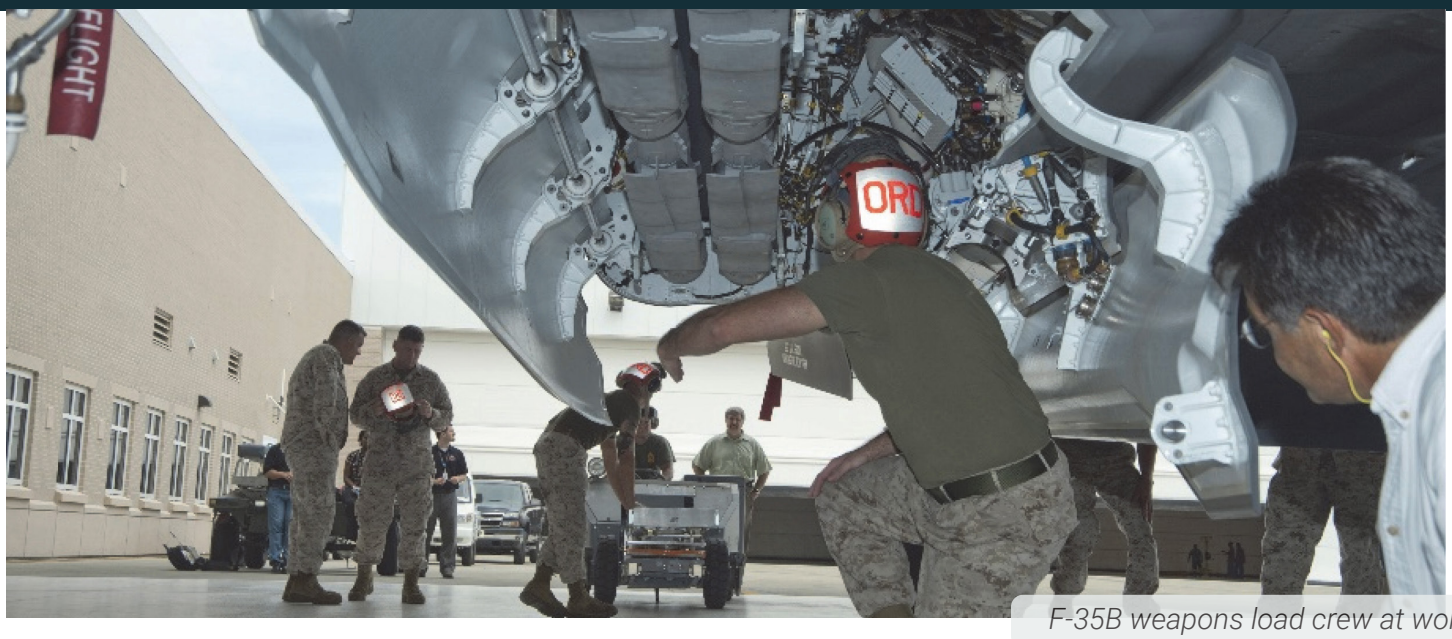
F-35 Joint Strike Fighter (JSF)



F-35B weapons load crew at work

During the period of this report, the F-35 program concluded preparations of the Joint Simulation Environment (JSE) for the 64 JSE test trials required to complete IOT&E. Test trials began and were completed in September 2023, three months later than the program's estimate reported in the FY22 Annual Report. As cited in last year's report, additional discoveries of deficiencies continued to delay readiness. The program certified the JSE as ready for operational test (OT) in September 2023 based on the Operational Test Agency (OTA) accreditation recommendation, with 65 remaining deficiencies against requirements carried into testing. The program plans to correct these deficiencies prior to and concurrent with using the JSE for Block 4 OT.

The F-35 program development cycle continues to experience delays due to immature and deficient Block 4 mission systems software and avionics stability problems with the new Technology Refresh 3 (TR-3) hardware going into Lot 15 production aircraft. As a result, deliveries of production Lot 15 aircraft in the TR-3 configuration are on hold until more testing can be completed and the avionics issues resolved. Additionally, these delays prevented the F-35 Joint Program Office (JPO) from adequately planning and programming for hardware modifications for OT of the upgraded hardware configuration. Furthermore, the necessary flight test instrumentation (FTI), including both aircraft and Open-Air Battle Shaping (OABS) instrumentation, for both the remaining TR-2 and upgraded TR-3 OT aircraft, are not all on contract and will not be available in time. As a result, the F-35 JPO is contracting an interim FTI solution to allow OT squadrons to have some data recording capability until sufficient test aircraft with full data recording capability become available.

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, specifies required capabilities and associated capability gaps that drive incremental improvements under an agile acquisition framework.

