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



In May 2023, USS *Gerald R. Ford* (CVN 78) deployed to meet operational needs, prior to completing IOT&E. In April 2023, DOT&E issued a classified early fielding report (EFR), based on limited data collected from IOT&E events. In FY23, prior to the ship's deployment, the Navy continued IOT&E on CVN 78, completing two significant at-sea periods as part of the carrier strike group (CSG), with an operationally representative crew executing operationally representative flight operations, and continuing land-based cyber survivability testing. In FY23, CVN 78 conducted almost as many flight operations as it had in the previous five years combined since commissioning. Reliability and maintainability challenges with systems critical to consistent and on-demand flight operations continue to pose the most risk to CVN 78 demonstrating operational effectiveness and suitability in IOT&E, which is now expected to extend through FY27. Executing planned sortie generation and self-defense tests will be critical to evaluating the ship's effectiveness and survivability, along with accrediting high-fidelity flight operations and Probability of Raid Annihilation ($P_{RA}$) models, which are essential for evaluating key performance parameters (KPPs).

## 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 Aircraft Launch System (EMALS) catapults and electromechanical Advanced Arresting Gear (AAG). The originally planned AAG engine and wire positioning (consisting of four engines and three wires) was similar to the USS *Ronald Reagan* (CVN 76) and USS *George H. W. Bush* (CVN 77) flight decks. However, the fourth AAG engine has not been installed on *Ford*-class to date as a cost savings measure. 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 compared to *Nimitz*-class (CVN 68) aircraft carriers. The CVN 78 class combat system incorporates the following systems:

- Dual Band Radar (DBR) that combines the phased-array SPY-4 Volume Search Radar and the SPY-3 Multi-Function Radar. CVN 78 is the only ship with DBR; it will eventually be replaced with the SPY-6(V)3 Enterprise Air Surveillance Radar (EASR) fixed variant, the SPQ-9B horizon search radar, and Mk 9 Tracker Illuminator System as will be installed on *John F. Kennedy* (CVN 79) and follow-on carriers.

- Ship Self-Defense System (SSDS) Mk 2 Mod 6 with Baseline 10 combat management system, which will be upgraded to the new capability build, Baseline 12, on CVN 79.

- AN/USG-2B Cooperative Engagement Capability (CEC) tracking, data fusion, and distribution system, which will be upgraded to CEC Block II starting on CVN 79.

- SLQ-32B(V)6 electronic warfare system equipped with the Surface Electronic Warfare Improvement Program (SEWIP) Block 2.

- Rolling Airframe Missile (RAM) Block 2 and Evolved Sea Sparrow Missile (ESSM) Block 1. CVN 79 and beyond will be upgraded to a mix of new RAM variants Block 2A and 2B, plus a mix of ESSM Block 1 and Block 2.

- Close-In Weapon System, which operates in stand-alone mode on CVN 78, but will be integrated with AN/USG-2B CEC and SSDS on CVN 79.

*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.

## MISSION

CSG 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 with a joint and/or allied maritime expeditionary force in response to crises; and

- Carry the war to the enemy, independent of forward-based land facilities, through joint multi-mission offensive operations by:

  - Operating and supporting aircraft to attack enemy forces ashore, afloat, or submerged;

  - Protecting friendly forces from enemy attack through the establishment and maintenance of battlespace control; and

  - Engaging in sustained operations in support of the United States and its allies.

## PROGRAM

The CVN 78 *Gerald R. Ford*-class is an Acquisition Category IC program. DOT&E approved Revision E of the Test and

Evaluation Master Plan (TEMP) in September 2022 and Revision B of the LFT&E Management Plan in September 2023. The first ship in the *Ford*-class, CVN 78, was delivered to the Navy in 2017. It completed Post Delivery Test and Trials in April 2021 to demonstrate the basic functionality of the carrier, certify the flight deck, and embark an air wing. CVN 78 also completed Full Ship Shock Trials (FSST) in August 2021 and a Planned Incremental Availability in February 2022. DOT&E approved the first of two planned phases of the IOT&E test plan, and IOT&E began in September 2022. IOT&E is now expected to complete in FY27. This timeline is three years longer than that reported in the FY22 Annual Report for two reasons: The first is a change in the ship's schedule, which has delayed key test events, including sortie generation rate (SGR) and self-defense tests, and the second is the time required for the Navy to incorporate data from the SGR and self-defense tests into the respective models, run the models, and analyze the model outputs.

