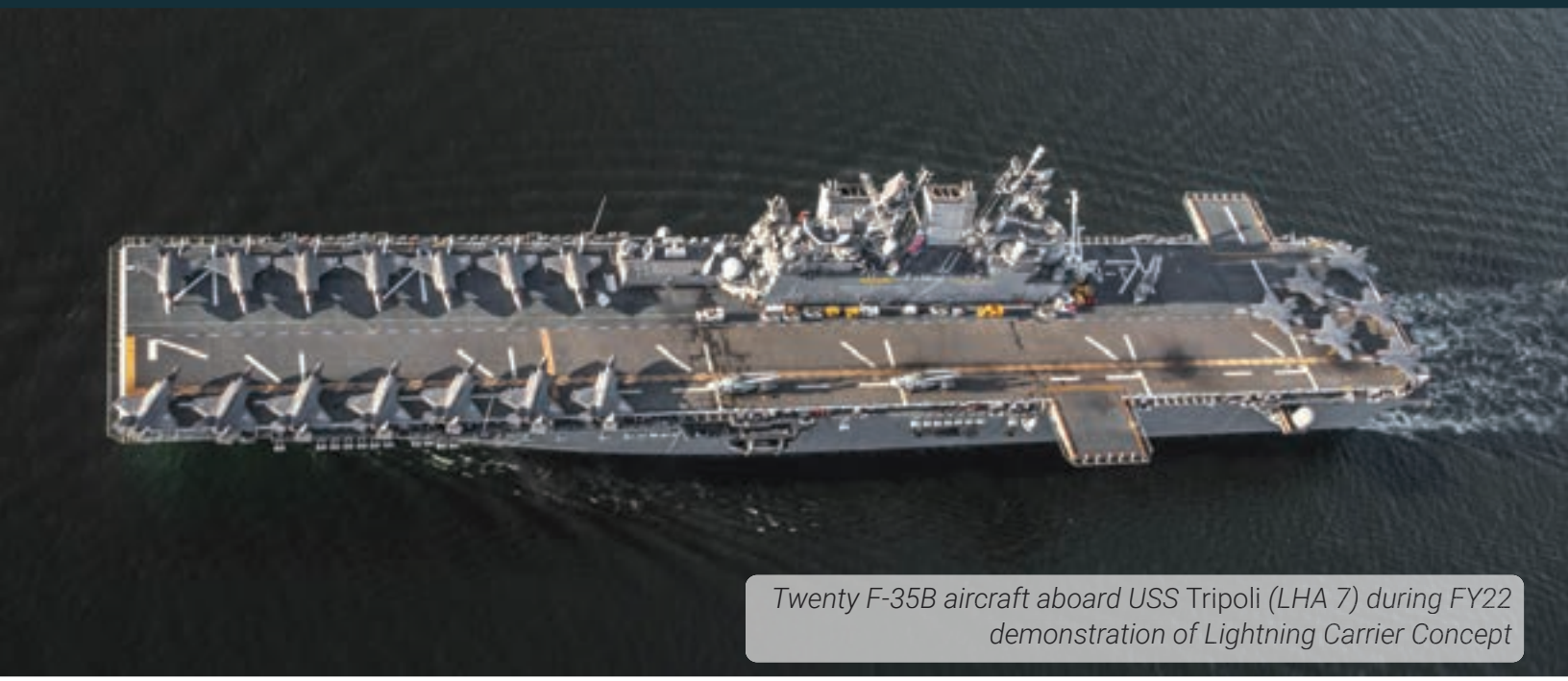
F-35 Joint Strike Fighter (JSF)



Twenty F-35B aircraft aboard USS Tripoli *(LHA 7) during FY22 demonstration of Lightning Carrier Concept*

The F-35 program made steady progress in FY22 to prepare the Joint Simulation Environment (JSE) for the 64 JSE test trials required to complete IOT&E. The current estimated completion of IOT&E trials in the JSE is the end of August 2023, a date that DOT&E considers at risk, due to the possibility of further discoveries of deficiencies and potential delays in the verification, validation, and accreditation (VV&A) process.

The F-35 program continues to field immature, deficient, and insufficiently tested Block 4 mission systems software to fielded units. The operational test (OT) teams continue to identify deficiencies that require software corrections and, with them, additional time and resources.

