CVN 78 *Gerald R. Ford*-Class Nuclear Aircraft Carrier

In FY22, USS *Gerald R. Ford* (CVN 78) completed its first Planned Incremental Availability (PIA, a 6-month maintenance period), conducted 84 days underway, transitioned from developmental test to integrated test to IOT&E, and continued operationally representative integration with its carrier air wing. Reliability challenges with systems critical for flight operations, including catapults, arresting gear, jet blast deflectors, and radar continue to pose the most risk to CVN 78 demonstrating operational effectiveness and suitability in IOT&E, which is scheduled to last through 4QFY24. Executing planned sortie generation and self-defense tests will be crucial to evaluating the ship's effectiveness and survivability, along with accrediting high-fidelity operational and Probability of Raid Annihilation (PRA) models, essential for evaluating key performance parameters and life-of-class sustainment.

SYSTEM DESCRIPTION

CVN 78 is a new class of nuclear-powered aircraft carriers based on the CVN 68 *Nimitz*-class hull, with significant design changes intended to enhance CVN 78's ability to launch, recover, and service aircraft while reducing required manning capacity by approximately 15 percent. CVN 78 includes a new nuclear power plant that increases electrical capacity to power ship systems, including new electromagnetic catapults and electromechanical arresting gear. CVN 78 also incorporates a larger and more efficient flight deck layout with additional aircraft fueling stations, along with redesigned weapons elevators, weapons handling spaces, and magazine stowage to reduce manning, improve safety, and increase weapons throughput. The CVN 78 Integrated Combat System incorporates several changes, including the following:

- A new Dual Band Radar (DBR) that combines the phased-array SPY-4 Volume Search Radar and the SPY-3 Multi Function Radar. *Ford* is the only ship in the Navy with DBR. It will be replaced with the SPY-6(V)3 Enterprise Air Surveillance Radar fixed variant, the SPQ-9B horizon search radar, and Mk 9 Tracker Illuminator System on PCU *John F. Kennedy* (CVN 79) and follow-on carriers.
- Ship Self-Defense System Mk 2 Mod 6 Baseline 10 combat management system, which will be upgraded to the new capability build, Baseline 12, on CVN 79 and follow-on carriers.
- Cooperative Engagement Capability USG-2B tracking, data fusion, and distribution system, which will be upgraded to Cooperative Engagement Capability Block II on CVN 79 and follow-on carriers.
- SLQ-32(V)6 electronic surveillance and warfare system, equipped with Surface Electronic Warfare Improvement Program Block 2.
- Rolling Airframe Missile (RAM) Block 2 and the Evolved Sea Sparrow Missile (ESSM) Block 1. CVN 79 and follow-on carriers will be upgraded to a mix of new RAM variants Block 2A and 2B, plus a mix of ESSM Block 1 and Block 2.

Ford-class ships also have enhanced survivability features, including improved protection for magazines and other vital spaces; shock-hardened mission systems and components; and installed and portable damage control, firefighting, and dewatering systems intended to expedite response to, and recovery from, fire, flooding, and battle damage. CVN 78 includes a new Heavy Underway Replenishment system capable of transferring cargo loads of up to 12,000 pounds.

MISSION

Carrier Strike Group Commanders will use *Ford*-class ships to:

- Provide credible, sustainable, independent forward presence during peacetime without access to land bases,
- Operate in a supported or supporting role in a joint and/or allied maritime expeditionary force in response to crises; and
- Carry the war to the enemy through joint multi-mission offensive operations by
  - Operating and supporting aircraft to attack enemy forces ashore, afloat, or submerged, independent of forward-based land facilities;
  - Protecting friendly forces from enemy attack through the establishment and maintenance of battlespace control, independent of forward-based land facilities; and
  - Engaging in sustained operations in support of the United States and its allies, independent of forward-based land facilities.

PROGRAM

CVN 78 is an Acquisition Category IC program. DOT&E approved Revision E of the Test and Evaluation Master Plan (TEMP) and the first of two phases of the IOT&E Test Plan in September 2022. The CVN 78 TEMP will be updated by 1QFY24 to refine the self-defense test strategy and resourcing to test CVN 79's self-defense capability. The CVN 78 test plan will be updated before the second phase of IOT&E, which is planned to begin in 2QFY24.

The first ship in the *Ford* class, CVN 78, was delivered to the

Navy in 2017. It completed Post Delivery Test and Trials in 2021 to demonstrate the basic functionality of the carrier, certify the flight deck, embark an air wing, and serve as the East Coast carrier qualification (CQ) platform for student and fleet naval aviators. Based on the Navy's assessment, it declared Initial Operating Capability in December 2021. CVN 79 delivery is scheduled for 2024 and will be capable of supporting F-35 operations upon completion of Post Shakedown Availability. *Enterprise* (CVN 80) construction began in 2017, and *Doris Miller* (CVN 81) construction began in 2021.