The Navy deployed CVN 78 in May 2023, which was earlier than the scheduled timeline for first deployment in TEMP Revision E. In preparation for the first deployment, CVN 78 completed its first Composite Training Unit Exercise (COMPTUEX) in April 2023. DOT&E approved Revision 1 to the IOT&E test plan in March 2023 to include IOT&E data collection opportunities during the COMPTUEX. Due to this schedule change, the original

two-phase structure of the IOT&E test plan will be replaced with a more incremental test plan approach. The Navy should submit a test plan revision to DOT&E to reflect this new approach.

CVN 79 delivery is now scheduled for late FY25, a year later than reported in the FY22 Annual Report. The delay is due to the Navy moving some work from CVN 79's post-delivery Post Shakedown Availability to before delivery, in order to mitigate schedule risk to its first deployment. CVN 79 will be capable of supporting F-35 operations. *Enterprise* (CVN 80) construction began in August 2017 and is expected to be delivered to the Navy in FY28. *Doris Miller* (CVN 81) construction began in August 2021 and is expected to be delivered to the Navy in FY32. The most significant upgrades with CVN 79 and beyond are related to the combat system. The TEMP is being updated to include operational testing of F-35 on *Ford*-class and CVN 79's self-defense capabilities. The Navy expects to update the TEMP in 1QFY25 before CVN 79 is delivered. This timeline is later than that reported in FY22 to facilitate synchronizing the test strategy with the ship's updated delivery schedule.

## » MAJOR CONTRACTOR

- Newport News Shipbuilding, a division of HII (formerly Huntington Ingalls Industries) – Newport News, Virginia

## TEST ADEQUACY

The Navy began CVN 78 IOT&E in September 2022 and is conducting it in accordance with TEMP Revision E and the DOT&E-approved portions of the IOT&E test plan. However, analysis of the data provided to DOT&E to date revealed gaps in data collection, which, if not rectified, could result in insufficient data to inform conclusive assessments of reliability, maintainability, logistics and/or availability (RMLA) for some key subsystems. In addition to affecting suitability assessments, these data gaps could also affect effectiveness assessments due to the on-demand nature of many key subsystems and the reliance upon accurate RMLA data in both the self-defense and SGR models. The Navy has acknowledged these shortcomings, committed to improve data collection, and will update the IOT&E test plan for the major remaining tests such as SGR, self-defense, and cyber survivability tests. In April 2023, DOT&E submitted a classified CVN 78 *Ford*-class Aircraft Carrier EFR to Congress, detailing operational and live fire test results to date.

Prior to deployment, CVN 78 conducted two significant underway periods during IOT&E that included fixed-wing flight operations, both of which were in accordance with the DOT&E-approved test plan and observed by DOT&E. A brief summary is below, and detailed results of the underway periods can be found in DOT&E's classified EFR.

In the first significant underway period of IOT&E, CVN 78 executed a service-retained early employment from October 4 to November 26, 2022, as part of CSG 12 that included Tailored Ship's Training Availability (first deployment work-up integrated with CSG); port calls in Halifax, Canada and Portsmouth, England; and multiple operations with allies and partners. The early employment was the first time the air wing, destroyer squadron staff, and CSG staff embarked on the ship together, and the first period of consistent cyclic flight operations for the *Ford*-class, which resulted in 896 arrested landings (not including carrier qualifications). During the early employment, the maximum air wing compliment was approximately 75 percent of the full air wing.

In the second significant underway period of IOT&E, CVN 78 completed its first COMPTUEX (final pre-deployment workup) from March 2 to April 2, 2023, off the U.S. east coast. Administered by CSG 4, COMPTUEX was the first time CVN 78 operated with an operationally representative air wing embarked, conducting consistent, combat-representative scenarios. During COMPTUEX, CVN 78 executed 1,600 total arrested landings, including 1,185 arrested landings during cyclic and alert flight operations. At the end of COMPTUEX, CVN 78 had conducted a total of 14,177 catapult launches and arrested landings since its commissioning.

