity changes.

ODIN hardware continues to proliferate in the field, and new ODIN hardware is in development. The first tranche of ODIN hardware is the unit-level ODIN Base Kit-Unclassified (OBK-U). The OBK-U is the replacement for the legacy unclassified ALIS unit-level hardware for the squadron kit, the SOU version 2. The OBK-U is smaller, faster, and can better facilitate operating system virtualization. The program anticipates complete replacement of all ALIS SOU version 2 instances with an OBK-U by the end of FY25. The program is also developing the classified, squadron-level adjunct for low-observable (LO) maintenance, the OBK-LO, as well as an upgraded version of the unclassified country-level CPE known as the ODIN Country Kit (OCK-U).

» CYBER SURVIVABILITY TESTING

In FY24, the UOTT cyber team completed a cyber survivability assessment of supply chain refurbishment practices, a high interest area for the DoD and the F-35 program. The UOTT cyber team also completed a risk reduction event to support testing of a Cross-Domain Solution in early FY25. They also observed the ALIS-disconnected contingency operations, discussed above, to assess cybersecurity implications. The UOTT started a cooperative vulnerability and penetration assessment and an adversarial assessment of the U.S. Reprogramming Laboratory (USRL), which provides mission data for the F-35. The assessments of the USRL will continue into FY25. The UOTT also attempted an assessment of the Multifunction Advanced Data Link but did not complete it due to test asset materiel condition issues.

All these cyber survivability test activities were conducted in accordance with DOT&E-approved plans and observed by DOT&E. The UOTT cyber team also participated in a Mission Based Cyber Risk Assessment (MBCRA) on an aircraft in a Lot 18, TR-3 configuration, which focused on select air vehicle management and mission systems. The effort was chartered and led by the JPO with developmental test team support to prioritize cyber survivability test opportunities for these Block 4 aircraft.

Additional cyber survivability testing planned for FY24 included Small Diameter Bomb Increment II interfaces, Variable Message Format communications protocol, and initial assessments of radar vulnerabilities – all of which were deferred into FY25 due to test team readiness and asset availability issues. DOT&E has required operational cyber survivability testing of each major update of ALIS software fielded and will do so for ODIN in the future. To date, the program has supported this requirement.

Aircraft made available for cyber survivability testing have been permanently grounded assets that are also used for software development and thus limit testing due to the potentially disruptive nature of cyber tests. More robust and representative aircraft cyber tests are needed, which will involve Service and JPO programmatic investment in requisite hardware- and software-in-the-loop capabilities. To address this need, the JPO plans to make another retired TR-2 mission systems DT aircraft available for dedicated cyber survivability testing in FY25.

PERFORMANCE

» EFFECTIVENESS

This Annual Report does not include effectiveness results contained in the DOT&E classified F-35 combined IOT&E and LFT&E report published in February 2024. That report provided an independent assessment of the overall mission capability of the F-35 in the Block 3F configuration in terms of its operational effectiveness, suitability, and survivability. The report included a separate annex that provided an assessment of F-35 Block 4 operational testing which occurred following IOT&E. Effectiveness details from the annex are not included in this report.

Block 4, TR-2, 30-Series Development

TThe F-35 program has shown no improvement in meeting schedule and performance timelines for developing and testing software designed to address deficiencies and add new capabilities. In fact, the program has shown it cannot simultaneously work out solutions to deficient 30-series software to improve capability of fielded systems that have the TR-2 avionics architecture while developing the 40-series software required to run on the new TR-3 architecture. Challenges added with the TR-3 avionics upgrades, both in development and testing, have caused additional 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 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.