» MAJOR CONTRACTOR:

- Huntington Ingalls Industries, Newport News Shipbuilding – Newport News, Virginia

TEST ADEQUACY

The Navy began CVN 78 IOT&E in September 2022. The Navy is conducting IOT&E in accordance with TEMP Revision E and the IOT&E Test Plan, which involves 10 underway periods (including integrated test), extensive modeling, and spans 2 years.

The first of three land-based cyber survivability tests was completed on the Electromagnetic Aircraft Launch System (EMALS) and Advanced Arresting Gear (AAG) in June 2022. This test was executed in accordance with a DOT&E-approved test plan and DOT&E observed the test. The planned test was limited in scope due to the Navy's lack of robust cyber testing capability on industrial control systems that are common on modern ships. The Navy Surface Warfare Center Philadelphia Division's Strategic Cyber-Physical Initiative is attempting to address this limitation. Land-based cyber testing will continue in FY23, and a shipboard test is scheduled for FY24.

The Navy conducted self-defense testing against unmanned aerial vehicles and unmanned small boats in July 2022, in accordance with a DOT&E-approved test plan that was executed during Combat Systems Operational Rehearsal Event Phase 2. DOT&E observed the testing, and the results are still undergoing analysis.

Additionally, CVN 78 conducted sea trials after its PIA and six underway periods that included fixed-wing flight operations, two of which were in accordance with a DOT&E-approved test plan and one was observed by DOT&E. Four of these underway periods involved training squadrons and two involved a portion of its carrier air wing. To date, CVN 78 has conducted 10,826 catapult launches (2,699 of which were in FY22) and 10,826 arrested landings (2,699 of which were in FY22). During these underway periods, the crew also performed two ammunition onloads and a RAM live fire. One of the ammunition onloads was part of a DOT&E-approved test plan, and the live fire was part of a Carrier Strike Group 12 self-defense exercise. DOT&E observed one ammunition onload and the RAM live fire. Although not part of the IOT&E test plan, the data from the RAM live fire will be adjudicated for score and is planned to contribute to the PRA model.

In April 2022, DOT&E submitted a classified report to Congress detailing system performance during planned test events against the Self Defense Test Ship (SDTS) configured to represent CVN 78's capability. This report covers testing between December 2018 and December 2020, during which the Navy completed three of the four planned test events against the SDTS, including the employment of RAMs and/or ESSMs.

There may not be enough data to determine the operational effectiveness and suitability of the self-defense capability of CVN 78 against anti-ship cruise missiles (ASCMs) due to test data that will not be available for reasons discussed in the Ship Self-Defense System article of this Annual Report. The self-defense tests planned in the Revision E TEMP will provide the only remaining live fire self-defense data points in IOT&E, and will not inform performance against some types of ASCM threats. It is vital that the Navy successfully verify, validate, and accredit the high-fidelity PRA model being developed by the Program Executive Office for Integrated Warfare Systems in order to gain adequate understanding of the Anti-Air Warfare mission capability by completion of IOT&E.

The Navy plans to eventually upgrade the combat systems

suite on CVN 78 to match CVN 79 and follow-on ships. Due to the differences between the combat systems, and the fact that CVN 79 will be the enduring self-defense configuration for the class, it is imperative that CVN 79 self-defense capabilities are adequately tested.

PERFORMANCE

» EFFECTIVENESS

Combat System

In April 2022, DOT&E submitted a classified interim report to Congress on the operational effectiveness of CVN 78's self-defense capability against ASCMs.

Regarding the self-defense testing against unmanned aerial vehicles and unmanned small boats in July 2022, no preliminary assessment is available because analysis is not yet complete.

Sortie Generation

The reliability of CVN 78 catapults, arresting gear, and jet blast deflectors (JBDs) continues to have an adverse effect on sortie generation and flight operations efficiency. During an underway period in August of 2022, the ship returned early due to unexpected problems with its JBDs. The early return was necessary to facilitate JBD repairs and did not allow completion of CQ. The ongoing reliability problems with these critical subsystems remains the primary risk to the successful completion of CVN 78 IOT&E. Executing the planned sortie generation-rate testing, as outlined in the Revision E TEMP, will be crucial to evaluating the ship's combat effectiveness and accrediting the high-fidelity Sea Strike/Sea Basing Aviation Model, an essential tool for evaluating the sortie generation rate key performance parameter and supporting life-of-class upgrades.

» SUITABILITY

The low or unproven reliability of the following five CVN 78 systems pose the most significant challenge to flight operations:

EMALS

During testing from March through June 2022 (after the PIA), EMALS achieved a reliability of 614 mean cycles between operational mission failures (MCBOMF) during 1,841 catapult launches (where a cycle is the launch of one aircraft). While this reliability is well below the requirement of 4,166 MCBOMF, EMALS showed slight improvement in reliability from FY21 (460 MCBOMF throughout 1,758 catapults). However, during the first underway of IOT&E in September 2022, EMALS reliability appeared to regress and slowed CQ. While the data are still being analyzed, the adverse effect to operations on two of the ten days of CQ was significant. Naval Air Systems Command is working on short- and long-term improvements to address EMALS reliability degraders. Short-term improvements are focused on improving component reliability and are expected to be incorporated on *Gerald R. Ford* by the end of FY23.

