Director, Operational Test and Evaluation

FY 2020 Annual Report

January 2021

This report satisfies the provisions of Title 10, United States Code, Section 139. The report summarizes the operational test and evaluation activities (including live fire testing activities) of the Department of Defense during the preceding fiscal year.

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Director

F-35 Joint Strike Fighter (JSF)

Executive Summary

IOT&E Progress

- Summary: As of the end of September 2020, the remaining required IOT&E events are 64 mission trials in the F-35 Joint Simulation Environment (JSE) and two AIM-120 missile trials that were awaiting corrections to deficiencies in the aircraft's mission systems software. Corrections were added to software version 30R04.52 that enabled one AIM-120 trial to be completed in late October, but the other trial requires additional corrections to deficiencies.
- JSE: The JSE is a man-in-the-loop, F-35 software-in-the-loop mission simulator that will be used to conduct IOT&E test missions with modern threat types and densities in scenarios that are not able to be replicated on the open-air ranges. The IOT&E plan requires 64 mission trials in the JSE against modern, fielded, near-peer adversary threats in realistic densities.
  - Despite clear requirements and focused efforts by the F-35 Joint Program Office (JPO) and JSE development teams, the JSE will not be ready for IOT&E events in CY20, which is over 3 years later than planned.
  - The ongoing IOT&E JSE verification, validation, and accreditation (VV&A) processes must be completed, along with consistent independent schedule reviews, to finish the JSE and IOT&E, now expected to occur in mid-to-late CY21.
  - The decision to move F-35 JPO management of the JSE into the F-35 JPO Training Systems and Simulation Program Management Office is concerning in that the JSE must still have adequate fidelity to be accredited for scored operational test (OT) trials to complete IOT&E.
  - The JSE is required to complete IOT&E as it is the only venue, other than actual combat against near-peer adversaries, to adequately evaluate the F-35.
- Weapons Trials: Having completed the majority of the weapons trials previously, the Joint Strike Fighter (JSF) Operational Test Team (JOTT) worked to complete the remaining events in FY20. The JOTT was able to complete one AIM-120 missile trial and two Paveway IV bomb trials in July 2020. These test trials were designed to evaluate weapon performance in a GPS-contested environment. The JOTT completed one of two remaining IOT&E AIM-120 trials in October. The remaining AIM-120 trial is expected to occur in early CY21 with the version of 30R06 that will be fielded. An additional weapons test trial, originally included in the IOT&E test plan, is deferred to post-IOT&E testing.
- Electronic Attack (EA) Trials: DOT&E approved the start of the EA mission trials at Point Mugu Sea Range (PMSR), California, on July 10, 2020. The JOTT completed the four EA trials later that same month.

Block 4 / Continuous Capability Development and Delivery (C2D2) Progress

- The current development process used by the F-35 JPO and Lockheed Martin, that is supposed to provide new capabilities and updates in 6-month increments, is not working. It is causing significant delays to planned schedules and results in poor software quality containing deficiencies.
- The current C2D2 process has not been able to keep pace with the scheduled additions of new increments of capability. Software changes, intended to introduce new capabilities or fix deficiencies, often introduced stability problems and/or adversely affected other functionality. Due to these inefficiencies, along with a large amount of planned new capabilities, DOT&E considers the program's current Revision 15 master schedule to be high risk.
- The JSF program continues to carry a large number of deficiencies, many of which were identified prior to the completion of System Development and Demonstration (SDD) in April 2018. As of October 2, 2020, the program had 871 open deficiencies, 10 of which were designated Category 1. Although initial development in Block 4 has focused on addressing deficiencies while developing some new capabilities, the overall number of open deficiencies has not changed significantly since the completion of SDD due to ongoing discoveries of new problems.
- The program continues to plan for a greater dependence on modeling and simulation (M&S) in Block 4 than was used during SDD and, as such, must establish internal processes to aid in the development and enhancement of the associated M&S capabilities. However, as of the writing of this report,

very little change in the laboratories and simulation venues has occurred or is currently programmed.
- Testing the planned new Technical Refresh (TR)-3 avionics configuration will further strain the program's limited test infrastructure (i.e., aircraft and labs). Software sustainment and capability modifications of both TR-3 and legacy TR-2-based aircraft will continue to be a concern, including the high cost and multiple hardware configurations of fielded aircraft, many of which will require updates and upgrades for years to come. The use of the F-35 JSE will continue to be a critical part of an adequate evaluation of F-35 Block 4 combat capabilities. As such, the F-35 JPO must continue work to align F-35 JSE VV&A with the C2D2 process to ensure that the JSE is able to be accredited for test and used for training with every 6-month release. Currently, during detailed test planning for each 6-month drop of capability, there is little activity to align collection of open air flight test data for use in VV&A of Block 4 capabilities in the JSE.
- As proven during IOT&E, adequate evaluation of Block 4 capabilities will require the continued use of Open Air Battle Shaping (OABS) instrumentation and Radar Signal Emulators (RSE).
- OT aircraft will be needed to support both developmental and operational test requirements. 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 relevant mission-level testing of future capabilities. However, as of this report modifications to OT aircraft are not funded, nor on contract to be able to support DT, let alone accomplish required OT mission-level evaluation.

Mission Data Load (MDL) Development and Testing
- Although the program has initiatives in progress, the U.S. Reprogramming Laboratory (USRL) still lacks adequate equipment to fully test and optimize MDLs under realistic stressing conditions to ensure performance against current and future threats. In spite of this fact, the F-35 JPO recently reduced funding to the USRL that cut flight test support of new MDLs, thus limiting dedicated MDL testing to inadequate laboratory venues only.
- Significant additional investments, well beyond the recent incremental upgrades to the signal generator channels and reprogramming tools, are required now for the USRL to support F-35 Block 4 MDL development. At the time of this report, the program has budgeted for some of these hardware and software tools, but they are already late to need for supporting fielded aircraft and Block 4 development.

Availability, Reliability, and Maintainability
- Although the fleet-wide trend in aircraft availability showed modest improvement in 2019 and early 2020, the average fleet-wide monthly availability rate for only the U.S. aircraft, for the 12 months ending in September 2020, is below the target value of 65 percent.
- Individual deployed units met or exceeded the 80-percent Mission Capable (MC) and 70-percent Fully Mission Capable (FMC) rate goals intermittently, but were not able to meet these goals on a sustained basis.
- Each variant is meeting at least one target value needed to reach requirements at maturity of the three reliability metrics defined in the JSF Operational Requirements Document (ORD). None of the variants are meeting target values for the two maintainability measures defined in the ORD.

Autonomic Logistics Information System (ALIS) and Operational Data Integrity Network (ODIN)
- Although the program released several versions of ALIS 3.5 in CY20, the program has not been able to generate and field quarterly updates as planned. While some delays are attributable to restrictions imposed by the coronavirus (COVID-19) pandemic, others are related to improving overall software quality and stability. Additionally, the program sought efficiencies in deploying the updates when practical, such as combining updates that required rebuilding Portable Maintenance Aids. Each delay in a quarterly release has had a waterfall effect on those following it. Users have reported improvements to ALIS stability and usability with the fielding of ALIS 3.5.
- Although the program continues data, software, and hardware development for ODIN, an overarching test strategy that includes government and contractor laboratory facilities has yet to be provided. The schedules for ODIN Initial Operational Capability (IOC) and Final Operational Capability (FOC) remain high risk.

Live Fire Test and Evaluation (LFT&E)
- DOT&E completed the evaluation of the F-35 vulnerability to kinetic threats. Testing and evaluation of the F-35 survivability against chemical, biological, radiological, and nuclear threats is nearing completion:
  - Chemical and biological decontamination of the Generation (Gen) III and Gen III Lite Helmet-Mounted Display System (HMDS) was not demonstrated, which must occur as part of Block 4 testing.
  - In FY20, the Naval Air Warfare Center Aircraft Division at Naval Air Station Patuxent River (Pax River), Maryland, completed system-level testing of the F-35B variant to evaluate tolerance to electromagnetic pulse (EMP) threats.
- The evaluation of the F-35 gun lethality against operationally relevant targets is ongoing and is expected to be completed in FY21.
- F-35 vulnerability and lethality evaluation details will be provided in the combined IOT&E and LFT&E report to be published in support of the Full-Rate Production decision.

Cybersecurity Operational Testing
- While some cybersecurity-related system discrepancies have been resolved, cybersecurity testing during IOT&E continued to demonstrate that some vulnerabilities identified during earlier testing periods have not been remedied. More testing is needed to assess cybersecurity of logistics support systems and the air vehicle (AV) itself.