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

Comparison Parameters	Production Software Version		
	30P06	30P07	30P08
Developmental software iterations planned	Four: 30R06.01, .02, .03, .04	Three: 30R07.01, .02, .03	Three: 30R08.01, .02, .03
Developmental software iterations delivered to flight test	Seven: 30R06.01, .02, .03, .031, .04, .041, .042	Eight: 30R07.01, .02, .03, .031, .033, .04, .041, .045	Ten (at least): 30R08.01, .02, .03, .04, .041, .051, .061, .062, .063, .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	TBD
All planned capabilities delivered?	Yes	No	TBD

Block 4, TR-2, 30-Series Open-Air OT

Due to the lack of adequate testing on the 30R08 software, DOT&E is unable to assess its operational effectiveness. The OT teams have flown with immature versions of the 30R08 software to support DT assessments of capabilities and have participated in large force exercises to assess integration and interoperability with other aircraft. However, these tests have not been adequate to evaluate effectiveness of the 30R08 capabilities in mission-level scenarios. The testing that the teams have been able to accomplish continues to lead to discovery of deficiencies. From March through May 2024, the UOTT reported four Category 1 deficiencies against capabilities in the 30R08 software, many of which were against capabilities that were working in previous versions of software, an indication of insufficient integration and regression testing.

Block 4, TR-3, 40-Series Development

Although the program and Services have begun accepting aircraft off the production line, as well as those coming out of long-term parking over the last year, no OT has been completed to date on the TR-3 aircraft in a production-representative configuration.

» SUITABILITY

Reliability, Maintainability, and Availability

This annual report provides an analysis of the historical RM&A performance of the U.S. F-35 fleet in the Block 3 (i.e., the TR-2) configuration. This analysis is an update to that which was included in the annex to the DOT&E classified F-35 combined IOT&E and LFT&E report published in February 2024. The operational suitability of the F-35 fleet continues to fall short of Service expectations and the requirements defined in F-35 Modernization Block 4 CDD and the JSF Operational Requirements Document (ORD). Since the CDD does not change the original reliability and maintainability requirements, the historical trend analyses of reliability and maintainability metrics of the fleet compare historical performance against ORD requirements.

Historical trend data show that, despite reliability improvements initiated by the program, improving and sustaining improvement in aircraft suitability metrics is difficult to achieve. The following assessment covers reliability and maintainability trends for the period from FY15 through FY23, and availability trends for the period from FY15 through FY24. Data for reliability and maintainability include the records of all maintenance activity and undergo an adjudication process by the government and contractor teams, a process which creates a lag in publishing those data.

As of the end of FY24, Lockheed Martin had produced and delivered 695 aircraft to the U.S. Services. Prior to starting the delivery of TR-3 configured aircraft out of long-term parking in July, 649 aircraft had been delivered to the U.S. Services. These numbers, which provide the basis of analyses contained in this section of the report, do not include any aircraft assigned to dedicated DT.

Availability Trends

Operational availability is measured in terms of the Mission Capable (MC) rate, of which the Fully Mission Capable (FMC) rate is a subset. As shown in Figure 1 below, these MC and FMC metrics are below, and well below, the Services' target values, respectively. The MC rate indicates the proportion of all fielded aircraft not in depot that are capable of flying at least one mission of the overall F-35 mission set. The FMC rate reports the proportion that can fly all F-35 mission sets, representing a more accurate assessment of overall combat readiness. Materiel availability is the percentage of all aircraft, including those in the depot, that are in an MC status. Materiel availability is generally considered a clearer representation of the overall health of the fleet of aircraft.