AAG

During testing from March through June 2022 (after the PIA), AAG achieved a reliability of 460 MCBOMF during 1,841 aircraft recoveries (where a cycle is the recovery of a single aircraft). While this reliability is well below the requirement of 16,500 MCBOMF, AAG showed slight improvement in reliability from FY21 (115 MCBOMF throughout 1,758 catapults). However, during the first underway of IOT&E in September 2022, AAG reliability appeared to regress and slowed CQ. While the data are still being analyzed, the adverse effect to operations on three of the ten days of CQ was significant. Naval Air Systems Command is working on short- and long-term improvements to address AAG reliability degraders. Short-term improvements are focused on improving indications and software and are expected to be incorporated on Gerald R. Ford by the end of 2QFY23.

JBDs

During early developmental testing, reliability concerns were identified with the Electro Mechanical Actuators (EMA) that are used to raise and lower the JBDs on the *Ford* class. Several modifications were implemented on CVN 78 during the PIA to improve reliability. During the August 2022 CQ, the ship experienced EMA failures on all four JBDs, which caused the ship to cancel the remainder of CQ and return early. The cause of the EMA failures

was corroded fasteners in various components of the EMA. The root cause of the fastener corrosion is being addressed, and repairs were completed prior to September's CQ. During the September CQ, JBD performance did not adversely affect flight operations.

Advanced Weapons Elevators (AWE)

The Navy conducted a partial ammunition onload in April 2022 and a full ammunition onload in September 2022. DOT&E observed the September ammunition onload; data are still being analyzed. Observation of the lower stage AWE performance was very promising as the ordnance was transferred from the hangar bay to the magazines more efficiently than on a *Nimitz*-class carrier. Through the first 19,767 elevator dispatches, 109 individual elevator failures were reported. AWE system reliability will be critical as the Navy develops standard procedures for moving ordnance from magazines to the flight deck. The Navy's planned service-retained employment of CVN 78 in 1QFY23 will provide the first operationally representative opportunity to fully stress the AWE system.

DBR

Through June 2022, DBR demonstrated a reliability of 100 hours mean time between operational mission failures, which does not meet the minimum threshold of 339 hours mean time between operational mission failures. DBR was operationally available 94% of the time, compared to the 98% requirement.

» SURVIVABILITY

An adequate survivability assessment depends upon a combination of Full Ship Shock Trials (FSST), extensive modeling based on surrogate testing, and a total-ship survivability test (TSST). Sufficient data to assess ship survivability against close-aboard explosions should be available by the end of FY23.

From June-August 2021, the Navy conducted FSST on CVN 78 including three shock events of increasing effect. The FSST identified several survivability improvement opportunities for CVN 78 against underwater threat engagements. In 1QFY23, DOT&E will publish a classified FSST report that details these results.

The Navy plans for the Naval Surface Warfare Center Carderock Division to provide model-based vulnerability assessment reports that assess the class's vulnerability to threat weapons in 2QFY23.

The TSST is scheduled for 3QFY23. TSST is an onboard, extensive damage-control test of both the crew and associated systems.

The Revision E TEMP outlines a strategy to use land-based cyber testing in 2022 and 2023 to build up to a shipboard cybersecurity test in 2024. The first cybersecurity test event was a cyber-survivability assessment of EMALS and AAG, using systems installed at Joint Base McGuire-Dix-Lakehurst, New Jersey in June 2022. Many subsystems on the ship were tested to various degrees in both developmental and operational testing on other ship platforms. However, required CVN 78 platform-level testing has not yet occurred, and some systems specific to CVN 78 have yet to undergo any operational cyber survivability assessments.

The survivability of CVN 78 in a contested and congested electromagnetic spectrum environment has not been evaluated. Tests to do so in FY24 are part of the second phase of the test plan.

RECOMMENDATIONS

The Navy should:

1. Continue to improve reliability for EMALS, AAG, JBDs, DBR, and AWE.
2. Execute planned sortie generation and self-defense tests, as outlined in the Revision E TEMP and the IOT&E Test Plan.
3. Address combat system deficiencies identified in the classified USS *Gerald R. Ford* (CVN 78) Self-Defense Interim Assessment report, dated April 2022.
4. Continue to develop more robust capabilities to test the cyber survivability of shipboard industrial control systems.
5. Fund the modeling and simulation suite required to assess the CVN 78 PRA requirement.

6. Upon release of DOT&E's CVN 78 FSST report, develop and resource a way forward to correct deficiencies and provide it to DOT&E.
7. Complete and deliver the vulnerability assessment reports and supporting documentation.
8. Update the CVN 78 TEMP to complete the test strategy and provide resources for requirements to adequately test the combat system on CVN 79.
9. Continue to fund the maintenance availability for the SDTS to ensure its readiness to support CVN 79 combat systems testing.
10. Update the IOT&E Test Plan to complete the test requirements and scheduling for the second phase of IOT&E.

An F/A-18E Super Hornet from Carrier Air Wing EIGHT lands on CVN 78 as part of strike group integration operations, marking the ship's 9,000th arrested landing, April 2022