MISSION

Combatant commanders employ units equipped with F-35 aircraft in joint operations to attack fixed and mobile land targets, surface combatants at sea, and air threats, including advanced aircraft and cruise missiles, 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 (SDD) Test and Evaluation Master Plan (TEMP), which governs the conduct of IOT&E, in March 2013.

A separate F-35 Overarching Block 4 TEMP and associated annexes govern the conduct of FOT&E. 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 developmental and operational flight testing of software versions 30R03 through 30R06, which were completed in FY21. Increment 2 Annexes, which cover Block 4 software versions 30R07, 30R08, and 40R01, 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. As reported in the FY22 Annual Report, Increment 3 Annexes, which cover Block 4 software versions 40R02, 41R01, and 42R01, and their associated hardware enablers are in coordination with the F-35 JPO, the Services, and DOT&E.

» MAJOR CONTRACTORS:

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

F-35A live air-to-air missile shot

Table 1. Linkage of Development Phase with Hardware, Block Designation, Mission Systems Software, and Operational Testing

F-35 Development Phase	Major Avionics Hardware	Capabilities	Mission Systems Software	Operational Testing*
SDD	TR-1	Block 2B	Block 2B Software	• Marine Corps Fielding Reports and F-35B IOC • Service and JOTT test events • Formal OUE canceled
	TR-2	Block 3i	Block 3i Software	• Air Force Fielding Reports and F-35A IOC • Service and JOTT test events
		Block 3F	Block 3F/ 3FR6**	**Pre-IOT&E Increment 1 (Jan – Feb 2018) Cold Weather Deployment** For-score testing to evaluate the suitability of the F-35 air system and alert launch timelines in an extreme cold weather environment
			Block 3F/ 30R00***	• Navy Service Fielding Reports • **Pre-IOT&E Increment 2 (Starting Mar 2018)** For-score testing of limited two-ship mission scenarios, F-35A deployment, F-35C deployment to a carrier, and weapons delivery events
C2D2		Block 4, 30 Series	30R02.04	**Portion of Formal IOT&E (Dec 2018 – Sep 2019)** For-score testing of more complex open-air missions
			30R04.52	**Portion of Formal IOT&E (Jul 2020)** For-score testing of more complex open-air missions
			30R06.041 & .042	UOTT evaluated these versions in FY21 IAW a DOT&E-approved FOT&E Test Plan
			30R06.042	Software fix needed for weapon event in **Jun 2021 that completed events approved in Pre-IOT&E Increment 2**
			30R07	UOTT completed their evaluation of this series of software in FY22 IAW a DOT&E-approved FOT&E Test Plan
			30R08	UOTT began flying with early versions of this software in August 2022. DOT&E approved four missile test events from the OT plan for 30R08; no other testing has been approved due to lack of readiness. No OT of 30R08 has been completed to date.
	TR-3	Block 4, 40 Series	40R0X	Dedicated OT events are planned for each release of capability in the series

Notes:

* **Bold** text highlights for-score IOT&E events.
** The final planned version of Block 3F software was 3FR6.
*** The program changed software nomenclature for the initial increments of Block 4 from "3F" used during SDD to "30RXX" for development and "30PXX" for fielding software. The 30 Series software is compatible with the Block 3F aircraft hardware configuration and is being used to address deficiencies and add Service-prioritized capabilities.

Acronyms: C2D2 – Continuous Capability Development and Delivery; IAW – in accordance with; IOC – Initial Operational Capability; JOTT – JSF Operational Test Team; OUE – Operational Utility Evaluation; OT – operational test; SDD – System Development and Demonstration; TR-X – Technology Refresh [version #], referring to the suite of various avionics and supporting subsystems; UOTT – U.S. Operational Test Team

TEST ADEQUACY

» IOT&E

Open-Air Testing

The F-35 program is nearing completion of a multi-year IOT&E which began in 2018. The JSF Operational Test Team (JOTT) completed, and DOT&E observed, a series of weapons trials (both bombs and missiles) and open-air test missions to evaluate the F-35 in multiple roles (i.e., offensive counter-air, defensive counter-air, cruise missile defense, suppression/ destruction of enemy air defenses (S/DEAD), reconnaissance, electronic attack (EA), close air support, forward air control (airborne), strike coordination and armed reconnaissance, combat search and rescue, anti-surface warfare, and air interdiction). The JOTT conducted test trials in varying threat environments using two-, four-, and eight-F-35 aircraft mission scenarios. During the S/DEAD and EA trials, the F-35 faced operationally representative surface-to-air threat environments represented by Radar Signal Emulators installed on the open-air ranges. Open-air test trials were finished with completion of the final AIM-120 missile trial in June 2021 when the program delivered software version 30R06.042 with the fixes needed to complete the trial.