The F-35 Joint Program Office (JPO) has not adequately planned for operational testing of the upgraded hardware configuration, referred to as Technology Refresh 3 (TR-3), that is currently scheduled to be delivered in production Lot 15 aircraft, beginning in 4QFY23. Additionally, the necessary flight test instrumentation (including both aircraft and Open Air Battle Shaping (OABS) instrumentation) for both the remaining Technology Refresh 2 (TR-2) and upgraded TR-3 OT aircraft is not all on contract and will not be available, so OT squadrons may not have sufficient test aircraft with adequate capability or sufficient time to test new capabilities before operational employment.

SYSTEM DESCRIPTION

The F-35 Joint Strike Fighter (JSF) is a tri-Service, multinational, single seat, single-engine strike fighter aircraft produced in three variants:

- F-35A Conventional Take-Off and Landing
- F-35B Short Take-Off/ Vertical Landing
- F-35C Aircraft Carrier Variant

The F-35 Block 4 Modernization Capability Development Document specifies required capabilities and associated capability gaps that drive incremental improvements.

MISSION

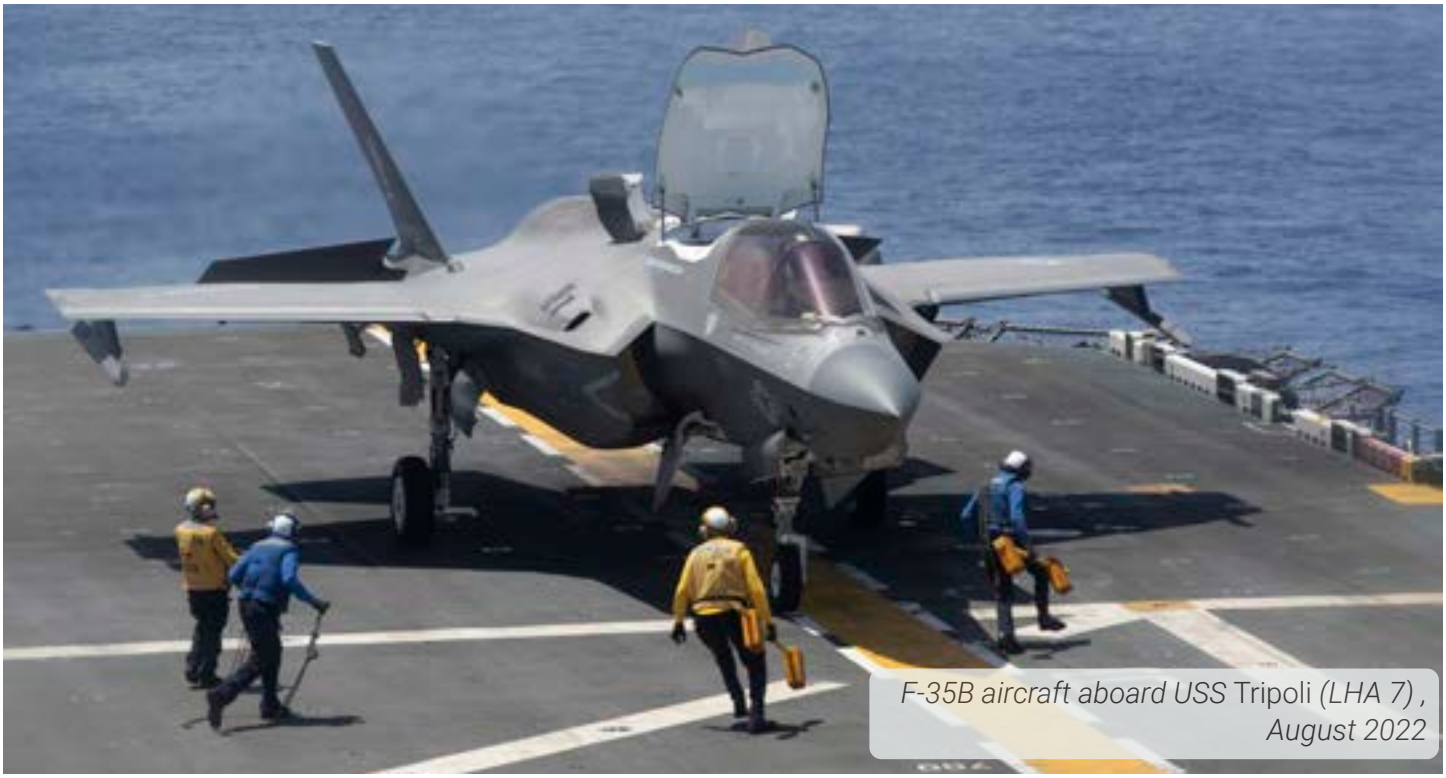
Combatant Commanders will employ units equipped with F-35 aircraft in joint operations to attack fixed and mobile land targets, surface combatants at sea, and air threats, including advanced aircraft and cruise missiles, during day and night, in all weather conditions, in heavily defended areas.