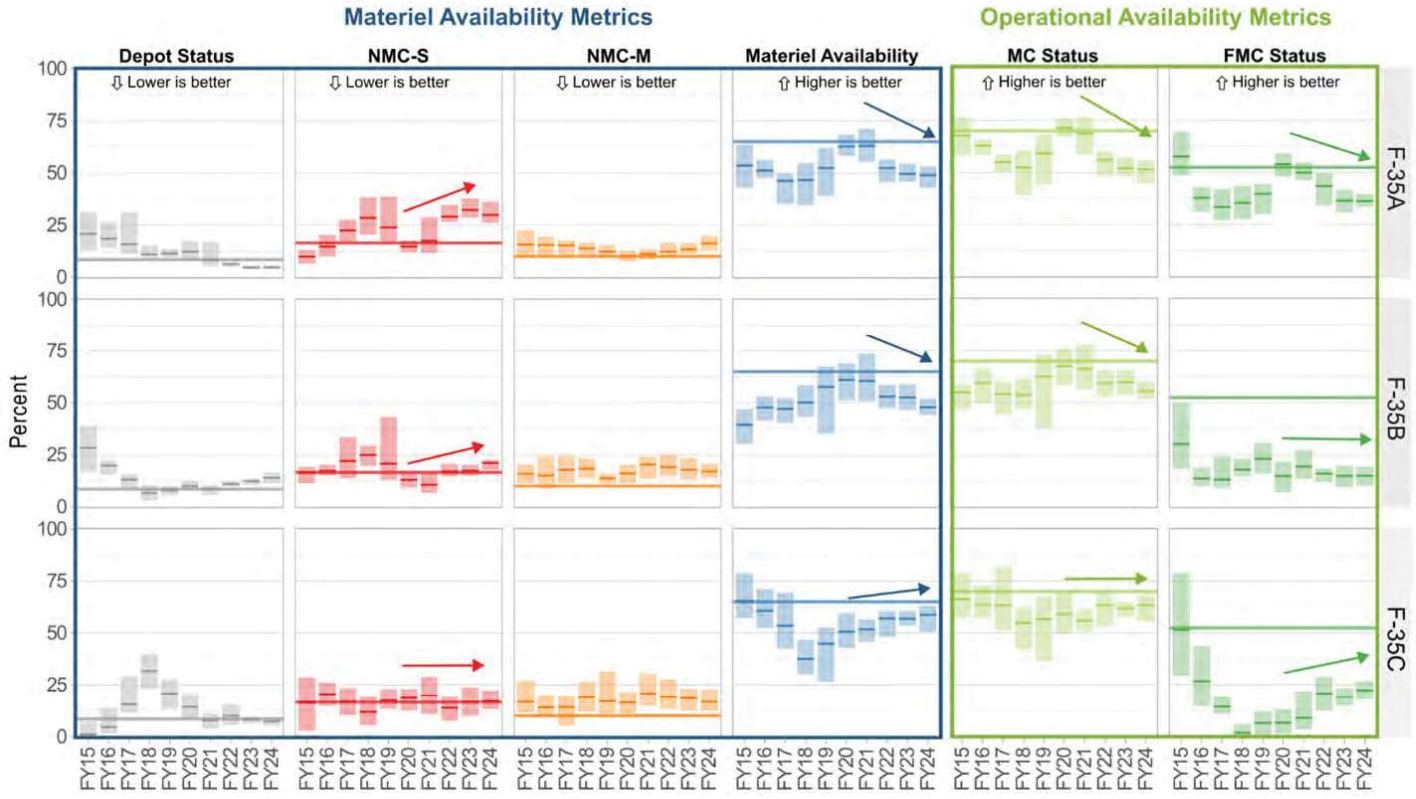
Aircraft that are not materially available (i.e., not able to fly) are designated in one of three

status categories: Depot (i.e., in the depot for modifications or repairs beyond the capability of unit level squadrons), Not Mission Capable for Supply (NMC-S), or Not Mission Capable for Maintenance (NMC-M). Figure 1 shows the annual average value (dark colored bar) for each metric from FY15 through FY24, as reported by the Services. Minimum and maximum monthly values in a given fiscal year are indicated by longer, lighter colored bars, and the target values are indicated by the horizontal lines. Trend arrows have been added to the plots of NMC-S and operational availability metrics to guide the reader and to highlight the trends discussed below.

Following FY19, there was a notable increase in the operational availability of the F- 35A and F-35B and a corresponding decrease in the proportion of aircraft that were down due to supply (i.e., waiting for parts). During the same time period, the proportion of aircraft that were down for maintenance remained relatively flat. Since FY19, F-35C operational availability has had more year-to-year variability but remained below the target values. There was more variability in the proportion of aircraft that were down due to supply than aircraft that were down for maintenance. The trends suggest that the most impactful near-term option for improving aircraft availability is to increase the pool of available spares – either by purchasing more or by maximizing depot capacity to repair broken parts and return them to the spares pool. Additionally, the JPO is actively working to address degraders that negatively affect aircraft availability.