System

- The F-35 JSF program is a tri-Service, multinational, single seat, single-engine family of strike fighter aircraft consisting of three variants:
  - F-35A Conventional Take-Off and Landing
  - F-35B Short Take-Off/Vertical-Landing
  - F-35C Aircraft Carrier Variant
- Per the JSF ORD for SDD, the F-35 is designed to operate and survive in the IOC and IOC-plus-10-years threat environment (out to 2025, based on the first IOC declaration by the U.S. Marine Corps in 2015). It is also designed to have improved lethality in this environment compared to legacy multi-role aircraft.
- Using an active electronically scanned array (AESA) radar and other sensors, the F-35, with Block 4, 30 Series software, currently employs precision-guided weapons (e.g., GBU-12 Laser-Guided Bomb, GBU-49 Dual GPS/Laser-Guided Bomb, GPS-Guided Joint Direct Attack Munition (JDAM), GPS-Guided Small Diameter Bomb I (SDB I), and Navy GPS-Guided Joint Stand-Off Weapon)); air-to-air missiles (e.g., AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM) and AIM-9X infrared guided, air-to-air missile); and a 25-mm gun.
- The F-35 Modernization Block 4 Capability Development Document addresses required capabilities and associated capability gaps that drive incremental improvements in capability from 2018 and beyond. Block 4 modernization will add new hardware, software, and weapons, including SDB II, AIM-9X Block II, B-61, Advanced Anti-Radiation Guided Missile-Extended Range (AARGM-ER), and several international partner weapons.

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 or night, in all weather conditions and in heavily defended areas.

Major Contractor

Lockheed Martin, Aeronautics Company – Fort Worth, Texas

Activity

IOT&E Progress

Activity

- The JOTT continued testing throughout FY20, in accordance with the DOT&E-approved F-35 IOT&E test plan, while preparing to execute the remaining IOT&E events and analyzing test data to draft their report.
- The program continued to make slow progress in preparing the JSE for IOT&E test trials. See subsequent section on the JSE on page 25 for further details.
- In August 2019, the program began moving 13 of the 16 total RSEs and supporting equipment from the Nevada Test and Training Range (NTTR) to the PMSR in preparation for the remaining four 4 EA open-air trials. All 13 RSEs completed movement to the west coast sites and were upgraded with the latest software in April 2020 to support final integration and testing.
- After several check-out missions that demonstrated successful integration of the RSEs at PMSR, along with overall test readiness and adequacy, DOT&E approved the start of the four EA test missions at PMSR on July 10, 2020. The EA mission trials, which were completed within the month of July, evaluated the F-35A and F-35C in the role of suppression/destruction of enemy air defenses versus modern fielded threats.
- The JOTT completed one AIM-120 missile trial and two Paveway IV bomb trials in July 2020. These test trials were designed to evaluate weapon performance in a GPS-contested environment. The JOTT completed one of two remaining IOT&E AIM-120 trials in October. The remaining AIM-120 trial is expected to occur in early CY21 with the version of 30R06 that will be fielded. An additional weapons test trial, originally included in the IOT&E test plan, is deferred to post-IOT&E testing.
- The JOTT completed the Low Observable Stability Over Time (LOSOT) testing required in the IOT&E test plan. The final aircraft to complete LOSOT testing during IOT&E was a U.K. F-35B OT aircraft, designated BK-4, which completed the testing in February 2020.

Assessment

- The JSE is required to complete 64 mission trials against modern, fielded, near-peer adversary threats in realistic densities. The JSE is the only venue available, other than actual combat against near-peer adversaries, to adequately evaluate the F-35 due to inherent limitations associated with open-air testing. The delays in having the JSE ready for formal test events will likely slip completion of IOT&E into mid-to-late CY21.
- All results of the F-35 IOT&E, including the weapons trials, will be included in the DOT&E combined IOT&E and LFT&E report, which will inform the Full-Rate Production decision.

Block 4 / C2D2 Progress

Activity: C2D2

- Block 4 is the overarching development program initiated at the end of SDD, which completed in April 2018. Since that time, the F-35 JPO and Lockheed Martin have continued to address software deficiencies while attemping to add new capabilities via the C2D2 process. Table 1 associates program development phases with major avionics architecture, capabilities and software nomenclature, and key operational test events.

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 the 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	**Formal IOT&E** (Dec 2018 - Sep 2019)
			30R04.52	**Formal IOT&E Electronic Attack trials** (Jul 2020)
			30R06.0X	Software fix needed for **IOT&E weapons event**
			30R06+	Dedicated Follow-on Operational Test for each planned field release of software.
	TR-3	Block 4, 40 Series	40R0X	Formal Operational Test with new hardware configuration and Dedicated Operational Test for each software release of capability.

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 of software is compatible with the Block 3F aircraft hardware configuration and is being used to address deficiencies and add some Service-prioritized capabilities.

C2D2 – Continuous Capability Development and Delivery; IOC – Initial Operational Capability; JOTT – JSF Operational Test Team; OUE – Operational Utility Evaluation; SDD – System Design and Development; TR-X – Technical Refresh [version#], referring to the suite of core avionics processors

- F-35 Block 4 continues to be on OT&E oversight. DOT&E reviews the content of each Block 4, 30 and 40 series increments, works with the U.S. Operational Test Team (UOTT) and F-35 JPO, and conducts both integrated developmental test/operational test (IDT/OT) and dedicated OT on each increment.
- The C2D2 process is designed to deliver a "Minimum Viable Product" (MVP) increment of software to the Services every 6 months. The 6-month cycle includes an aggressive IDT/OT period, followed by an integrated test team assessment and production recommendation from both DT and OT within 7 days after flight test completion. This process is followed by delivery of any required updates to mission planning software, mission data, ALIS, joint technical data, flight series data, training simulators, and other support capabilities that were still in development and not tested during the 6-month test window. The operational flight program software and support products are then bundled

together into the MVP (planned to be within 6 months after completion of IDT/OT, but updates to training simulators and mission data usually take longer), and delivered to the Services. As a result, the final MVP configurations receive minimal, if any, testing prior to fielding, and significant problems are being discovered during OT and in the field.
- DOT&E requires adequate testing of the full capability of the MVP prior to delivery to the warfighter, but this testing is constrained by the aggressive F-35 JPO delivery schedule and has not been adequately accomplished to date. Going forward, DOT&E will continue working with both the UOTT and F-35 JPO to accomplish dedicated OT on every increment using the final MVP.
- Since the start of the Block 4 C2D2 process over 2 years ago, the program has added the Automatic Ground Collision Avoidance System, which is a priority capability from the Services; interim Full Motion Video, which is a priority capability to the U.S. Marine Corps; some radar updates; and additional weapons capability with the GBU-49 Enhanced Paveway II 500-pound class dual-mode bomb. However, other planned capabilities have slipped to later increments.

Activity: Block 4, 30 Series
- The initial set of Block 4, 30 Series software releases, represented by 30RXX (for test software versions) and 30PXX (for software going to the field), are compatible with aircraft in the TR-2 avionics hardware configuration. These releases are being used to address deficiencies and add some Service-prioritized capabilities.
- During FY20, the program developed and tested multiple versions of 30 Series software, with the plan to field three releases – 30P04.012 in January 2020, 30P04.5 in April 2020, and 30P05 in October 2020.

Activity: Block 4, 40 Series
- Block 4, 40 Series development, which will include the new TR-3 avionics hardware configuration and 40RXX or 40PXX software, is scheduled to begin developmental testing in late CY21 and deliver Lot 15 production aircraft starting in CY23. The Block 4, 40 Series continues to use the C2D2 process to integrate the remaining Decision Memorandum (DM) 90 capabilities and Service-unique priority requirements.
- Block 4 Test and Evaluation Master Plan (TEMP)
  - The program completed coordination on the overarching Block 4 TEMP and Increment 1 Annexes (both unclassified and classified) for software releases 30R03 through 30R06. DOT&E approved the TEMP and Increment 1 Annexes on May 18, 2020.
  - The program is coordinating the Increment 2 Annexes of the TEMP as of the time of this report. These annexes will cover the remaining 30RXX software versions (currently planned as 30R07, 30R08, 30R09) and the first two 40RXX software versions (40R01 and 41R01).

Assessment
- The current development process used by the F-35 JPO and Lockheed Martin, which is supposed to provide new capabilities and updates in 6-month increments, is resulting in significant delays, deferrals of planned capabilities, and poor software quality containing deficiencies. For these reasons, the 6-month development and delivery timeline for the C2D2 process has not worked and remains high risk.
- 30R04 software development took longer and required more software increments than planned. Deficiencies continued to be discovered after development and fielding, both during IOT&E and in the field.
  - The program planned for four DT software builds (30R04.00, 01, 02, 03), but needed 12 (30R04.00, 01, 011, 012, 02, 021, 03, 031, 015, 4.5, 4.51, 4.52) to produce a final 30P04 version that was fielded.
  - The time from first DT flight to field release was approximately 13 months (May 2019 to July 2020) vice the 6 months planned.
  - After the first 6 months and four builds of testing 30R04, the program fielded version 30P04.012. However, combat units found multiple software issues in 30P04.012. Due to these and other issues, the program developed a new software version, 30R04.5.
  - The program added fixes to 19 deficiencies and 37 Software Product Anomaly Reports into 30R04.5.
  - Although the Services planned to field 30R04.5 software in March 2020, continued discoveries of deficiencies and need for fixes delayed fielding until July 2020 with 30R04.52.
  - After fielding of 30P04.52, operational test units continued testing the software and discovered two Category 1 and six additional deficiencies during OT.
- 30R05 software development also took longer and required more software increments than planned.
  - The program planned for four DT software builds (30R05.00, 01, 02, 03), but has produced seven to date (30R05.00, 01, 02, 03, 04, 041, 042).
  - As of October 2020, DT flight testing continues after 11 months (after starting in November 2019), with plans to continue through mid-November 2020.
  - Due to significant unresolved deficiencies and the need to continue development of the next iteration of software (30R06.XX series), the program and Services determined that 30P05 will not be released to the field, which is a deviation from the planned delivery schedule.
  - The delays in development and testing of 30R04 and 30R05 have also caused the integration, testing, and fielding of SDB II and AIM-9X Block II (among other capabilities) to slip from 30R06 to later software versions.
- The program continues to carry a large number of deficiencies, many of which were identified prior to the completion of SDD. As of October 2, 2020, the program had 871 open deficiencies, 10 of which were designated Category 1. Although initial development work in Block 4 has focused on addressing deficiencies while developing some capabilities, the overall number of open deficiencies has not changed significantly since the completion of SDD

in April 2018, at which time the program had 941 open deficiencies, 102 of which were Category 1. This is due to ongoing problems with initial software quality and limited lab and flight test capacity, resulting in a high rate of problem discoveries in OT and the field.