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. DOT&E approved the F-35 Overarching Block 4 TEMP and Increment 1 Annex on May 18, 2020. The Increment 1 Annex covers the Block 4 developmental and operational flight testing of software versions 30R03 though 30R06, which were completed in 3QFY21. The Increment 2 Annex, which covers Block 4 software versions 30R07, 30R08, and 40R01, and their associated hardware enablers, to include the transition from TR-2 to TR-3 equipped aircraft in the production line, is in final staffing within OSD at the time of this report. Increment 3 Annexes, which cover Block 4 software versions 40R02 through 42R01, and their associated hardware enablers are in coordination with the F-35 JPO. The Block 4 TEMP and associated Annexes govern the conduct of FOT&E.

» MAJOR CONTRACTORS

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



F-35B aircraft aboard USS Tripoli *(LHA 7) , August 2022*

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*
SSD	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 evaluated this series of software versions 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 approval of a FOT&E Test Plan for 30R08 is TBD
	TR-3	Block 4, 40 Series	40R0X	Dedicated operational tests planned for each release of capability in the series

Notes:

* For-score IOT&E events are highlighted in bold.
** 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; EA – Electronic Attack; IAW – In accordance with; IOC – Initial Operational Capability; JOTT – JSF Operational Test Team; OUE – Operational Utility Evaluation; SDD – System Development and Demonstration; TBD – To be determined; 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. The JSF Operational Test Team (JOTT) completed and DOT&E observed a series of weapons trials (both bombs and missiles); mission trials; and testing that compared F-35 performance to that of fourth-generation fighters against traditional and more modern surface-to-air threats currently fielded by potential adversaries. Open-air test missions evaluated the F-35 in multiple roles: offensive counter-air (OCA), defensive counter-air (DCA), 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 completed with the execution of the final AIM-120 missile trial, which was accomplished using an F-35C aircraft. Deficiencies in earlier versions of the aircraft software prevented this event from being accomplished until June 2021, when the program delivered software version 30R06.042 with the fixes needed to complete the trial.

Modeling and Simulation Development

The required events in the IOT&E test plan that remain to be accomplished are 64 trials, which is 42 percent of the overall mission trial requirement, in the JSE at Naval Air Station Patuxent River, Maryland. These trials include 11 DCA, 22 cruise missile defense, and 31 combined OCA/air interdiction/DEAD trials in operationally representative, dense, defense-in-depth scenarios with the latest threat systems that are not available on open-air ranges. All three F-35 variants will be involved in the execution of the trials.

A robust process has been established to identify, prioritize, track, and fix the remaining JSE deficiencies. The JSE team has focused on addressing open deficiencies that would affect trial validity in the simulator, reducing the list of "must-fix" deficiencies requiring resolution to two as of 26 October 2022. The VV&A effort is ongoing and as of 19 October 2022, 74 percent of the component V&V packages were rated as likely to accredit by the accreditation authority, with the remaining component packages still in work. The team is currently focusing effort on the systems level V&V, which ensures multiple models interact correctly. Current program estimates show IOT&E test missions occurring in August 2023. However, the ongoing VV&A process, as well as test readiness preparations, will likely lead to the discovery of new deficiencies that will need to be corrected prior to the for-score test missions. The time required to fix these deficiencies and update the analysis in the final system-level VV&A documentation will be key indicators of additional schedule pressures. Assuming any remaining key deficiencies are addressed and no significant uncorrectable discoveries occur, the JSE will be on track to provide a well-documented, accredited test venue with sufficient threat and system-under-test fidelity to determine F-35 effectiveness against a near-peer adversary in an operationally representative environment.