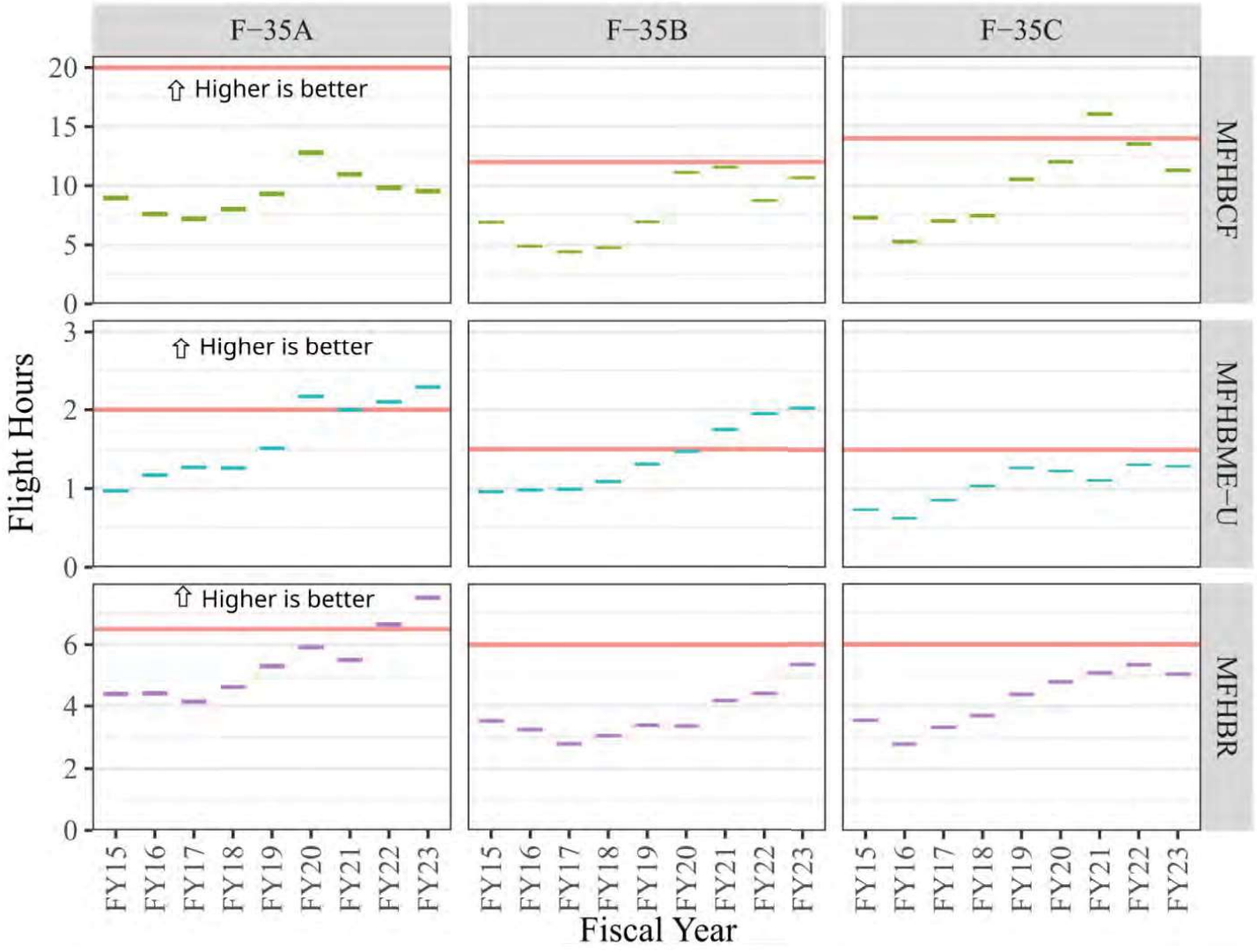
Reliability Trends

The U.S. F-35 fleet remained below the requirements defined in the JSF ORD for some overall



Acronyms: FMC – Fully Mission Capable; MC – Mission Capable; NMC-M – Not Mission Capable for Maintenance; NMC-S – Not Mission Capable due to Supply

Figure 1. F-35 Availability Metrics, U.S. Fleet (FY15 – FY24)



Acronyms: MFHBCF – Mean Flight Hours Between Critical Failures; MFHBME-U – Mean Flight Hours Between Maintenance Events - Unscheduled; MFHBR – Mean Flight Hours Between Removals

Figure 2. F-35 Reliability Metrics, U.S. Fleet (FY15 – FY23)

reliability metrics as shown in Figure 2, based on adjudicated data reported by the JPO. Higher numbers reflect better performance and a more reliable system. Since FY15, there was some reliability improvement with increased variability. In FY23, the F-35A met two, the F-35B met one, and the F-35C met none of the three reliability requirements.