- Although the program continues to plan for a greater dependence on M&S in Block 4 development than was used during SDD, including expanding the use of the JSE for contract specification verification, very little has been done to upgrade the laboratories and simulation venues.
  - Adequate funding to develop and sustain robust laboratory and simulation environments, along with adequate VV&A plans that include the use of data from representative open-air missions, must be planned and programmed so that accredited M&S capabilities are ready to support system development and OT of future increments. Adequate M&S capabilities are not currently planned, nor fully funded, as part of the overall Block 4 development processes.
  - Plans to rely heavily upon M&S (to include a "digital twin" high-fidelity F-35 M&S capability) are neither funded nor in development for use in delivery of future increments. Other programs that presuppose the use of digital twin and M&S to reduce cost and development cycle times should reference initial F-35 program plans and associated lessons learned.
- The cost of software sustainment continues to be a concern. Sustaining multiple hardware configurations of fielded aircraft, while managing developmental and operational test fleets with updated hardware to support the production of new lot aircraft, will continue to strain limited Service budgets.
- DOT&E cited concerns with the overall schedule of development, testing, and fielding of Block 4 capabilities, along with the supporting test infrastructure and resources in the Block 4 TEMP approval memo. The Services and F-35 JPO OT representatives developed a tail-by-tail accounting of OT aircraft, and identified critical modifications to OT aircraft, instrumentation, and other test infrastructure requirements (i.e., USRL, Online Knowledge Management, and JSE hardware upgrades). However, these requirements are not fully funded, programmed, or scheduled for completion by the F-35 JPO in time to support the DT, integrated DT/OT, and dedicated OT periods in the current C2D2 schedule. Additionally, DOT&E identified six requirements that must be addressed for approval of the Increment 2 Annexes:
  - The program must fully fund, develop, and update the detailed plan to modify all OT aircraft with the capabilities, life limit, and instrumentation, including OABS requirements necessary to accomplish OT events in support of the relevant program delivery schedules.
  - A 30-day demonstration of flight operations without ALIS connectivity must be scheduled to be completed by mid-CY21.
  - Collaborative government/contractor cybersecurity testing of the contractor-based supply chain must be scheduled for completion by mid-CY21.
  - The program must 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, including mission planning, operational mission data, Joint Technical Data and support systems, prior to release to the warfighter.
  - The Scope and Prioritization of Cyber Test Resources for Evaluation process for Block 4 cyber test prioritization must be defined and included in TEMP Increment 2 documentation.
  - The program must conduct an OT Readiness Review for dedicated OT of Block 4 capabilities, which is estimated to begin in late CY20, based on the associated Air System Playbook plan.
- Adequate operational testing will require mission-level evaluations of Block 4 capabilities. These evaluations will require the continued use of OABS instrumentation, RSEs, and the JSE.
  - As proven during F-35 IOT&E testing, the OABS capability is essential to accurately evaluate complex mission trials. DOT&E coordinated the program management function and funding for OABS to reside with the USD(R&E) Test Resource Management Center (TRMC).
    - The F-15C/D/E, F-16 Block 30, F/A-18E/F, EA-18G, and F-22 also have OABS capability, several of which have supported F-35 OT.
    - Going forward, operational testing of the F-22 Release 1 capability, F-15EX and F-16 Block 40/50 upgrades, along with the need to leverage combat air forces and fleet fighter aircraft as a resource for both blue support and adversary air, will continue to require use of OABS in each of the aforementioned aircraft.
  - The RSEs emulate modern air defense radars that are otherwise not available to support testing. Upgrades to, and reprogramming of, the RSEs must continue to be supported by the program. The Service range program managers in coordination with the U.S. Operational Test Team (UOTT) and DOT&E should fully fund new RSEs, as well as upgrades to the RSEs and OABS systems, to meet adequate test requirements for each C2D2 release of capability.
  - The use of the F-35 JSE will continue to be a critical part of an adequate evaluation of F-35 Block 4 combat capabilities. The government JSE team, composed of participants of the F-35 JPO and of Naval Air Systems Command, remains responsible for development and delivery of the F-35 JSE for developmental and operational testing. Use of the JSE for adequate testing of near-term Block 4 capabilities is planned for the 30R09 and each 6-month release thereafter.

Joint Simulation Environment (JSE)

Activity

- Originally slated to be operational by the end of CY17 to support IOT&E spin-up and testing, the JSE encountered significant contractual and developmental delays and is not expected to be ready for IOT&E trials until mid-to-late CY21.
- The JSE physical facilities (i.e., cockpits, visuals, and buildings) and synthetic environment (i.e., terrain, threat, and target digital models) are present; however, full integration and tuning of the F-35, along with other threat and weapon models, are not yet complete.
- The JSE team is preparing to host formal events leading up to IOT&E trials. During those events, the JOTT will man and operate the JSE as they plan for scored trials to assess their scenarios and processes, train test conductors and threat operators, and ensure data integrity in preparation for IOT&E. Those formal events, originally planned to begin in May 2020, have slipped multiple times into CY21 due to continued integration problems and COVID-19 impacts.
- Due to these problems, the F-35 JPO is rebaselining the JSE schedule to account for the delays and incorporate an additional set of full system tests to ensure readiness for the formal events.

Assessment

- In spite of clear requirements for an F-35 simulation to complete IOT&E, the program continued to struggle throughout most of CY20 to complete JSE development and required preparations for test trials in CY20, already 3 years later than originally planned. Completion of IOT&E and the report will occur following successful completion of the required 64 IOT&E trials in the JSE, now expected to occur in mid-to-late CY21.
- The government-led JSE team made progress in early CY20 completing integration of the F-35 In-A-Box model into the high-fidelity threat environment, both of which are likely to meet requirements for IOT&E. However, development and integration testing intended to discover deficiencies in test execution processes were hampered by COVID-19 restrictions and continued problem discoveries.
- During assessments in mid-CY20, the JOTT noted significant progress in simulator stability, simulator operations, data collection processes, and facilities. However, problems involving the interaction of several models persisted and were difficult to solve with disparate teams unable to travel. By fall 2020, reduced travel restrictions allowed more integrated approaches and discrepancies were being addressed at a good rate. However, continued problem discoveries showed the JSE was still not maturing fast enough to meet a CY20 test-for-score timeline.
- In CY21, after completing integration, VV&A, and the for-score IOT&E trials, the JSE will be an invaluable resource for high-end training, tactics development, early pilot-vehicle interface developmental testing, and operational testing of Block 4 capabilities. To ensure it is adequate to support operational testing in Block 4, the JSE V&V processes must be continued.
- The OABS, RSEs, and other open-air test capabilities must be used to gather accurate flight test data that will be used for VV&A of the JSE. Without the open-air test data to validate the JSE, it may not be an accurate representation of installed F-35 performance and thus could provide misleading results to acquisition decision-makers, the warfighter, and Congress.
- The JSE team and other stakeholders must continue work to align F-35 JSE VV&A with the C2D2 process to ensure that the JSE is able to be accredited for test and used for training with every 6-month release. Currently, during detailed test planning for each 6-month drop of capability, there is little activity to align collection of open air flight test data for use in VV&A of Block 4 capabilities in the JSE.
- The decision to move F-35 JPO management of the JSE into the F-35 JPO Training Systems and Simulation Program Management Office is concerning in that the JSE must still have adequate fidelity to be accredited for scored OT trials to complete IOT&E.

Mission Data Load (MDL) Development and Testing

Activity

- F-35 effectiveness relies on the MDL, which is a compilation of the mission data files needed for operation of the sensors and other mission systems. The MDL works in conjunction with the avionics software and hardware to drive sensor search behaviors and provide target identification parameters. This enables the F-35 avionics to identify, correlate, and respond to sensor detections, such as threat and friendly radar signals.
- The USRL at Eglin AFB, Florida, creates, tests, and verifies operational MDLs – one for OT and training, and one for each potential major geographic area of operation, called an area of responsibility (AOR). The OT and fielded aircraft use the applicable USRL-generated MDLs for each AOR.
- Testing of the USRL MDLs is an operational test activity on DOT&E oversight. During SDD, test plans included laboratory as well as flight testing of the MDL on OT aircraft. The F-35 JPO recently reduced or eliminated funding support for flight testing of new MDLs, essentially reducing testing to inadequate laboratory venues only.
- As a part of their organizational restructuring, the F-35 JPO created a Combat Data Systems Program Management Office to address fiscal and organizational challenges in developing mission data for all U.S., partner, and foreign military sales countries, particularly under the rapid, 6-month cycle of product development in Block 4.