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

» FOT&E

Open-Air Testing

The U.S. Operational Test Team (UOTT) conducted operational testing of 30R07 in FY22 in accordance with the DOT&E-approved test plan. DOT&E observed the test mission trials and weapons events, which included: four Close Air Support test missions flown with F-35B aircraft; three DCA test missions flown with F-35A and F-35C aircraft; four OCA test missions flown with F-35A and F-35C aircraft; four S/DEAD test missions flown with F-35A and F-35C aircraft; and two missiles-test events, one AIM-120 and one AIM-9X. Test efficiency was hindered by poor preparation and readiness of the F-35 test enterprise and the performance of the OABS system, which resulted in invalid trials and the need to reschedule test events..

Per the Block 4 TEMP and associated Annexes, OT aircraft are required to support both developmental and operational testing. Modifications to these aircraft must be funded, scheduled, and completed just after developmental test (DT) aircraft modifications to enable integrated DT/OT, DT assist, and mission-level testing of future capabilities. Although the JPO has funded and contracted for some of the OT aircraft modifications, it currently does not have a scheduled and coordinated plan to ensure that all of 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 TR-3. Because of these issues, adequate OT of the 30R08 capability is not forecast to be completed prior to fielding in the fall of 2023, nor will OT of the first TR-3 production configuration in 40R01 be done prior to the Services accepting the first aircraft in 4QFY23. The TR-3 configuration contains upgraded integrated core processors and other critical hardware updates.

Modeling and Simulation Development

The extended delay in completing the necessary VV&A of the F-35 JSE for conducting the IOT&E test missions has also delayed preparations for operational testing of current F-35 upgrades. Licensing issues associated with the F-35-In-A-Box (FIAB) have also contributed to the delayed JSE modernization efforts. While completing the current VV&A effort, the program should simultaneously make every effort to align JSE delivery to required Block 4 FOT&E periods now, so that the UOTT can use the JSE to accomplish critical testing of future capabilities. These plans must include capability upgrades to the FIAB, blue and red weapons models, and red ground threat models required for FOT&E.

Suitability Testing

The UOTT conducted suitability testing per the annual DOT&E-approved suitability test plan in FY22. The test team conducted interviews with maintenance personnel and pilots on training, technical orders, the use of ALIS, software updates, maintenance of the low observable characteristics of the aircraft, support equipment and tools, and safety issues.

Operational test teams from the Navy and the Marine Corps, supported by the UOTT, participated in testing on the USS *Tripoli* (LHA 7) (pictured at the beginning of this article) to explore the F-35B Heavy Air Combat Element (ACE) concept of operations (CONOPS). This was conducted as FOT&E for the LHA 6 program, per the DOT&E-approved test plan. DOT&E observed the concept exploration exercise and recommends that the Services continue to refine and test the F-35B Heavy ACE CONOPS based on feedback from this event. This should include considerations of ship manning, ACE composition, increased dedicated classified workspace, provisioning of additional Ship's Inertial Navigation Systems

cables and refueling stations, and optimizing ALIS to support increased numbers of F-35s over a ship's SATCOM connection to the ALIS Central Point of Entry, accounting for potential reduced emissions control scenarios.

The UOTT continued developing plans to conduct a 30-day demonstration of the capability to conduct F-35 flight operations without ALIS connectivity. The UOTT has not been able to identify a unit to perform this test event, which remains unscheduled. DOT&E considers this testing to be a high priority.

Cybersecurity Testing

The UOTT cybersecurity test teams conducted an on-aircraft cybersecurity assessment of Identification Friend or Foe (IFF) Mode 5 in an anechoic chamber at the Patuxent River Naval Air Station in FY22, in accordance with the DOT&E-approved test plan. More in depth testing is needed to assess the cybersecurity of the AV. To date, on the AV, the UOTT has tested IFF Mode 5, IFF Mode S, GPS, Variable Message Format, Link 16, and weapons interface testing for air-to-ground and air-to-air weapons on the AV. Key systems such as the Multifunction Advanced Data Link, Small Diameter Bomb II, and RADAR are planned for FY23 and later. AV test assets are made available to support AV testing, which is limited in scope based on the potentially disruptive nature of cyber. The Services and JPO should invest in requisite hardware- and software-in-the-loop capabilities to support more robust and representative AV cyber testing.