Modeling and Simulation - JSE

Throughout FY23, the JSE and OT teams focused on preparations to conduct runs for score in the JSE. The JPO completed the OT readiness review for JSE trials in September 2023, and certified it as ready for testing, despite 65 deficiencies against the baseline JSE requirements, including the F-35-in-a-box (FIAB) model, the battlespace environment, and other threat and friendly models used in the simulation. The JPO and JSE teams intend to address these deficiencies prior to or in conjunction with Block 4 testing in the JSE. The F-35 Executive Committee (EXCOM) accredited JSE, with limitations, for IOT&E on September 1st, 2023. DOT&E assessed the mitigations for the deficiencies, determined the testing would be adequate, and approved the remaining portion of the IOT&E plan to allow JSE testing to proceed. Test missions for score began and were completed in September 2023.

The remaining IOT&E events were completed in September and included 64 test trials in the JSE at Naval Air Station Patuxent River, Maryland. These trials included 11 defensive counter-air, 22 cruise missile defense, and 31 combined offensive counter-air/air interdiction/DEAD trials in operationally representative scenarios with modern threat systems that are not available on open-air ranges. All three F-35 variants were involved in the conduct of these trials.

Suitability Testing

The JOTT completed, and DOT&E observed, cold-weather testing; deployments to ships and austere environments; observation of day-to-day maintenance and sustainment activities; interviews with maintenance and sustainment personnel; joint technical data verification; and reliability, maintainability, and availability data analysis and adjudication. The JOTT completed all required suitability-related test plan activities by the end of 1QFY21.

Survivability Testing

The JOTT completed and DOT&E observed cyber survivability testing of the air vehicle (AV), training systems, mission data reprogramming laboratory, and the Autonomic Logistics Information System (ALIS), to include an enterprise cyber adversarial assessment. The JOTT completed all required survivability-related test plan activities by the end of 1QFY21.

» FOT&E

Block 4 Open-Air Testing

The U.S. Operational Test Team (UOTT) completed OT of software version 30R07 in June 2022 in accordance with the DOT&E-approved test plan. DOT&E observed the test. The UOTT submitted an OT plan for 30R08, but DOT&E only approved four weapon events in the plan in February 2023, due to the lack of readiness of key requirements

such as flight test instrumentation, aircraft modifications, and OABS, which are needed to conduct other testing in the plan. As reported in the FY22 Annual Report, no OT of 30R08 has been completed from the test plan.

Per the Block 4 TEMP and associated annexes, OT aircraft are required to support both developmental test (DT) and OT in various Block 4 configurations. Modifications to these aircraft must be funded, scheduled, and completed just after DT aircraft modifications to enable integrated DT/OT, DT assist, and mission-level OT of capabilities. Although the JPO has funded and contracted for some of the OT aircraft modifications, it does not yet have a scheduled and coordinated plan to ensure that all the required hardware, flight test instrumentation, and OABS modifications are completed for test aircraft that will remain in the TR-2 configuration or are slated to be modified to the TR-3 configuration. Because of these issues, the UOTT has been unable to conduct OT events of the 30R08 capabilities as required in the test plan. The JPO and OT organizations plan to conduct an updated readiness review in 1QFY24.

The UOTT began making plans for OT of the first TR-3 production configuration, with aircraft software version 40R01, but the program's DT effort is significantly behind schedule. The UOTT will be providing two OT aircraft in a DT assist role in FY24 to accelerate the DT baseline plan and allow early OT exposure to TR-3 testing. Major hardware changes with the TR-3 transition include upgraded integrated core processors, aircraft memory system, next generation distributed aperture system, and a panoramic cockpit display. The program planned to deliver aircraft in the TR-3 configuration beginning in Lot 15, in July 2023, but DT schedule delays have pushed the U.S. Services' acceptance of these aircraft into FY24. In FY23, just 32 of 205 baseline DT flights were completed after the first DT flight in January 2023. Delays caused by aircraft modifications, software maturity, avionics architecture instabilities, and ongoing troubleshooting and debugging have all contributed to the slow progress in development. The JPO and the Services are not accepting deliveries of aircraft in the TR-3 configuration until the problems are resolved enough to complete DT.

Block 4 Modeling and Simulation Development - JSE

The extended delay in completing the necessary verification, validation, and accreditation of the F-35 JSE for conducting IOT&E test missions delayed preparations for OT of Block 4. Licensing issues associated with the FIAB have also contributed to the delayed JSE modernization efforts. To support OT requirements, the JPO needs to align updated FIAB deliveries with the Block 4 OT periods as soon as possible. This alignment is needed so that the OT teams can use the JSE to accomplish critical testing of future capabilities, beginning with the 30R08 release that is currently in developmental and operational flight test. In addition, the program must account for new capabilities in upgrades to the FIAB, the environment, blue and red weapons models, and red ground threat models, as well as correcting the 65 remaining deficiencies against JSE requirements carried over from the IOT&E configuration.