Assessment

- Because MDLs are software components essential to F-35 mission capability, the DOD must have a reprogramming lab that is capable of rapidly creating, testing, and optimizing MDLs, as well as verifying their functionality under stressing conditions representative of real-world scenarios.

- The USRL still lacks adequate equipment to be able to test and optimize MDLs under conditions stressing enough to ensure adequate performance against current and future threats in near-peer combat environments.
  - As DOT&E has reported in the past, the USRL lacks a sufficient number of high-fidelity radio frequency signal generator channels, which are used to stimulate the F-35 electronic warfare (EW) system and the radar with simulated threat radar signals. While some improvement has been made, additional improvements, above and beyond those currently planned, are required. Also, some of the USRL equipment lacks the ability to accurately pass the simulated signals to the F-35 sensors in a way that replicates open-air performance.
  - In 2019, both USRL mission data test lines were upgraded from three to eight high-fidelity signal generator channels. Eight high-fidelity channels per line represent a substantial improvement, but are still far short of the 16-20 recommended in the F-35 JPO's own 2014 gap analysis.
- The reprogramming lab must also be able to rapidly modify existing MDLs because frequent changes in threat capabilities, based on new intelligence data, require updated MDLs.
  - Reprogramming tools continue to be unique to specific software builds and are cumbersome to use.
  - This situation improved some in 2018 with the delivery of a new Mission Data File Generation tool set from the contractor, but additional improvements are still necessary for the tools to fully meet expectations.
- Significant additional investments are required now for the USRL to support F-35 Block 4 MDL development. The current lab infrastructure is not keeping pace with the planned 6-month delivery of aircraft software and the large number of operational MDLs for different geographic regions. Based on future Block 4 capabilities, the USRL will only continue to fall further behind program deliveries.
  - To provide mission data for the aircraft with new avionics hardware in the Block 4 configuration, the new avionics hardware is also required in the USRL. After the development program enters the Block 4, 40 Series phase, the previously fielded F-35 Block 4, 30 Series configurations will also continue to need support indefinitely (i.e., until a specific configuration is modified or retired). These fielded configurations include aircraft with TR-2 processors, 30 Series software, and the original EW system; TR-2 aircraft with new EW equipment called the Digital Channelized Receiver Techniques Generator and Tuner Insertion Program in Lot 11 and later aircraft; and possibly an additional TR-2 configuration with new display processors. Adequate plans for supporting all these configurations are not in place.
  - In order to support the planned Block 4, 40 Series capability development timeline, the Block 4 hardware upgrades for the USRL should have already been on contract. However, as of this report, the requirements for the Block 4 software integration lab and USRL have yet to be fully defined.

Static Structural and Durability Testing

Activity

- Teardown inspections of the F-35A full scale durability test article (AJ-1) completed in July 2019. The F-35A Durability and Damage Tolerance (DADT) report was released in August 2020.
- Teardown inspections of the original F-35B full scale durability test article (BH-1) completed in October 2018. The program canceled third lifetime testing of BH-1 due to the significant amount of discoveries, modifications, and repairs to bulkheads and other structures that caused the F-35B test article to no longer be representative of the wing-carry-through structure in production aircraft. Release of the DADT report on BH-1 was expected in November 2020, but has been delayed to 2021. The program secured funding and contracted to procure another F-35B ground test article, designated BH-2, which will have a redesigned wing-carry-through structure that is production-representative of Lot 9 and later F-35B aircraft. Contract actions for BH-2 were completed in November 2019 and testing of the first lifetime is scheduled to begin in 1QFY24. The BH-2 ground test article will come from Lot 15 production.
- Disassembly and teardown of the F-35C durability test article (CJ-1) completed in November 2019. The program stopped testing during the third lifetime testing in April 2018, following the discovery of more cracking in the Fuselage Station (FS) 518 Fairing Support Frame. The cracking was discovered near the end of the second lifetime and required repairs before additional testing could proceed. After estimating the cost and time to repair or replace the FS 518 Fairing Support Frame, coupled with other structural parts (i.e., fuel floor segment, bulkheads FS 450, FS 496, FS 556, and front spar repair) that had existing damage, the program determined that the third lifetime testing would be discontinued. Release of the DADT report on CJ-1 was expected in November 2020, but has been delayed to 2021.

Assessment

- For all F-35 variants, structural and durability testing during SDD led to significant discoveries requiring repairs and modifications to production designs, some as late as Lot 12 aircraft, and retrofits to fielded aircraft.
- Based on durability test data, there are several life-limited parts on early production F-35 aircraft that require mitigation. In order to mitigate these durability and damage tolerance shortfalls, the program plans to make modifications to these early production aircraft, including the use of laser shock peening to increase fatigue life for specific airframe parts on the F-35B (i.e., bulkheads). The F-35 JPO will also continue to use individual aircraft tracking of actual usage to help the Services project changes in timing for

required repairs and modifications, and to aid in fleet life management.
- Although the program planned for a third lifetime of testing to accumulate data for life extension, if needed, the program has no plan to procure another F-35C ground test article.

Availability, Reliability, and Maintainability

F-35 Availability

Activity

- As of the end of September 2020, 563 aircraft have been produced for the U.S. Services, international partners, and foreign military sales. These aircraft are in addition to the 13 aircraft dedicated to developmental testing.
- The following assessment of fleet availability, reliability, and maintainability is based on sets of data collected from the operational, test, and training units and provided by the F-35 JPO. The assessment of aircraft availability is based on data provided through the end of September 2020. Reliability and maintainability (R&M) assessments in this report are based on data covering the 12-month period ending April 30, 2020. Data for R&M 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. The differences in data sources and processes create an apparent disparity in dates for the analyses in this report.
- In March 2020, the program set a baseline Mission Capable (MC) rate goal of 70 percent and a Full Mission Capable (FMC) rate goal of 40 percent for the whole fleet to attain by September 2020. Additionally, the program set elevated MC and FMC goals for units that were training to deploy of 75 percent and 60 percent, respectively, and even higher MC and FMC goals of 80 percent and 70 percent, respectively, for units that were in a deployed status. The MC rate represents the percentage of unit-assigned aircraft capable of performing at least one defined mission, excluding those aircraft in depot status or undergoing major repairs. MC aircraft are either FMC, meaning they can perform all missions assigned to the unit, or Partial Mission Capable (PMC), meaning they can fly at least one, but not all, missions. The MC rate is different than the availability rate, which is the number of aircraft capable of performing at least one mission divided by all aircraft assigned, including aircraft in depot status or undergoing major repairs.

Assessment

- The operational suitability of the F-35 fleet remains at a level below Service expectations, but has shown improvement in several metrics. After several years of remaining stable or only moving within narrow bands, several key suitability metrics began to show signs of slow, but continuous, improvement in CY19, a trend that continued into early CY20, but then became more ambiguous and variable by mid-year.
- 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 2020.
  - For this report, DOT&E is reporting availability rates only for the U.S. fleet, vice including international partner and foreign military sales aircraft, as was done in previous reports.
- The average fleet-wide monthly availability rate for only the U.S. aircraft (includes all aircraft categories – those designated for combat, training, and operational test and tactics development), for the 12 months ending September 2020, is below the target value of 65 percent. The DOT&E assessment of the trend shows evidence of slight overall improvement in U.S. fleet-wide availability from 2019 through at least early 2020, followed by an extended period of no clearly discernible trend. Monthly availability surpassed the target value of 65 percent for the first time ever in 2020, and peaked in April at an all-time program high, but it has been as much as 9 percent lower than the all time high since then.
- The combat coded fleet of aircraft are assigned to units that can deploy for combat operations; the training fleet for new F-35 pilot accession; and the test fleet for operational testing and tactics development. The proportion of the fleet that is combat coded has risen steadily over time, and was a little less than half of the whole U.S. fleet over the period considered. Consistent with prior annual reports, the combat coded fleet, which has the newest aircraft on average, demonstrated the highest availability and achieved the 65 percent target for monthly average availability for the 12 months ending in September 2020.
- Aircraft that are not available are designated in one of three status categories: Not Mission Capable for Maintenance (NMC-M), Depot (in the depot for modifications or repairs beyond the capability of unit level squadrons), and Not Mission Capable for Supply (NMC-S).
  - The average monthly NMC-M and Depot rates were relatively stable, with little variability, and near program targets. Both rates were slightly worse than program targets, however, with the NMC-M rate slightly farther off the goal than the Depot rate. Additional focused maintenance system improvements are needed, especially for common processes that are distributed amongst many different NMC-M drivers, such as low observable repairs and adhesive cure times.
  - After significant investment by the program on spare parts, the average monthly NMC-S rate was more variable, but continued to improve until reaching program target levels in September 2020. This improvement was largely responsible for the corresponding improvement in fleet-wide availability. Alternate sources of repair (including organic repair) for current and projected NMC-S drivers are needed to sustain this improvement.
- The average monthly utilization rate can be measured in either flight hours or sorties per aircraft per month. For this report, DOT&E is using flight hours per aircraft per month.