PERFORMANCE

» IOT&E

Effectiveness

The results of effectiveness testing during IOT&E will be reported within 90 days of completion of testing in the F-35 JSE.

Suitability

Suitability testing is complete. The results of suitability testing during IOT&E will be reported within 90 days of completion of testing in the F-35 JSE.

Survivability

Survivabiliy testing is complete. The results of survivability testing (to include cybersecurity testing) during IOT&E will be reported within 90 days of completion of testing in the F-35 JSE.

» FOT&E

Effectiveness

The JPO designed the current development process, referred to as Continuous Capability Development and Delivery (C2D2), to provide new capabilities and updates in time-phased increments. The program continues to field immature, deficient, and insufficiently tested mission systems software to fielded units without adequate operational testing. Although the program designed C2D2 around commercial "agile software" development concepts, it does not adhere to the industry best practices that include clear articulation of the capabilities required in the Minimum Viable Product, focused testing, comprehensive characterization of the product, and full delivery of the specified operational capabilities. The program has consistently failed to deliver the full set of capabilities contained in their master schedule as defined by the Air System Playbook, which was updated again in FY22 to realign capability delivery to another delayed schedule. Although the program has begun addressing some of the key findings from the 2021 software independent review team, more needs to be done to reduce the discovery of deficiencies in the field, including expansion of and updates to hardware- and software-in-the-loop labs.

The program plans to begin developmental flight testing of the TR-3 configuration in December 2023, with software version 40R01. To begin the transition to TR-3 from TR-2, this version of software was developed using the baseline capabilities provided in the 30R07 Series, which completed development in 1QFY22.

The JSF program continues to carry a large number of deficiencies, and conducts recurring reviews with Service requirements representatives to

prioritize resources to address them. Although initial development in Block 4 was intended to both introduce new capabilities and address deficiencies identified during SDD, the overall number of open deficiencies has not significantly decreased since the completion of SDD due to the continued discovery of problems. The new deficiencies include those associated with new capabilities as well as some associated with previously functioning capabilities that no longer work. The operational test teams identified deficiencies associated with communication systems, weapons, fusion, pilot-vehicle-interfaces, and the radar during testing of the 30R06 and 30R07 software versions.

Suitability

The operational suitability of the F-35 fleet remains below Service expectations. In FY22, the trend in aircraft availability was flat, after declining for most of FY21 after a historic program high in January 2021.

At the close of FY22, 540 aircraft have been produced for the U.S. Services. These aircraft do not include any aircraft assigned to dedicated developmental testing 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 2022. 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 operational test) is below the target value of 65 percent. The DOT&E assessment shows a relatively flat trend in FY22.

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 operational testing. The proportion of the fleet that is combat coded has risen steadily over time and represents approximately half of the U.S. fleet over the 12 months ending in September 2022. 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 and achieved the 65 percent target for monthly average availability for the overall, combined 12 months ending in September 2022.

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), and 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 FY22 with a worsening trend in the last quarter. 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, and spares posture for those critical items most in demand.

A significant shortage of fully functional F135 engines has also contributed to reduced aircraft availability. The F-35A variant is most affected by the engine shortage, which has been exacerbated by a lack of depot repair capacity. Recent efforts to lay in additional depot resources, improve depot efficiencies, and ruggedize key engine components have reduced the number of aircraft without an engine. Nonetheless, the program projects that without further action, a lack of propulsion spares will result in some aircraft not having a functional engine through at least 2028.

The F-35 fleet remains below JSF Operational Requirements Document (ORD) thresholds in some areas for overall reliability and maintainability. Maintenance data gathered through April 2022

from the U.S. fleet of all three variants show that the F-35A and F-35B are not meeting the full set of ORD reliability and maintainability requirements for mature aircraft. The F-35C, which reached the 50,000-hour milestone designated for maturity in 2QFY22, is meeting the ORD 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 and 3 show trends in the reliability and maintainability metrics, respectively, based on data aggregated in 3-month rolling windows, where monthly reports are generated based on the last 3 months of data. This process enables trends to be observed more clearly than reports generated by only a single month of data.