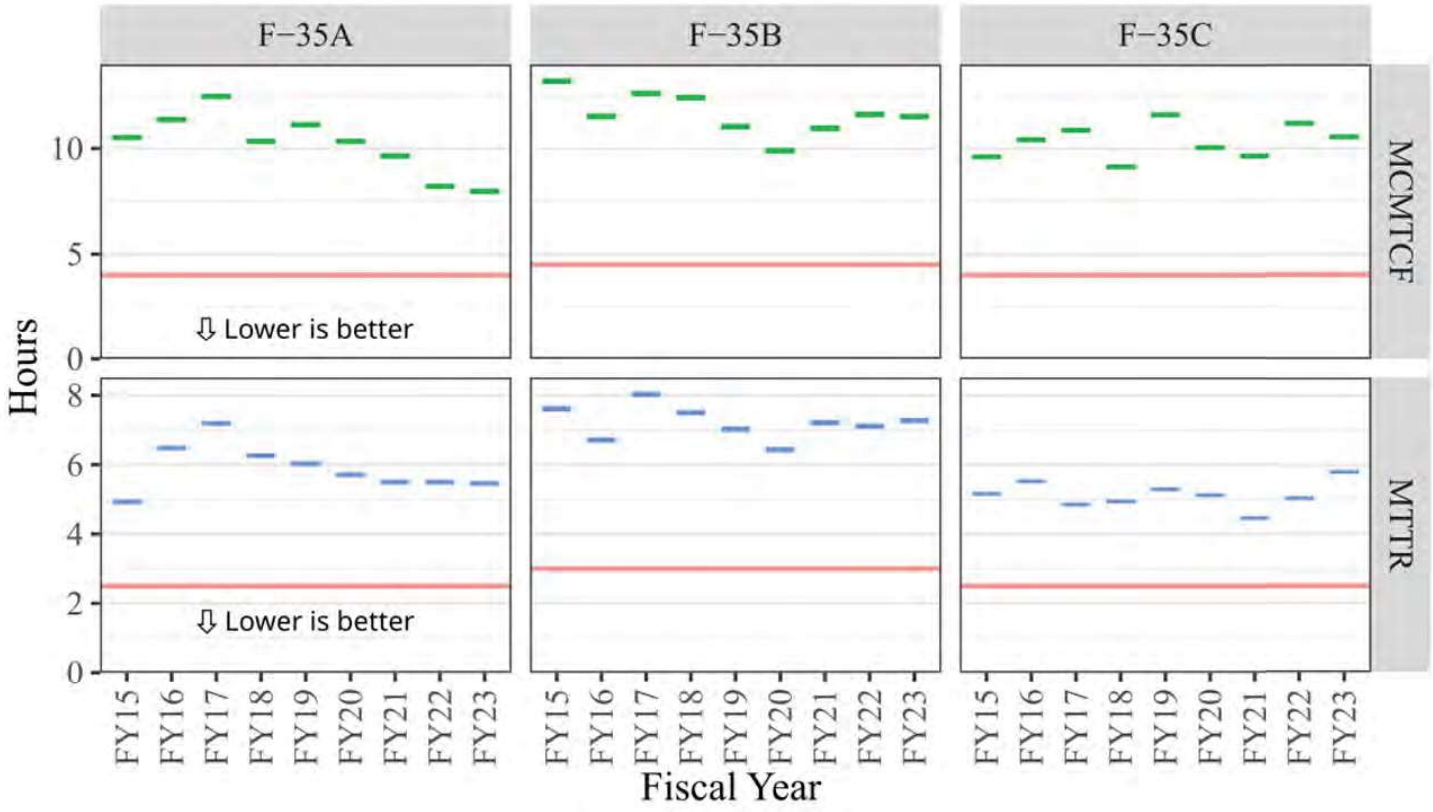
In FY23, the F-35A was significantly below, and the F-35B and F-35C were slightly below, the threshold requirement for time between critical failures. Mean flight hours between critical failures (MFHBCF) includes all failures that render the aircraft unsafe to fly, along with any equipment failures that would prevent the completion of any defined F-35 mission. It includes failures discovered in the air and on the ground. The MFHBCF for the F-35A peaked in FY20 and has declined ever since, although FY23 was only slightly worse than FY22, possibly leveling off in the worsening trend. The F-35B had its highest MFHBCF in FY21, declined significantly in FY22, but then regained some ground in FY23 while remaining below requirement. It has approached, but never surpassed its requirement. The F-35C had shown year-over-year improvement