The average utilization rate for the whole fleet overall increased slightly over previous years, but remains below original Service plans. However, this improvement was due entirely to an increase in utilization of the F-35A fleet, and was particularly concentrated within the combat-coded portion of the F-35A fleet.

- Low utilization rates continue to prevent the Services from achieving their full programmed fly rates, which are the basis of flying hour projections and sustainment cost models. For the 12 months ending in September 2020, the average monthly utilization rate for the whole U.S. fleet was 19.6 flight hours per aircraft per month. For the F-35A, it was 20.6 flight hours; the F-35B was 14.6 flight hours; and the F-35C was 23.1 flight hours. This compares to Service plans from 2013, which expected F-35A and F-35C units to execute 25 flight hours per aircraft per month and F-35B units to execute 20 flight hours per aircraft per month to achieve Service goals.

- DOT&E conducted a separate availability analysis of the OT fleet of aircraft, using data from the 20-month period beginning December 2018, when formal IOT&E started, through July 2020. This assessment accounts for the full complement of 23 U.S. and international partner aircraft assigned to the OT fleet at the end of September 2019 (eight F-35A, nine F-35B, and six F-35C).
  - The average monthly availability rate for F-35 OT aircraft was below the planned 80 percent needed for efficient conduct of IOT&E. However, judicious maintenance planning, test range scheduling, and effective mission execution allowed the JOTT to execute trials at a quicker pace than planned for worst-case scenario projections.
- The MC and FMC rates of the whole U.S. fleet followed a similar trend as availability, improving slightly in 2020.
  - Both the combat coded and the OT aircraft, including those used by tactics development, achieved an average monthly MC rate at or surpassing the 70 percent baseline MC rate goal the program set for all units. However, neither the training fleet nor the entire U.S. F-35 fleet as a whole met this goal.
  - The U.S. F-35A variant-specific fleet met the 70 percent MC rate goal, but neither the F-35B nor the F-35C fleets did.
  - Overall, FMC rates still lag MC rates by a large margin, indicating relatively low readiness for the mission sets requiring fully-capable aircraft (i.e., versus near-peer threats).
  - The fleet-specific trends were very similar relative to the program-set 40 percent baseline goal. The combined (i.e., all variants) combat coded and OT fleets (including aircraft dedicated to tactics development), and the F-35A fleet met or surpassed this FMC rate goal. However, the overall fleet, the combined training fleet, and the F-35B and F-35C fleets did not.
  - While all three F-35 variants exhibited MC rates within a relatively tight band, which all increased slowly throughout 2020, the FMC rates between each variant were widely dispersed and diverged in 2020.
  - Almost all FMC growth was concentrated in the F-35A fleet, which exhibited FMC performance far in exceedance of the F-35B and F-35C variants. The F-35B fleet actually saw a decline in its FMC rate over the period, but it still maintained a higher FMC rate than the F-35C, which showed a stagnant trend at a very low rate between 2019 and 2020.
- Individual deployed units met or exceeded the 80 percent MC rate and 70 percent FMC rate goals on occasion, but were not able to meet these goals on a sustained basis.

F-35 Fleet Reliability

Activity

- The F-35 program developed reliability growth projection curves for each variant throughout the development period as a function of accumulated flight hours. These projections compare observed reliability with target numbers to meet the threshold requirement at maturity (200,000 total F-35 fleet flight hours, with a minimum of 50,000 flight hours per variant). In the program's reliability growth plan, the target flight hour values were set at 75,000 flight hours each for the F-35A and F-35B, and 50,000 flight hours for the F-35C to establish the 200,000 flight hours of fleet maturity. The F-35A fleet reached 75,000 flight hours in July 2018 and had not reached ORD thresholds for reliability and maintainability at the time. DOT&E is continuing to track the following metrics beyond the flight hours required for maturity of the F-35A fleet for reporting purposes. As of April 30, 2020, the date of the most recent set of reliability data available, the fleet and each variant accumulated the following flight hours, with the percentage of the associated hour count at maturity indicated:
  - The complete F-35 fleet accumulated 232,885 flight hours, or 116 percent of its maturity value.
  - The F-35A accumulated 146,452 hours, or 195 percent of its target value in the reliability growth plan.
  - The F-35B accumulated 56,529 hours, or 75 percent of its target value in the reliability growth plan.
  - The F-35C accumulated 29,904 hours, or 60 percent of its target value in the reliability growth plan.
- The program reports reliability metrics for the three most recent months of data. This rolling 3-month window dampens month-to-month variability while providing a short enough period to distinguish current trends.

Assessment

- Aircraft reliability assessments include a variety of metrics, each characterizing a unique aspect of overall weapon system reliability.
  - Mean Flight Hours Between Critical Failure (MFHBCF) includes all failures that render the aircraft unsafe to fly or would prevent the completion of a defined F-35 mission.

- Mean Flight Hours Between Removal (MFHBR) indicates the degree of necessary logistical support and is frequently used in determining associated costs.
- Mean Flight Hours Between Maintenance Event Unscheduled (MFHBME_Unsch) is a reliability metric for evaluating maintenance workload due to unplanned maintenance.
- Mean Flight Hours Between Failure, Design Controllable (MFHBF_DC) includes failures of components due to design flaws under the purview of the contractor.

- Table 2 shows the trend in each reliability metric by comparing values from April 2019 to those of April 2020 and whether the current value is on track to meet the requirement at maturity.

TABLE 2. F-35 RELIABILITY METRICS (UP ARROW REPRESENTS IMPROVING TREND)

Variant	Flight Hours for ORD or JCS Threshold	Assessment as of April 30, 2020												
		Cumulative Flight Hours	MFHBCF (hours)			MFHBR (hours)			MFHBME (hours)			MFHBF_DC (hours)		
			ORD Threshold	Change: Apr 2019 to Apr 2020	Meeting Interim Goal for ORD Threshold	ORD Threshold	Change: Apr 2019 to Apr 2020	Meeting Interim Goal for ORD Threshold	ORD Threshold	Change: Apr 2019 to Apr 2020	Meeting Interim Goal for ORD Threshold	JCS Requirement	Change: Apr 2019 to Apr 2020	Meeting Interim Goal for JCS Threshold
F-35A	75,000	146,452	20	↑	No	6.5	↑	Yes	2.0	↑	Yes	6.0	↑	Yes
F-35B	75,000	56,529	12	↑	Yes	6.0	↑	No	1.5	↑	Yes	4.0	↑	Yes
F-35C	50,000	29,904	14	↑	Yes	6.0	↑	No	1.5	↑	Yes	4.0	↑	Yes

- Between April 2019 and April 2020, all nine of the ORD metrics increased in value, some to a historically unprecedented degree for the program. As a result, in April 2020, six of the nine ORD metrics were at or above their requirement or interim growth goal based on the program's reliability growth plan, whereas in April 2019, none were. Similarly, all three of the JSF Joint Contract Specification metrics increased.
- The cause of these rapid increases in reliability are still under investigation, and likely not due entirely to the proliferation of new, redesigned hardware components throughout the fleet. Preliminary research shows that some of the reliability increases are concentrated almost entirely within certain production lots, which are not necessarily the most recent lots. The lots that exhibited the increased reliability performance also tended to be the lots that made up the bulk of the deployed aircraft over the time period considered. These deployed aircraft flew considerably longer missions during the deployments, and accrued flight hours at a much higher rate than the non-deployed aircraft. This change in usage may partly explain some of the reliability increases. Software changes are also a candidate driver for reliability improvements, but investigations of root causes are currently inconclusive.

Maintainability

Activity

- The program reports maintainability metrics for the three most recent months of data. This rolling 3-month window dampens month-to-month variability while providing a short enough period to distinguish current trends.

Assessment

- The amount of time needed to repair aircraft and return them to flying status has changed little over the past year, and remains higher than the requirement for the system at maturity. The program assesses this time with several measures, including Mean Corrective Maintenance Time for Critical Failures (MCMTCF) and Mean Time To Repair (MTTR) for all unscheduled maintenance. Both measures include "active touch" labor time and cure times for coatings, sealants, paints, etc., but do not include logistics delay times, such as how long it takes to receive shipment of a replacement part.
- Table 3 shows the nominal change in each maintainability metric by comparing values from April 2019 to those of April 2020. While nominally five of six metrics improved, the improvements were minor and longer term trend analyses

show no significant improving or worsening trend in maintenance times.

- All mean repair times are longer, some up to more than twice as long, as their original ORD threshold values for maturity, reflecting a heavy maintenance burden on fielded units.
- The F-35 JPO, after analyzing MTTR projections to maturity, acknowledged that the program would not meet the MTTR requirements defined in the ORD. The F-35 JPO sought and gained relief from the original MTTR requirements. The new values are 5.0 hours for both the F-35A and F-35C, and 6.4 hours for the F-35B. This will affect the ability to meet the ORD requirement for Sortie Generation Rate (SGR), a Key Performance Parameter.