Suitability Testing

In August 2023, DOT&E approved the UOTT's limited Autonomic Logistics Information System (ALIS) disconnected operations test plan, which included the scenario of disconnecting the Standard Operating Unit (SOU) from flight line operations. The test plan did not cover other off-line conditions, so DOT&E directed that additional scenarios be tested later.

No other operational suitability test plan was approved by DOT&E in FY23.

Cyber Survivability Testing

In FY23, the UOTT cyber test teams conducted cyber survivability assessments of ALIS software version 35P21.Q4 and supporting functionality (both a cooperative vulnerability and penetration assessment and an adversarial assessment). Four additional cyber survivability tests were planned to be accomplished in

FY23, but were moved to FY24 due to test team readiness and asset availability issues.

AV test assets are made available to support AV tests, which are limited in scope based on the potentially disruptive nature of cyber tests. However, more robust and representative AV cyber tests are needed, which will involve Service and JPO programmatic investment in requisite hardware- and software-in-the-loop capabilities. Cyber survivability testing is also often limited by available trained and qualified test personnel, so Service OTAs should improve staffing levels.

PERFORMANCE

» IOT&E

Effectiveness, Suitability, and Survivability

The results of operational effectiveness, suitability, and survivability testing from IOT&E will be reported in the DOT&E IOT&E report, expected in 2QFY24.

» FOT&E

Effectiveness

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

Due to the lack of testing on the 30R08, DOT&E is unable to assess its operational effectiveness. The OT teams have flown with immature versions of the 30R08 software to support developmental and operational assessments of capabilities and have participated in large force exercises to assess integration and interoperability with other aircraft. However, this testing has not been adequate to evaluate effectiveness of the 30R08 capabilities in mission-level scenarios.

The OT teams have also conducted weapons integration and employment characterization testing to support the overall development effort, but these events have not been adequate to satisfy the DOT&E-approved weapons delivery events in the test plan.

Block 4, TR-3, 40 Series Development

The program began developmental flight testing of the TR-3 configuration in January 2023, with software version 40R01. This version of software was developed using the baseline capabilities provided in the 30R07 software, which completed development in 1QFY22. The ongoing avionics stability problems with the TR-3 configuration have delayed the integration of 30R08 software capabilities and 40R0X hardware and software.

Suitability

Reliability, Maintainability, and Availability

The operational suitability of the F-35 fleet remains below Service expectations and requirements. In FY23, aircraft availability was slightly below that in FY22, after declining for most of FY21 despite reaching a historic program high in January 2021.

As of the end of September 2023, 628 aircraft have been produced for the U.S. Services. These aircraft do not include any aircraft assigned to dedicated DT and provide the basis of analyses contained in this section of the report.

Aircraft availability is determined by measuring the percentage of time individual aircraft are in an "available" status, aggregated monthly over a reporting period. The historic program-set availability goal is 65 percent; the following fleet-wide availability discussion uses data from the 12-month period ending September 2023. The average fleet-wide monthly availability rate for only the U.S. aircraft (includes all aircraft categories – those designated for combat, training, advanced training and tactics development, and OT) was 51 percent. The DOT&E assessment shows a relatively flat trend for the 12 months of data in FY23.

Availability tracks aircraft capable of performing at least one designated F-35 mission and may not represent the capability to execute desired missions for combat or for specific OTs. The Full Mission Capable (FMC) rate tracks what proportion of F-35s are capable of executing all assigned missions and provides a better evaluation of combat readiness. For the 12-month period ending September 2023, the FMC rate for the whole U.S.

fleet was 30 percent, and the rate for the OT fleet was 9 percent.

The program and Services track aircraft by unit and mission assignment. The combat-coded fleet of aircraft are assigned to units that can deploy for combat operations; the training fleet is for new F-35 pilot accessions; the advanced training and tactics development fleet is used for fighter weapons school; and the test fleet for OT. The proportion of the fleet that is combat-coded has risen steadily over time and represents slightly more than half of the U.S. fleet over the 12 months ending in September 2023. Consistent with prior Annual Reports, the combat-coded fleet, which has the newest aircraft on average and often receives elevated supply priority, demonstrated the highest availability. However, unlike in FY22, the combat-coded fleet did not achieve the 65 percent target for monthly average availability for the overall, combined 12 months ending in September 2023. Instead, the combat-coded fleet attained an average monthly availability of 61 percent, and only achieved or surpassed the 65 percent goal in one of the 12 months. The FMC rate of the combat-coded fleet over the same 12-month period was 48 percent, compared to 30 percent for the entire U.S. fleet.