since FY16, peaking above its requirement in FY21, but then declining in both FY22 and FY23.

In FY23, the F-35A was above, and the F-35B and the F-35C were below, the threshold requirements for removals. Mean flight hours between removal (MFHBR) indicates the degree of necessary logistical support and is frequently used in determining associated costs. MFHBR includes any removal of an item from the aircraft for replacement, except for consumables like fasteners and tires. While all removals are actions triggered by the need to conduct maintenance, not all removed components actually failed. Some removed components are later determined to have not failed when tested at the repair site – which can be caused by many factors including training issues, incorrect aircraft diagnostics, or maintainer error, amongst others. Other components can be removed due to excessive signs of wear before a failure, such as worn tires. All variants have generally shown steady improvement in MFHBR across most years since around FY16, but in FY23, the F-35C had a slightly worse MFHBR than in FY22.

In FY23, the F-35A and F-35B were above, and the F-35C was below, the threshold requirements for unscheduled maintenance events. Mean flight hours between maintenance events - unscheduled (MFHBME-U) is a reliability metric for evaluating maintenance workload due to unplanned maintenance. Maintenance events are either scheduled (e.g., inspections or planned part replacements) or unscheduled (e.g., failure remedies, troubleshooting, replacing worn parts such as tires). The F-35A and F-35B have exhibited year-over-year improvement in MFHBME-U since FY19, whereas the F-35C improved substantially prior to FY19 but has plateaued since then.

The overall trends in reliability of the U.S. F-35 fleet from FY15 through FY23 are shown in Figure 2. Since only partial reliability data from FY24 were available due to the lag in adjudicating maintenance records, they were



Acronyms: MCMTCF – Mean Corrective Maintenance Time for Critical Failures; MTTR – Mean Time to Repair

Figure 3. F-35 Maintainability Metrics, U.S. Fleet (FY15 – FY23)

not included in this figure. This figure shows yearly average value for each metric for a given fiscal year, and the horizontal line indicates the threshold requirement. MFHBME-U and MFHBR both show more reliability improvement, with some metrics above requirement, but little apparent effect on operational availability rates. For reliability metrics, higher values are better.

Maintainability Trends

The maintainability metrics for the U.S. F-35 fleet from FY15 through FY23 are shown in Figure 3, based on adjudicated data reported by the JPO. Since only partial maintainability data from FY24 were available due to the lag in adjudicating maintenance records, they were not included in this figure. This figure shows yearly average values for each metric for a given fiscal year, and the horizontal line indicates the threshold requirement. For maintainability metrics, lower values are better, indicating shorter average maintenance durations.

For all variants, the average maintenance durations for the U.S. F-35 fleet are longer than the ORD requirements. There has been little improvement in these maintainability metrics since FY15. As of February 2024, no variant met the maintainability requirements.

The mean corrective maintenance time for critical failures (MCMTCF) remains almost double or more than the threshold requirement. No variant showed significant improvement over the period, except for MCMTCF for the F-35A, which remains at nearly twice the required value. This metric measures the active maintenance touch labor time and cure times associated with repairs to LO materials required to correct only the subset of failures that prevent the F-35 from being able to perform a specific mission. It indicates the average time for maintainers to return an aircraft from Not Mission Capable to MC status.