Table 2. F-35 Reliability Metrics Assessment as of April 30, 2022

Variant	Flight Hours for ORD or JCS Threshold	Cumulative Flight Hours	MFHBCF (hours)			MFHBR (hours)			MFHBME (hours)			MFHBF-DC (hours)		
			ORD Threshold	Change: Apr 2021 to Apr 2022	Meeting ORD Threshold	ORD Threshold	Change: Apr 2021 to Apr 2022	Meeting ORD Threshold	ORD Threshold	Change: Apr 2021 to Apr 2022	Meeting ORD Threshold	JCS Requirement	Change: Apr 2021 to Apr 2022	Meeting JCS Threshold
F-35A	75,000	246,843	20	↑	No	6.5	↑	Yes	2.0	↑	Yes	6.0	↑	Yes
F-35B	75,000	90,895	12	↓	No	6.0	↑	No	1.5	↑	Yes	4.0	↑	Yes
F-35C	50,000	54,920	14	↑	Yes	6.0	↑	Yes	1.5	↑	Yes	4.0	↓	Yes

Note:
Up arrow (↑) represents improving trend

Acronyms: JCS – Joint Capability Specification; MFHBCF – Mean Flight Hours Between Critical Failures; MFHBF-DC – Mean Flight Hours Between Failures-Design Controllable; MFHBME – Mean Flight Hours Between Maintenance Event; MFHBR – Mean Flight Hours Between Removal; ORD – Operational Requirements Document

Table 3. F-35 Maintainability Metrics Assessment as of April 30, 2022

Variant	Flight Hours for ORD Threshold	Cumulative Flight Hours	MCMTCF (hours)			MTTR (hours)		
			ORD Threshold	Change: Apr 2021 to Apr 2022	Meeting ORD Threshold	ORD Threshold	Change: Apr 2021 to Apr 2022	Meeting ORD Threshold
F-35A	75,000	246,843	4.0	↓	No	2.5	↓	No
F-35B	75,000	90,895	4.5	↓	No	3.0	↓	No
F-35C	50,000	54,920	4.0	↑	No	2.5	↑	No

Note:
Down arrow (↓) represents improving trend

Acronyms: MCMTCF – Mean Corrective Maintenance Time for Critical Failures; MTTR – Mean Time To Repair; ORD – Operational Requirements Document

ALIS and Operational Data Integrated Network (ODIN)

ALIS is a large, 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. In FY22, 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 Standard Operating Unit (SOU) to the ODIN Base Kit (OBK), reached selected field units during FY22, and the program has contracted for OBK delivery to all units by September 2023. To support eventual shipboard operations, the program recently completed shock and vibration testing of the OBK. The testing identified minor changes needed to meet U.S. Navy and Marine Corps requirements for shipboard installation. The transition for ALIS software to be hosted on ODIN hardware has been divided in to three pathways: architecture and environment, data, and ALIS applications.

The path to containerized ALIS, which will be the software bundle ported from the legacy ALIS hardware systems into the OBKs to formalize an ODIN software and hardware system, follows three steps. Step one, called 35P21.Q4, is the current release of ALIS software in testing. Testing of this version discovered a number of Category One (i.e., safety critical) deficiencies, resulting in significant changes to the software code and subsequent delays. Currently, 35P21.Q4 is preparing for flight test and is projected to be released to the fleet in November 2022. Step two, called 35P22.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 release, and is now projected to be released in 4QFY23. A number of code infrastructure and cybersecurity updates are planned for this release to cover anticipated software obsolescence during the required software freeze period to perform containerization. Noteworthy in the 35P22.Q4

release, are planned improvements to transport layer protocols to better support maritime and forward deployed operations. The final step, containerization of ALIS, which was originally planned to enter flight test in July 2023, is now projected to enter flight test in June 2024. Between the release of 35P22.Q4 and the release of containerized ALIS, there are no plans to make any performance or capability improvements to ALIS, as changes mid-containerization would produce significant delays in the transformation process and potential errors in the software.

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 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. However, because software instability issues are underreported, they are not reflected in the metrics. Currently, only proprietary tools used by contractor field service engineers can identify pilot-initiated reset events. DOT&E recommends, in order to improve F-35 aircraft mission systems stability, that ODIN include the capability to automatically document pilot-initiated resets of mission systems.