Aircraft that are not available are designated in one of three status categories: Not Mission Capable for Maintenance (NMC-M), Depot (i.e., in the depot for modifications or repairs beyond the capability of unit level squadrons), or Not Mission Capable for Supply (NMC-S). The monthly NMC-S rate began climbing (worsening) in July 2021, compared to earlier trends, and stayed relatively flat for most of FY23. For the 12 months ending in September 2023, the average monthly NMC-S rate was 27 percent, slightly worse than the overall rate in FY22. The average monthly NMC-M rate for the 12 months ending in September 2023 was 15 percent. To improve aircraft availability, the program should continue to pursue maintenance system improvements, especially for common processes distributed among many different NMC-M drivers, such as low-observable repairs, adhesive cure times for attaching hardware such as nutplates, and spares posture for those critical items most in demand. The program should also focus reliability improvements on the components most often not immediately available in supply.

As previously reported, the significant shortage of fully functional F135 engines had contributed to reduced aircraft availability, particularly for the F-35A variant. Aggressive program efforts to lay in additional depot resources, improve depot efficiencies, and ruggedize key engine components have reduced the number of aircraft without an engine and increased the number of spare modules ready for issue. However, despite those efforts, other degraders such as canopy and egress system issues have contributed to stagnant, or slightly declining, availability.

The F-35 fleet remains below JSF Operational Requirements Document (ORD) thresholds in some areas for overall reliability and maintainability. Maintenance data gathered through May 2023 from the U.S. fleet of all three variants show that the F-35C is not meeting any of the ORD reliability and maintainability requirements for mature aircraft. The F-35A meets two and the F-35B meets one of the three reliability requirements. No variant is meeting the maintainability requirements.

The tables below show reliability and maintainability performance compared to ORD requirements. For the reliability metrics, higher numbers reflect better performance (i.e., a more reliable system), and for maintainability metrics, lower numbers reflect better performance (i.e., less maintenance burden). Tables 2 through 5 show the values of the reliability metrics, and Tables 6 and 7 show the values of the maintainability metrics, respectively, based on data aggregated in three-month rolling windows, where monthly reports are generated based on the last three months of data. This process enables trends to be observed more clearly than reports generated by only a single month of data. The tables also show the metric values for the three-month period ending May 2022 for comparison, as well as the component or system drivers

most significantly degrading that metric's performance.[1]

In Table 2, Mean Flight Hours Between Critical Failure (MFHBCF) includes all failures that render the aircraft unsafe to fly, along with any equipment failures that would prevent the completion of a defined F-35 mission. It includes failures discovered in the air and on the ground. Historically, MFHBCF has fluctuated widely for the F-35, showing little year-to-year trends.

Table 2. Reliability Measure: Mean Flight Hours Between Critical Failures (MFHBCF)

F-35 Reliability: MFHBCF (hours)								
Variant	ORD Threshold		Values as of May 31, 2023			Values as of May 2022		Trend**
	Flight Hours	MFHBCF	Cumulative Flight Hours	Observed MFHBCF* (3 Months Rolling Window)	Observed Value as Percent of Requirement	Cumulative Flight Hours	Observed MFHBCF* (3 Months Rolling Window)	May 2023 Compared to May 2022
F-35A	75,000	20	288,926	10.5	53%	245,317	10.1	↑
F-35B	75,000	12	106,553	11.1	93%	89,469	8.8	↑
F-35C	50,000	14	62,192	9.6	69%	53,067	16.2	↓

Drivers (by frequency): troubleshooting (including software stability), attaching hardware (including nutplates), wires/tubes/ducts/fiber optics, throttle grip, aircraft memory device, LO repair, standby flight display, refueling door, position lights

Notes:
* Red = Does Not Meet Threshold Requirement; Green = Meets Threshold Requirement
** For Reliability Metrics, Trend ↑ = Improved; Trend ↓ = Worse; Trend ↔ = Flat

Acronyms: LO – Low Observable; ORD – Operational Requirements Document

1 All reliability metrics in this report are calculated as mean flight hours between events. DOT&E notes that these metrics are based on a fleet with a relatively low FMC rate, which means they are flying with many failed components awaiting resupply. The low FMC rate effectively skews the resulting metrics to look more reliable than a fleet that has failed components replaced quickly.

In Table 3, Mean Flight Hours Between Removal (MFHBR) indicates the degree of necessary logistical support and is frequently used in determining associated costs. It includes any removal of an item from the aircraft for replacement, except for consumables like fasteners. Not all removals are failures; some removed items are later determined to have not failed when tested at the repair site, and other components can be removed due to excessive signs of wear before a failure, such as worn tires.