The trend is similar for the mean time to repair (MTTR), the average time for all unscheduled maintenance actions, including cure times associated with repairs to LO materials. This metric includes only active maintenance time and is a general indicator of the ease and timeliness of repair.

Mission Reliability and Software Performance

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, affecting overall mission reliability. ALIS does not currently have the capability to automatically log these events in the Computerized Maintenance Management System (CMMS). While pilots can manually document instability events, this occurs infrequently as the process is cumbersome and Service policy is to rely on an ALIS automated process. The data in CMMS are used to report reliability and maintainability metrics. Software instability issues are not reflected in the metrics and are historically underreported by flight crews. Currently, only proprietary tools used by contractor field-service engineers can identify pilot-initiated reset events. DOT&E recommends, to improve F-35 aircraft mission systems stability, that ODIN include the capability to automatically document pilot-initiated resets of mission systems.

ALIS Disconnected Operations

Data from the testing described in the Test Adequacy section above were under analyses at the time of this report.

» SURVIVABILITY

Results from the cyber survivability assessment of the supply chain refurbishment practices were under review at the time of this report.

Multiple ALIS cyber survivability deficiency reports were created in FY24 based on the FY23 testing, with an additional finding still under evaluation. Several deficiency reports were closed. Many cyber survivability deficiencies remain across the F-35 program. To address the deficiencies, the JPO invested in cyber mitigations associated with recent UOTT testing, and key test findings are being tracked to closure by the Authorizing Official for ALIS and ODIN.

The F-35 JPO is using Development Security Operations (DevSecOps) and Agile software

methods to advance frequent software updates to the field in support of the ODIN path forward. The Block 4 30RXX and 40RXX software version development process is also providing more frequent operational flight profile software updates to the combat forces than during the system development and demonstration phase. An increased frequency of new software deployments is stressing the capacity of cyber test teams to thoroughly evaluate each update. Under these new constructs, the importance of cyber survivability testing of the software development environments will also increase – further stressing the cyber test teams' capacity – and will result in the fielding of capabilities not fully tested for cyber survivability until DoD-wide cyber test team capacity expands.

Candidates for cyber survivability testing are continually assessed for inclusion in the cyber test roadmap. Additionally, once cyber effects are adequately and systematically characterized – through a validation process and informed by intelligence centers cyber threat assessments – 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. Further insights into air vehicle (AV) priority testing 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.
2. Ensure programming, funding, and contracting are in place to modify sufficient OT aircraft to meet operational test requirements, including 4-ship test formations for each variant, with the appropriate capabilities, life limit, and instrumentation, including OABS requirements, in time to accomplish DOT.
3. As recommended in the FY22 and FY23 Annual Reports, continue to pursue maintenance system improvements, training, and tools; especially for common processes distributed among NMC-M drivers, such as LO repairs, adhesive cure times for attaching hardware such as nutplates, and spares posture for those critical items most in demand.
4. As recommended in the FY22 and FY23 Annual Reports, continue to accomplish rigorous testing of data integrity while the transition from ALIS to ODIN continues, as this will be critical to the success of ALIS to ODIN while also supporting operational unit day-to-day activities.
5. As recommended in the FY22 and FY23 Annual Reports, continue to ensure both DT and OT for ALIS and ODIN are adequately resourced to reduce the high risk associated with fielding an immature and inadequately tested replacement.
6. As recommended in the FY22 and FY23 Annual Reports, conduct more in-depth cyber survivability testing of the AV, ALIS/ODIN, training systems, and eventually JSE; provide dedicated hardware- and software-in-the-loop AV 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 once cyber effects have been characterized and validated.
7. As recommended in the FY22 and FY23 Annual Reports, 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.
8. As recommended in the FY22 and FY23 Annual Reports, develop and routinely report software sustainment and stability metrics that show how well the program's overall software development capability for the AV and logistics sustainment system is progressing. In particular, incorporate the ability of the aircraft's prognostics health management to detect pilot-initiated resets

of mission critical systems in flight and produce records in the Computerized Maintenance Management System to more accurately track AV system stability.

The UOTT should:

1. Work with the U.S. Services to resume dynamic radar cross-section measurements of two OT aircraft per variant, in accordance with the TEMP.