TABLE 3. F-35 MAINTAINABILITY METRICS (DOWN ARROW REPRESENTS IMPROVING TREND)

Variant	Flight Hours for ORD Threshold	Assessment as of April 30, 2020						
		Cumulative Flight Hours	MCMTCF (Hours)			MTTR (Hours)		
			ORD Threshold	Change: Apr 2019 to Mar 2020	Meeting Interim Goal for ORD Threshold	ORD Threshold	Change: Apr 2019 to Mar 2020	Meeting Interim Goal for ORD Threshold
F-35A	75,000	142,094	4.0	↓	No	2.5	↓	No
F-35B	75,000	55,428	4.5	↑	No	3.0	↓	No
F-35C	50,000	29,130	4.0	↓	No	2.5	↓	No

ALIS

Activity

- ALIS activity in 2020 centered on stabilizing ALIS with several releases of ALIS 3.5. The program completed testing during flight operations with ALIS 3.5 in October 2019, but only fielded it at Nellis AFB, Nevada. ALIS 3.5.1 flight operations testing completed in December 2019 and was fielded to four sites in early 2020 before ALIS 3.5.2 completed flight operations testing in January 2020. After that, most sites received ALIS 3.5, 3.5.1, and 3.5.2 simultaneously, with fielding completed in the summer of 2020.
- Content in these updates includes the following.
  - ALIS 3.5 enhancements included the alignment of mission capable status across ALIS applications, correcting deficiencies in time accrual associated with Production Aircraft Inspection Reporting System (PAIRS) processing, and improvements in the Low Observable Health Assessment System.
  - ALIS releases 3.5.1 and 3.5.2 included display improvements so users could more easily view the overall assessment of aircraft status with reduced user workload. This allows maintainers to view Health Reporting Codes (HRCs) and work orders on one screen, see prioritized groupings of HRCs, view the missions available and unavailable for each aircraft depending on its maintenance status. The improvements also provide a direct link between ALIS applications to streamline HRC submission options, allow bulk sign-off of multiple maintenance actions at one time, and loading of multiple weapons stations using a single work order.
- In May 2020, the planned first quarter ALIS update at Edwards AFB, California, was evaluated by the developmental test team, which recommended the program not release it to the fleet due to the presence of a Category 1 deficiency affecting the software data load. Delays in development and flight test, due in part to COVID-19 restrictions, caused the program to delay release of this update until it could be released concurrently with the second quarter update. Additionally, both quarterly updates required rebuilding the Portable Maintenance Aids (PMAs) and the program elected to combine the releases to reduce the administrative burden of rebuilding the PMAs twice. The program originally planned an August 2020 fielding for both (now concurrent) updates.
  - Content in this combined update includes modernized alternate mission equipment (AME) and weapons management, technology upgrades, Internet Explorer 11 on servers, improved end-of-life support for baseline products, security improvements, improved Customer Relations Management validation, user notification of Distribution Tracking Record (DTR) packages, and usability improvements in the Customer Maintenance Management System (CMMS), which is the application line maintainers use most often. It also addresses 17 of the documented issues that frequently burden maintainers. Usability improvements include navigation, page configuration persistence, and table usage.
- The program also released an urgent fix, ALIS 3.5.2.2, during the summer of 2020 to address a deficiency in the onboard Full Authority Digital Engine Control (FADEC) software – which is the software that converts pilot inputs to engine control – that resulted in ALIS generating up to 40 HRCs during each maintenance debrief. This high rate of HRC recordings was roughly 10 times the normal number. The urgent fix in ALIS 3.5.2.2 filtered the large number of nuisance codes generated by the deficient FADEC software.
- Testing of the planned second quarter ALIS update began July 27, 2020. During flight operations and testing on

the Operationally Representative Environment (ORE), two Category 1 deficiencies were identified. To address the Category 1 and some Category 2 deficiencies, the program installed software fixes on August 14 and 15, 2020. However, flight operations and ORE testing determined that the updates resulted in problems with the Electronic Equipment Logbook (EEL) viewer and the install tool, and that the release required too many manual workarounds to recommend release to the field. After adding software fixes, the program completed a third round of flight operations and ORE testing in early October 2020. The program planned to install the combined first and second quarter updates at Nellis AFB in October 2020 and release it to the fleet in November 2020.
  - Content of the second quarter update includes an auto-loader that allows ALIS administrators to simultaneously complete baseline software installations on up to 24 PMAs, a wireless barcode scanner that improves the supply chain receipt process, Windows 10 upgrade, and improvements in system security. Usability improvements include better PMA synchronization with Standard Operating Units (SOU), automation in DTR workflow, and improvements in the PAIRS air vehicle transfer process related to parts management.
- In October 2020, the program indicated that it would combine the third and fourth quarterly ALIS updates, thus planning to release two updates in 2020 instead of the four planned, with release of the second update occurring approximately 45 days after the first. The program planned to begin flight test of the combined release in December 2020 with fleet release expected in February 2021.
  - Content of the third quarterly update now prioritizes correction of more deficiencies identified by the users, including PAIRS handling of EELs, synchronization of PMAs with the Maintenance-Vehicle Interface, workflow handling of Time Compliance Technical Directives and deferred work orders, and the transfer of air vehicle data between SOUs. The fourth quarterly update also focuses on improving ALIS cybersecurity. The program also plans to release a capability allowing maintainers to print technical data from PMAs or workstations.
- The Integrated Test Force (ITF) at Edwards AFB stood up an unclassified SOU. Although DOT&E has recommended this for a number of years and it does expand the ability of the ITF to test ALIS capabilities, the ITF and ORE cannot test all ALIS capabilities using operationally representative quantities of data, as would be available from operational or OT units. The ITF has limited ability to process classified data, while the ORE cannot process any classified material. For this reason, ALIS releases recommended for fielding are generally tested at Nellis AFB before enterprise-wide fielding.

Assessment

- Although the program has released several versions of ALIS 3.5 in 2020, the program has not been able to generate quarterly updates as planned. While some delays are attributable to restrictions imposed by COVID-19, others are related to overall software quality and stability. Each delay in a quarterly release has had a waterfall effect on those following it. Improvements contained within ALIS 3.5 releases include enhanced ALIS stability and usability, decreased aircraft debrief times and improvements in EELs inductions, bulk work order sign-off, and AME single work orders, all of which have reduced maintainer workload.
- Although testers responded positively to specific usability and functionality improvements during flight test operations, operational units have provided limited feedback and there is no indication that the ALIS user community has eliminated workarounds.
- Most improvements in ALIS have not eliminated long-standing issues with data quality and integrity which continue to burden maintenainers and ALIS administrators, and is a primary source of workarounds. Although the program has begun to address data quality issues in general (after 8 years of issues), and EELs in particular, more improvements are needed before maintainers will establish trust in ALIS.
- The program has not prioritized a long-standing request from maintainers to provide a mature, easily readable, illustrated parts breakdown for the F-35, such as the Identify-Location tool, that supports CMMS.
- The program has not demonstrated the capability to develop, integrate, test, and release ALIS quarterly updates without also causing significant software stability problems and breaking capabilities that already worked. Although hindered by COVID impacts to personnel availability, DOT&E expects these problems to persist due to flawed software development processes and inherent software stability issues. In October 2020, the program indicated it plans to streamline the contractual vehicle for ALIS so that all phases of development, test, and fielding are covered by one contract. Currently, the program uses separate contracts for development, test, and fielding.
- Unit maintenance personnel rely on PMAs to conduct daily maintenance tasks. PMA availability is not currently tracked at the unit level, which often adds to workload for ALIS users to track down usable PMAs. As PMAs age, PMA tracking becomes more important.
- The JOTT administered ALIS usability surveys to support assessments of ALIS for IOT&E. These surveys provide valuable data and feedback for improving what has been a chronic issue with ALIS at the unit level.
- The program does not have a single operationally representative venue that allows development and testing (to include cybersecurity testing) of ALIS software to improve the quality of hardware and software while decreasing the time required to so.
- Although planned to do so, the program did not transition the ORE to Hill AFB, Utah, in 2020. Instead, the stand up of the ORE at Hill AFB was delayed until the ORE could support ODIN tesitng.

- The program conducted a test of the National ALIS/ODIN Support Center (NASC) at Luke AFB, Arizona. The NASC is intended to decrease the burden on unit-level ALIS administrators by providing centralized administration. The program has not released a report on the results but has indicated that the test successfully completed tasks normally completed by unit-level ALIS administrators in a manner that was transparent to affected units.