Table 3. Reliability Measure: Mean Flight Hours Between Removal (MFHBR)

F-35 Reliability: MFHBR (hours)								
Variant	ORD Threshold		Values as of May 31, 2023			Values as of May 2022		Trend**
	Flight Hours	MFHBR	Cumulative Flight Hours	Observed MFHBR* (3 Months Rolling Window)	Observed Value as Percent of Requirement	Cumulative Flight Hours	Observed MFHBR* (3 Months Rolling Window)	May 2023 Compared to May 2022
F-35A	75,000	6.5	288,926	7.0	108%	245,317	6.8	↑
F-35B	75,000	6.0	106,553	4.7	78%	89,469	4.0	↑
F-35C	50,000	6.0	62,192	4.7	78%	53,067	5.6	↓

Drivers (by frequency): nose & main landing gear tires, ejection seat assembly, brake assembly, seat survival kit, crash survivable memory unit, throttle grip, divergent exhaust nozzle segments & seals, backup oxygen bottle, position lights

Notes:
* Red = Does Not Meet Threshold Requirement; Green = Meets Threshold Requirement
** For Reliability Metrics, Trend ↑ = Improved; Trend ↓ = Worse; Trend ↔ = Flat

Acronyms: ORD – Operational Requirements Document

Aviation Boatswain's Mate signals F-35B on USS America *(LHA 6)*

In Table 4, Mean Flight Hours Between Maintenance Events Unscheduled (MFHBME_Unsch) 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). MFHBME_Unsch is an indicator of aircraft reliability and must meet the ORD requirement.

Table 4. Reliability Measure: Mean Flight Hours Between Maintenance Events Unscheduled (MFHBME_Unsch)

F-35 Reliability: MFHBME_Unsch (hours)								
Variant	ORD Threshold		Values as of May 31, 2023			Values as of May 2022		Trend**
	Flight Hours	MFHBME_ Unsch	Cumulative Flight Hours	Observed MFHBME_ Unsch* (3 Months Rolling Window)	Observed Value as Percent of Requirement	Cumulative Flight Hours	Observed MFHBME_ Unsch* (3 Months Rolling Window)	May 2023 Compared to May 2022
F-35A	75,000	2.0	288,926	2.2	110%	245,317	2.1	↑
F-35B	75,000	1.5	106,553	1.8	120%	89,469	1.7	↑
F-35C	50,000	1.5	62,192	1.2	80%	53,067	1.5	↓

Drivers (by frequency): troubleshooting (including software stability), LO repair, attaching hardware (including nutplates), nose & main landing gear tires, wires/tubes/ducts/fiber optics, LO system seals, maintenance & refueling door, landing gear struts

Notes:
* Red = Does Not Meet Threshold Requirement; Green = Meets Threshold Requirement
** For Reliability Metrics, Trend ↑ = Improved; Trend ↓ = Worse; Trend ↔ = Flat

Acronyms: LO – Low Observable; ORD – Operational Requirements Document

F-35C lands on USS Carl Vinson *(CVN 70)*

In Table 5, Mean Flight Hours Between Failure, Design Controllable (MFHBF_DC) includes failures of components due to design flaws under the purview of the contractor, such as the inability to withstand loads encountered in normal operation.

Table 5. Reliability Measure: Mean Flight Hours Between Failure, Design Controllable (MFHBF_DC)

F-35 Reliability: MFHBF_DC (hours)								
Variant	JCS Threshold		Values as of May 31, 2023			Values as of May 2022		Trend**
	Flight Hours	MFHBF_DC	Cumulative Flight Hours	Observed MFHBF_DC* (3 Months Rolling Window)	Observed Value as Percent of Requirement	Cumulative Flight Hours	Observed MFHBF_DC* (3 Months Rolling Window)	May 2023 Compared to May 2022
F-35A	75,000	6.0	288,926	12.2	203%	245,317	10.6	↑
F-35B	75,000	4.0	106,553	6.7	168%	89,469	6.3	↑
F-35C	50,000	4.0	62,192	3.4	85%	53,067	8.8	↓

Drivers (by frequency): DAS sensor, EOTS window cover, throttle grip, fiber channel switch, canopy assembly, 80 kW inverter/converter/controller, divergent exhaust nozzle segments and seals, manifold filter, power and thermal management system

Notes:
* Red = Does Not Meet Threshold Requirement; Green = Meets Threshold Requirement
** For Reliability Metrics, Trend ↑ = Improved; Trend ↓ = Worse; Trend ↔ = Flat

Acronyms: DAS - Distributed Aperture System; EOTS - Electro Optical Targeting System; JCS – Joint Contract Specification

F-35A maintainer at work

In Table 6, Mean Time to Repair (MTTR) measures the average active maintenance time for all unscheduled maintenance actions. It is a general indicator of the ease and timeliness of repair.