In April-May 2022, the U.S. Air Force conducted agile combat employment operations with the F-35A in Exercise Valiant Shield. This exercise highlighted the need for ALIS and ODIN to operate with limited data, or entirely disconnected at forward operating locations. While the Services are experimenting with distributed operations and limited data transfer in contested environments, DOT&E maintains the need to formally test and document F-35 aircraft operations and maintenance – for up to 30 days – with ALIS or ODIN disconnected from their supporting network infrastructure.

Survivability

No cybersecurity discrepancies were resolved during FY22 testing and a large number of cybersecurity deficiencies remain across the F-35 program. To address the discrepancies, the JPO invested in cyber mitigations associated with recent JOTT testing, and key test findings are being tracked to closure by the newly delegated Authorizing Official for ALIS and ODIN. Access to proprietary information for contractor cybersecurity testers impeded execution of several planned tests in FY22, requiring their rescheduling for FY23. 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 cybersecurity testing on AV components and support systems.

The F-35 JPO is using a Security Development Operations and agile software construct with frequent software updates to the field in support of the ODIN path forward. The Block 4 30 and 40 Series construct is also providing more frequent operational flight profile software updates to the combat forces than SDD. An increased frequency of new software deployments may stress the capacity of cybersecurity test teams to thoroughly evaluate each update. Under these new constructs, the importance of cybersecurity testing of the software development environments will also increase, further stressing the cybersecurity test teams' capacity.

In light of current cybersecurity threats and vulnerabilities, along with peer and near-peer threats to bases and communications, DOT&E continues to require the F-35 program and Services to conduct testing of aircraft operations without access to the ALIS SOU for extended periods of time, with an objective of demonstrating the SOU-specified 30 days of operations, which is also a suitability testing requirement. The program has yet to meet this requirement, and is currently in the planning stages for a test of the ALIS Contingency Operations Plan, which will test standardized procedures for lack-of-connectivity scenarios.

Emerging candidates for cybersecurity testing are the F-35 JSE and the activation of

data ports on operational aircraft for use in downloading aircraft performance data. Further insights into priority testing will be forthcoming from a Mission-Based Cyber Risk Assessment commencing in 1QFY23.

RECOMMENDATIONS

The F-35 JPO and Services as appropriate should:

1. Complete the remaining VV&A of the JSE to enable timely completion of the required IOT&E trials.
2. Develop and begin executing plans for upgrading the JSE 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.
3. In accordance with the DOT&E-approved Block 4 TEMP, Increment 1 approval memo:
   - Fully fund, develop, and update the detailed plan to modify all OT aircraft with the appropriate capabilities, life limit, and instrumentation, including OABS requirements;
   - Complete a 30-day demonstration of flight operations without ALIS connectivity; and
   - 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. Reduce discovery of deficiencies in the field by continuing to address more findings from the 2021 software independent review team, and upgrading and increasing the capacity of hardware- and software-in-the-loop labs.
5. Continue to pursue maintenance system improvements, especially for common processes distributed among Non-Mission Capable Maintenance drivers, such as low observable repairs and adhesive cure times.
6. 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.
7. 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.
8. Ensure both developmental and operational testing for ALIS and ODIN are adequately resourced to reduce the high risk associated with fielding an immature and inadequately tested replacement.
9. Conduct more in-depth cyber testing of the AV, ALIS/ODIN, US Reprogramming Lab, training systems, and eventually JSE; provide dedicated hardware- and software-in-the-loop cyber-test assets that can be used for the full extent of cyber testing.
10. Correct program-wide deficiencies identified during cybersecurity testing in a timely manner and verify corrections within ALIS prior to rehosting ALIS software on ODIN.
11. 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.
12. Apply lessons learned from observations of the USS *Tripoli* deployment to refine F-35B Heavy ACE CONOPS. These include:
    - The Marine Corps should continue to refine the F-35B Heavy ACE CONOPS and determine the size and composition of an F-35B Heavy ACE for a LHA 6-class vessel based on its unique flight deck, hangar bay, and aviation support services configuration.
    - The UOTT should incorporate information learned from this detachment in future test planning processes to assess the effects of long-term ALIS-denied or -degraded conditions of up to 30 days, on the ability of a unit to generate sorties.