ODIN

Activity

- A new F-35 program initiative called ODIN combines efforts from the ALIS Next program, Mad Hatter project from the Air Force's Kessel Run office, and Lockheed Martin's independently funded research and development. ODIN is being led by the F-35 JPO and is designed by the Air Force's Kessel Run office, 309th Software Engineering Group, and the Naval Information Warfare Center, with supporting contracts with Lockheed Martin for data, software, and hardware development. Contracts with Pratt & Whitney are in work to provide the necessary engine data for ODIN.
- ODIN's IOC objective is September 2021 with FOC full system deployment by the end of December 2022. ODIN is planned to be released in multiple stages through agile software development in a cloud environment.
- ODIN will require new hardware and software applications throughout the entire JSF enterprise.
- The ODIN effort requires a number of artifacts to use the Adaptive Acquisition Framework in the September 2020 release of the DoDD 5000.01 and January 2020 release of the DoDI 5000.02. To date, the Capability Needs Statement (CNS) and User Agreement (UA) were submitted to DOT&E for review and comment and both documents were undergoing final signature process within F-35 JPO channels. One of the required documents for this process, the Test Strategy, had not yet been provided to DOT&E.
- A number of candidate hardware solutions have been prototyped to host the ODIN software at the squadron level. These solutions fall into two categories: the ODIN Base Kit (OBK) and the ODIN Deployment Kit (ODK).
- An ODK is being fabricated currently at Lockheed Martin with initial hardware demonstrations planned at Patuxent River Naval Air Station in November, 2020. The candidate OBK is currently at Marine Corps Air Station (MCAS) Yuma, Arizona, undergoing operational testing as a replacement for its squadron-level SOU. This hardware was hosting ALIS 3.5.2.2 as a surrogate for ODIN and to demonstrate interoperability in the transition period between the two programs.
- The program transferred air vehicle data from the squadron SOU to the OBK using a stand-alone Lockheed Martin tool.
- The program has identified several gaps in ODIN development, including immature or non-existent test, acquisition, architecture design, ALIS to ODIN transition, and cloud implementation strategies.

Assessment

- ODIN development is designed around the Adaptive Acquisition Framework, a process codified in formal DoD Instructions. Although the program has two key planning documents in signature coordination – the CNS and UA – other key strategy documents, including an overarching test strategy, has not been provided to DOT&E. Without a roadmap for testing, the DOD will not have an adequate assessment of the overall system development and operational suitability.
- The ODIN software and hardware deployment schedules are even more aggressive and less-defined than the accelerated quarterly ALIS software releases. The schedule for fielding ODIN is high risk.
- The accelerated ODIN software and hardware deployments demonstrated to date appeared to have limited developmental testing and associated test reporting. The lack of ODIN developmental testing may leave system and design flaws undiscovered until after release to the field, requiring significant rework and patching.
- Feedback from users involved in ODIN development is being sought early in the process, but is only being gathered from small audiences, partly for expediency, and partly due to COVID-19 travel restrictions. Including as many users as early as possible in the development process is intented to prevent changes to features of the software required by other users from other Services.
- The gaps in development identified by the program, coupled with limited resources within the JPO, will continue to make the plan to field a fully functional ALIS replacement in September 2021 high risk.

Live Fire Test and Evaluation

F-35 Vulnerability to Kinetic Threats

Activity

- In April 2018, Lockheed Martin delivered the F-35 Vulnerability Assessment Report summarizing the force protection and vulnerabilities of all three F-35 variants, and the F-35 Consolidated LFT&E Report, which summarizes the live fire test and analysis efforts supporting the vulnerability assessments.

Assessment

- DOT&E will publish an independent evaluation of the vulnerabilities of the F-35 aircraft variants to expected and emerging threats in the combined IOT&E and LFT&E report to support the Full-Rate Production decision.

F-35 Vulnerability to Unconventional Threats

Activity

- In FY20, the Naval Air Warfare Center Aircraft Division at Pax River completed system-level testing of the F-35B variant to evaluate tolerance to electromagnetic pulse (EMP) threats.

- To assess the protection capability of the Generation (Gen) II Helmet-Mounted Display System (HMDS) against chemical-biological agents, the JPO completed a comparison analysis of HMDS materials with those in an extensive DOD aerospace materials database.

Assessment

- System-level EMP testing was done to the 6 decibel threat level defined in Military Standard 2169B. Only minor, recoverable system upsets were recorded.
- To assess the protection capability of the Gen II HMDS against chemical-biological agents, the JPO completed a comparison analysis of HMDS materials with those in an extensive DOD aerospace materials database. Analysis shows that the materials used in the F-35 protective equipment can survive exposure to chemical agents and decontamination processes; however, the decontamination process of the HDMS has not been demonstrated and must be tested as part of Block 4 testing.

F-35 Gun Lethality

Activity

- The Air Force delivered two reports to DOT&E detailing the ground and air-to-ground lethality tests.
- The Navy is completing the analysis for air-to-ground engagement gun burst lethality.

Assessment

- DOT&E will provide an independent F-35 gun lethality assessment after the Navy completes the analysis for air-to-ground engagement gun burst lethality against the remaining ground targets as specified in the LFT&E Strategy to support the Full-Rate Production decision.

Cybersecurity Operational Testing

Activity

- The JOTT continued to accomplish testing to support IOT&E based on the cybersecurity strategy approved by DOT&E in February 2015.
- The JOTT conducted cybersecurity weapons interface testing of the F-35 air vehicle (AV) in July 2019 and July 2020 at the Lockheed Martin Mission System Integration Laboratory (MSIL) in Fort Worth, Texas. A test team from Naval Air Station (NAS) Point Mugu, California, provided technical support and tools for the test.
- The JOTT conducted cybersecurity testing of F-35 AV navigation systems in July 2019 at the MSIL, and follow-on F-35 AV navigation testing in April 2020 in an anechoic test chamber at Pax River, Maryland. A test team from Pax River provided technical support and tools for the test.
- The JOTT conducted cybersecurity testing of F-35 AV Variable Message Format in January 2020 at Pax River. A test team from Pax River provided technical support and tools for the test.
- The JOTT conducted a limited ALIS Enterprise cooperative vulnerability and penetration assessment (CVPA) on the ORE in Fort Worth, Texas, and Edwards AFB, California, in July 2020. The JOTT completed an ALIS Enterprise adversarial assessment (AA) in October 2020.
- JOTT cybersecurity tests in 2020 were completed in accordance with their individual, DOT&E-approved test plans.
- Throughout 2020, the JOTT continued to work with stakeholders across the DOD to identify relevant scenarios, qualified test personnel, and adequate resources for conducting cyber testing on AV components and support systems.
- In 2020, the F-35 JPO, JOTT, and the UOTT continued developing a test strategy for assessing cybersecurity of the JSF supply chain. The strategy is being informed by the results of a supply chain Cyber Table Top (CTT) exercise conducted in 2019, a yet to be scheduled deep dive into the overall supply chain, and agreements between the program and contractor test communities. The CTT analyzed the potential threats to two AV systems, plus the possible consequences to F-35 mission capability and suitability of a compromise of production or re-supply of select components within these systems.

Assessment

- While some cybersecurity-related system discrepancies have been resolved, cybersecurity testing during IOT&E continued to demonstrate that some vulnerabilities identified during earlier testing periods have not yet been remedied.
- Despite several successful tests to-date, more testing is needed to assess the cybersecurity of the AV. Actual aircraft, as well as appropriate hardware- and software-in-the-loop facilities, must be used to enable operationally representative AV cyber testing. To this end, the F-35 JPO arranged for an operationally representative F-35 AV at Pax River to facilitate testing in 2020 and will continue to support cybersecurity testing in 2021 and beyond.
- Testing of the JSF supply chain to date has not been adequate. Additional testing is needed to ensure the integrity of hardware and software components for initial production and sustainment of AVs and the maintenance information system, plus resupply of replacement parts. The F-35 JPO is in the process of developing a comprehensive supply chain cybersecurity test strategy that will, in conjunction with the 2019 supply chain CTT, guide future supply chain cybersecurity testing.
- Cybersecurity testing to-date identified vulnerabilities that must be addressed to ensure secure ALIS, training systems, USRL, and AV operations.
- The F-35 JPO intends to use a SecDevOps 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 OFP 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 relevance of cybersecurity

testing of the software development environments will increase.

- Per the F-35 JPO, the AV is capable of operating for up to 30 days without connectivity to ALIS via the SOU. In light of current cybersecurity threats and vulnerabilities, along with peer and near-peer threats to bases and communications, DOT&E required 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 30 days of operations. The program is currently planning for a test of the ALIS Contingency Operations Plan in 2021, which addresses standardized procedures for the lack of connectivity scenarios.