Table 6. Maintainability Measure: Mean Time to Repair (MTTR)

F-35 Maintainability: MTTR (hours)					
Variant	ORD Threshold	Values as of May 31, 2023* (3 Months Rolling Window)	Observed Value as Percent of Threshold	Values as of May 2022* (3 Months Rolling Window)	Trend** May 2023 Compared to May 2022
F-35A	2.5	5.2	208%	5.2	↔
F-35B	3.0	6.7	223%	7.2	↓
F-35C	2.5	5.6	224%	5.9	↓

Drivers (by Sum Elapsed Maintenance Time): LO repair, attaching hardware (including nutplates), LO system seals, canopy assembly, wires/tubes/ducts/fiber optics, three-bearing swivel module, maintenance & refueling door, position lights

Notes:
* Red = Does Not Meet Threshold Requirement; Green = Meets Threshold Requirement
** For Maintainability Metrics, Trend ↑ = Worse; Trend ↓ = Improved; Trend ↔ = Flat

Acronyms: LO – Low Observable; ORD – Operational Requirements Document

F-35A pilot ground operations

In Table 7, Mean Corrective Maintenance Time for Critical Failures (MCMTCF) measures active maintenance time 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 Non-Mission Capable to Mission Capable status.

Table 7. Maintainability Measure: Mean Corrective Maintenance Time for Critical Failures (MCMTCF)

F-35 Maintainability: MCMTCF (hours)					
Variant	ORD Threshold	Values as of May 31, 2023* (3 Months Rolling Window)	Observed Value as Percent of Threshold	Values as of May 2022* (3 Months Rolling Window)	Trend** May 2023 Compared to May 2022
F-35A	4.0	8.0	200%	7.4	↑
F-35B	4.5	12.5	278%	11.5	↑
F-35C	4.0	9.3	233%	11.8	↓

Drivers (by Sum Elapsed Maintenance Time): attaching hardware (including nutplates), wires/tubes/ducts/fiber optics, LO repair, canopy assembly, position lights, engine assembly, radar, position lights, communication/navigation/identification system

Notes:
* Red = Does Not Meet Threshold Requirement; Green = Meets Threshold Requirement
** For Maintainability Metrics, Trend ↑ = Worse; Trend ↓ = Improved; Trend ↔ = Flat

Acronyms: LO – Low Observable; ORD – Operational Requirements Document

ALIS and Operational Data Integrated Network (ODIN)

ALIS is the distributed information system that supports F-35 operations and maintenance, supply, and training. ALIS is composed of hardware and software components located at both the squadron level and enterprise level and includes both government- and contractor-owned assets. ODIN is the migration of ALIS applications into a cloud-based environment hosted on updated hardware. New ODIN applications are planned to add capabilities and improve cyber survivability.

In FY23, the program continued planned development efforts while transitioning from ALIS to ODIN, adding hardware to the field while migrating software. The first transition of hardware, from the ALIS SOU to the ODIN Base Kit (OBK), reached selected field units in FY22, but was delayed by contracting and production of the remainder of the legacy hardware-equipped units. Original plans were to have OBKs to the remaining squadrons by September 2023, but current projections place the complete transition from SOUs to OBKs in 2025.

The path to ODIN, which will be the software bundle ported from the legacy ALIS hardware systems into the OBKs to formalize the ODIN software and hardware system, follows three steps:

- Step one, referred to as ALIS 21.Q4, is the current release of ALIS software, which finished fielding in July 2023, representing a roughly 1.5-year delay from the originally planned release date laid out by the program in FY21.
- Step two, referred to as ALIS 22.Q4, which is planned as the last software version to be used on ALIS hardware, was also delayed as resources were shifted to correct issues with the preceding releases.

ALIS 22.Q4 is now projected for release in sub-phases (dot releases) beginning 3QFY24. The first increment, 22.Q4.1, will focus on burning down identified cyber issues and TR-3 compatibility. Follow-on dot releases are being investigated to deliver needed capabilities to the field.

- The final step in the path to an ODIN Minimum Viable Capability Release occurs after a rehost of ALIS 22.Q4 into the ODIN format. This was to begin testing by the Integrated Test Force in July 2023 but is now projected to begin at some point in FY25.

ALIS provides units the ability to evaluate the Low Observable (LO) characteristics of their aircraft, given damages and repairs accumulated in service, via an LO Dedicated System Processor (DSP). Units require a functioning LO DSP to determine whether their aircraft have an adequate LO signature for missions relying on these characteristics. However, LO DSP reliability issues are hindering the fleet's ability to track the LO status of fielded F-35 aircraft. As an example, during FY23, two of the three OT squadrons were without a functional LO DSP for extended periods of time. When an LO DSP fails, the backorder time to receive a replacement is also significant.