Recommendations

The program (i.e., F-35 JPO, Services, Lockheed Martin) should:

1. Complete the remaining development and VV&A of the JSE as soon as possible to enable the required IOT&E trials to be completed.
2. Fully fund new and upgrades to the RSEs, JSE, and OABS systems to meet adequate test requirements for each C2D2 release of capability.
3. Program adequate funding to develop and sustain robust laboratory and simulation environments, along with adequate VV&A plans that include the use of data from representative open-air missions in support of developmental and operational testing.
4. Per the DOT&E TEMP, Increment 1 approval memo:
   - Fully fund, develop, and update the detailed plan to modify all OT aircraft with the capabilities, life limit, and instrumentation, including OABS requirements.
   - Complete a 30-day demonstration of flight operations without ALIS connectivity by mid-CY21.
   - Complete collaborative government/contractor cybersecurity testing of the contractor-based supply chain by mid-CY21.
   - 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.
   - Define the Scope and Prioritization of Cyber Test Resources for Evaluation process for Block 4 cyber test prioritization.
   - Conduct an OT Readiness Review prior to the start of operational test periods.
5. Quickly complete development of the requirements for the Block 4 software integration lab and USRL while ensuring adequate lab infrastructure to meet the aggressive development timelines of C2D2 and the operational requirements of the Block 4 F-35, both 30 and 40 Series aircraft.
6. Continue to pursue maintenance system improvements, especially for common processes that are distributed amongst many different NMC-M drivers, such as low observable repairs and adhesive cure times.
7. Continue to resource and develop alternate sources of repair (including organic repair) for current and projected NMC-S drivers to sustain improvements in NMC-S.
8. Continue to expedite fixes to EELs.
9. Provide ALIS users with the ability to track PMA availability at the unit level.
10. Include surveys to evaluate ALIS usability during Block 4, 30 and 40 Series suitability testing.
11. Prioritize development of a mature, easily readable, illustrated parts breakdown for the F-35, such as the Identify-Location tool, based on feedback from field users.
12. Develop an overarching test strategy for ODIN hardware and software.
13. Develop a single operationally representative venue that allows development and testing (to include cybersecurity testing) of ALIS and ODIN software to improve system quality.
14. Demonstrate Gen III HMDS decontamination procedures during Block 4 testing.
15. Conduct more in-depth cyber testing of the AV and provide a dedicated AV cyber-test asset.
16. Correct program-wide deficiencies identified during cybersecurity testing in a timely manner.

Global Command and Control System – Joint (GCCS-J)

Executive Summary

- In FY20, the Global Command and Control System – Joint (GCCS-J) Program Manager sustained the existing GCCS-J v4.3 baseline and developed GCCS-J Global v6.x. The Joint Planning and Execution Services (JPES) Program Manager sustained the existing Joint Operation Planning and Execution System (JOPES) v4.3 baseline and developed JPES.
- In January 2020, the Defense Information Systems Agency (DISA) halted development of the GCCS-J Enterprise Modernization program after a yearlong effort. Moving forward, DISA plans to evolve technical capabilities and implement an enterprise-centric architecture as part of the GCCS-J v6.x program.

GCCS-J Global

- The Joint Staff and DISA sunset GCCS-J v4.3 in September 2020 prompted all users to migrate to version 6.x.
- Coronavirus (COVID-19) pandemic restrictions prevented the Joint Interoperability Test Command (JITC) from validating fixes to defects identified during previous operational testing and from determining GCCS-J v6.0.1.11 stability in the operational environment, prior to the GCCS-J v4.3 sunset.
- COVID-19 restrictions also prevented JITC from completing cybersecurity testing of GCCS-J v6.0.1.6 at U.S. Southern Command (USSOUTHCOM), Miami, Florida.

JPES

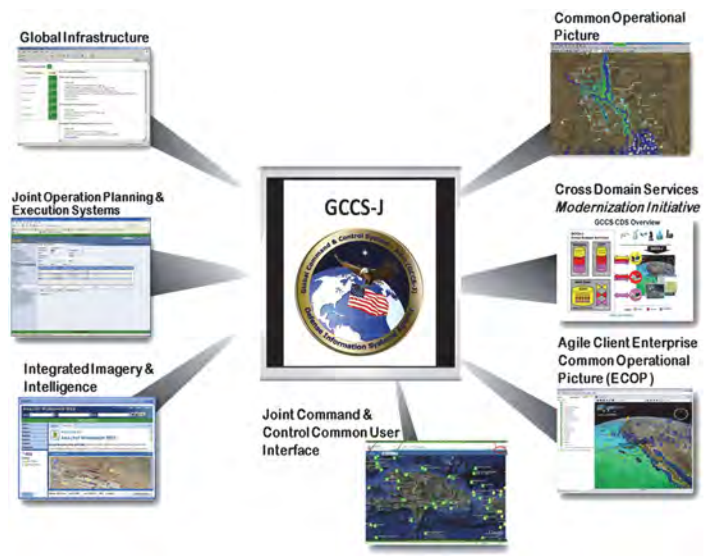
- DISA rebaselined JPES in November 2019. The Program Office plans to use "agile" software processes to develop the system.

System

GCCS-J consists of hardware, software (both commercial off-the-shelf and government off-the-shelf), procedures, standards, and interfaces that provide an integrated, near real-time picture of the battlespace that is necessary to conduct joint and multi-national operations. Its client/server architecture uses open systems standards and government-developed military planning software. GCCS-J comprises GCCS-J Global and JPES.

GCCS-J Global

- GCCS-J v6.0.1.11 is intended to provide back-end services, databases, and system administration functions. Agile Client v5.2 is intended to provide visualization and presentation of GCCS-J mission applications and functionality to the user. The Program Office is using agile development to evolve GCCS-J Global v6.0.1.11, using incremental Maintenance Releases (MRs) to expand capabilities available to the warfighter.



JPES

- DISA is developing JPES to replace the legacy JOPES v4.3 baseline. JPES provides all of the functionality of the current JOPES in a modernized architecture.

Mission

Joint Commanders use the GCCS-J to accomplish command and control.

GCCS-J Global

- Commanders use GCCS-J to:
  - Link the National Command Authority to the Joint Task Force, Combatant Commanders, and Service-unique systems at lower levels of command
  - Process, correlate, and display geographic track information integrated with available intelligence and environmental information to provide the user a fused battlespace picture
  - Provide integrated imagery and intelligence capabilities (e.g., battlespace views and other relevant intelligence) into the common operational picture and allow commanders to manage and produce target data using the joint tactical terminal
  - Provide a missile warning and tracking capability
- Air Operations Centers use GCCS-J to:
  - Build the air picture portion of the common operational picture
  - Correlate or merge raw track data from multiple sources
  - Associate raw electronics intelligence data with track data
  - Perform targeting operations

JPES

- Commanders use JPES to:
  - Translate policy decisions into operations plans that meet U.S. requirements to employ military forces
  - Support force deployment
  - Conduct contingency and crisis action planning

Major Contractors

- Government Integrator: DISA – Fort Meade, Maryland
- Software Developers:
  - Northrop Grumman – Arlington, Virginia
  - Leidos – Arlington, Virginia
  - InterImage – Arlington, Virginia
  - CSRA – Falls Church, Virginia

Activity

GCCS-J Modernization

- In January 2020, DISA halted development of the GCCS-J Enterprise Modernization program after a yearlong effort. Moving forward, DISA plans to evolve technical capabilities and implement an enterprise-centric architecture as part of the GCCS-J v6.x program.

GCCS-J Global

- The Program Office approved the following releases in FY20:
  - v6.0.1.5 MR in October 2019
  - v6.0.1.6 MR in December 2019
  - v6.0.1.7 MR in February 2020
  - v6.0.1.8 MR in May 2020
  - v6.0.1.9 MR in May 2020
  - v6.0.1.10 MR in June 2020
  - v6.0.1.11 MR in September 2020
  - v6.0.1.12 MR in September 2020
  - v6.0.1.13 MR in November 2020
- JITC conducted a cooperative vulnerability and penetration assessment of GCCS-J v6.0.1.6 at USSOUTHCOM February 5 – 14, 2020. COVID-19 restrictions prevented JITC from completing the adversarial assessment. JITC is planning to complete GCCS-J v6.x cybersecurity testing in 4QFY21.
- JITC conducted a user assessment of the JPES Collaboration Tool (JCT), a component of GCCS-J v6.0.1.11 MR, at 15 sites, August 3 – 18, 2020. DISA developed the JCT to replace the legacy NEWSGROUP capability in GCCS-J v4.3. In accordance with DOT&E policy, this low-risk upgrade warranted a level I operational test, which did not require a DOT&E-approved test plan.
- Following poor results during the user assessment, DISA removed the JCT capability from the GCCS-J v6.0.1.11 MR and extended the GCCS-J Authority to Operate to allow continued use of the GCCS-J v4.3 NEWSGROUP capability.
- The Joint Staff and DISA sunset GCCS-J v4.3 in September 2020 prompting all users to migrate to version 6.0.12.

JPES

- DISA rebaselined JPES in November 2019. The Program Office plans to use "agile" software processes to develop the system.

Assessment

GCCS-J Global

- COVID-19 restrictions prevented JITC from validating OT&E fixes to defects identified during previous operational testing and from determining GCCS-J v6.0.1.11 stability in the operational environment, prior to the GCCS-J v4.3 sunset.
- The JCT user assessment showed that the capability did not support JPEC collaboration. Thirteen problem reports remained open at the conclusion of testing, of which seven resulted in complete or partial mission failure with no means to resolve and mitigate the deficiencies. The DISA developmental test program should have discovered many of these defects prior to the JCT user assessment.

Recommendations

DISA should:

1. Resolve JCT Priority 1 and 2 problem reports.
2. Operationally test GCCS-J v6.1 at Combatant Command sites to validate Program Office fixes to defects identified during previous operational testing and to determine system stability in the operational environment.
3. Complete cybersecurity testing on the operational version of GCCS-J Global v6.1, in accordance with DOT&E-approved cybersecurity test guidelines.
4. Continue to improve the GCCS-J developmental test program.