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. ALIS does not currently have the capability to automatically capture AV software instability events in the Computerized Maintenance Management System (CMMS). While pilots can manually document instability events, they do so 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. However, because software instability events are not captured and reflected in the metrics, the effect of these events is clearly under-reported. Currently, only proprietary tools used by contractor field service engineers can identify pilot-initiated reset events. In order to improve F-35 aircraft mission systems stability, ODIN will need to have the capability to automatically document pilot-initiated resets of mission systems.

In August 2023, the UOTT conducted eight days of a formal test of F-35 aircraft operations and maintenance with the ALIS squadron kit offline. This partially satisfies the DOT&E adequacy requirement to test the ability of an F-35 unit to conduct operations with ALIS or ODIN disconnected from their supporting infrastructure, as required in the TEMP. Further testing in additional ALIS or ODIN degraded conditions must still be conducted to fully satisfy DOT&E adequacy of test requirements. Preliminary results of this test also highlight the need to formally test agile combat employment operations in which small detachments of F-35 aircraft may have to operate for significant periods of time without on-site access to an SOU or OBK.

Survivability

Twelve ALIS cyber survivability deficiency reports were verified as being fixed during FY23 testing; however, numerous cyber survivability deficiencies remain across the F-35 program. To address the deficiencies, the JPO invested in cyber mitigations associated with recent JOTT testing, and key test findings are being tracked to closure by the Authorizing Official for ALIS and ODIN. Lack of access to proprietary information for government support contractor cyber survivability testers, overall test team capacity constraints, and test asset availability impeded execution of several planned tests in FY23, requiring their rescheduling for FY24 or later. The UOTT worked with the F-35 JPO and stakeholders across the DoD to identify relevant scenarios, qualified test personnel, and adequate resources for conducting cyber survivability testing on AV components and support systems.

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 SDD phase. An increased frequency of new software deployments is

stressing the capacity of cyber test teams to thoroughly evaluate each update and will continue to stress future capacity without appropriate mitigation.

In light of current cyber threats and vulnerabilities, along with peer and near-peer threats to operating bases and communications, DOT&E continues to require the F-35 program and Services conduct testing of aircraft operations without access to the ALIS SOU as required in the TEMP, which is also a suitability testing requirement. The program has yet to meet this requirement and is currently in the planning stages for complete testing of the ALIS Contingency Operations Plan, which will test standardized procedures for lack-of-connectivity scenarios and is intended to satisfy the requirement.

Emerging candidates for cyber survivability testing are continually assessed, updated, and incorporated into test plans, to include insights into prioritization from a Mission-Based Cyber Risk Assessment commencing in 1QFY24. Additionally, including emulation of cyber effects from actual testing into mission rehearsals in the JSE is key to assessing potential mission consequences from cyber exploits against the AV.

RECOMMENDATIONS

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

1. Expedite preparations for required F-35 follow on operational testing in the JSE beginning with the 30R08 capability release.
2. As recommended in the FY22 Annual Report, develop and begin executing detailed planning for upgrading the JSE in time to support Block 4 OT requirements. These plans must include capability upgrades to the FIAB, blue and red weapons models, red ground threat models, and improved environment characteristics to ensure test adequacy.
3. In accordance with the DOT&E-approved Block 4 TEMP:
   - As recommended in the FY22 Annual Report, fully fund, develop, and update the detailed plan to modify all OT aircraft with the appropriate capabilities, life limit, and instrumentation, including OABS requirements.
   - As recommended in the FY22 Annual Report, continue work to align the components of the F-35 air system delivery framework for each increment of capability to allow enough time for adequate testing of the fully representative system that is planned to be fielded.
4. As recommended in the FY22 Annual Report, continue to pursue maintenance system improvements, especially for common processes distributed among Non-Mission Capable Maintenance drivers, such as low observable repairs, adhesive cure times for attaching hardware such as nutplates, and spares posture for those critical items most in demand.
5. As recommended in the FY22 Annual Report, improve spares posture, especially for F135 engines, to reduce down-time for aircraft waiting spare parts by developing alternate sources of repair, including organic repair.
6. As recommended in the FY22 Annual Report, 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.
7. As recommended in the FY22 Annual Report, 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.
8. As recommended in the FY22 Annual Report, 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.
9. As recommended in the FY22 Annual Report, 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.

10. As recommended in the FY22 Annual Report, 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 CMMS to more accurately track AV system stability.
11. Since cyber survivability testing is often limited by available trained and qualified test personnel, Service OTAs should continue to work improve staffing levels.