In July 2023, the second of three planned CVN 78 land-based cyber survivability operational tests was completed on SSDS, CEC, and SEWIP. The test was conducted in accordance with the DOT&E-approved test plan and observed by DOT&E. These land-based tests are intended both to inform planning for shipboard testing and to perform testing deemed too risky to conduct during shipboard cyber survivability tests prescribed by TEMP Revision E.

Many systems specific to CVN 78 have yet to undergo any operational cyber survivability assessments. In June 2023, the Navy updated its cyber survivability testing strategy by replacing the third land-based cyber survivability test with additional testing during shipboard cyber assessments after deployment. The third land-based test was scheduled for late FY23, and its focus was on hull, mechanical, and electrical systems. This change in strategy was primarily due to a lack of existing, robust cyber survivability testing facilities for shipboard industrial control systems. The Navy needs to conduct the shipboard tests to assess CVN 78's overall cyber survivability and enable post hoc accreditation of the test facilities used in completed land-based cyber survivability tests. The Navy is still developing these shipboard cyber survivability test plans.

The CVN 78 Total Ship Survivability Trial (TSST) has been delayed by approximately one year, until 4QFY24, due to the ship's deployment being earlier than planned. The TSST is an onboard, extensive damage-control test to demonstrate how the ship design enables the crew to perform its recoverability-related procedures. For the CVN 78 TSST to be adequate, the testing will require at-sea execution with participation of an embarked air wing. Planning is ongoing to ensure that this adequacy requirement is met.

In 1QFY24, the Navy intends to publish two vulnerability assessment reports (VARs) examining the class's survivability against above-water and underwater kinetic threats. These reports will include findings from survivability testing and modeling of the ship conducted since 2007. However, these reports as drafted do not accurately model the ship as built and do not include findings from more recent testing. Without updating the models, the analysis in the VARs will not support conclusions on the survivability of the CVN 78 class against threat weapons. The Navy intends to issue a final survivability assessment report that will include the findings from recent testing and update model-based survivability analysis by 4QFY25. If the survivability modeling and simulation (M&S) is updated to accurately model the ship as built, this assessment will support DOT&E's report on the survivability of the class against threat weapons.

Together the CVN 78 TEMP Revision E and the Capstone Enterprise Air Warfare Ship Self-Defense (AW SSD) TEMP 1714 of March 2008 provide for a series of

live missile fire events aboard CVN 78 against specific types of ASCM threat surrogates to assess the ship's anti-air warfare capabilities. The Navy intends to execute these tests in FY25. These live tests are necessary to assess ship self-defense capability of the as-built, deployed combat system, and to provide validation data for the M&S suite of the CVN 78 combat system. While these live fire tests, as planned, are adequate, DOT&E has concerns with the Navy's ability to adequately resource them. The M&S is intended to assess the Navy's $P_{RA}$ KPP. These tests, combined with those conducted on the self-defense test ship, and the $P_{RA}$ model runs are required to determine CVN 78's operational effectiveness against specific types of ASCM threats. In FY23, the Navy continued to develop a draft new Enterprise TEMP in support of SSDS Mk 2 Baseline 12 and SPY-6 V(2) and V(3) platforms (TEMP 1910) that includes FOT&E on CVN 79. While CVN 79 self-defense test design will mature during the TEMP 1910 development, any delay in the current timeline for testing the CVN 79 combat systems will be challenged by the planned deactivation timeline for the self-defense test ship, the ex-USS *Paul F. Foster*. The Navy should maintain the capability of the self-defense test ship, currently provided by the ex-USS *Paul F. Foster*.

The CVN 78 SGR evaluation comprises M&S (for both *Ford* and *Nimitz* class), a four-day sustained test on CVN 78, a one-day surge test on CVN 78, and flight operations observations on a *Nimitz*-class carrier. Development of the M&S suite intended to evaluate the SGR, the Sea Strike/Sea Basing Aviation Model (SSAM), is ongoing. The CVN 78 SGR tests are incomplete. The CVN 78 sustained SGR test was originally scheduled for the first COMPTUEX; however, due to COMPTUEX syllabus changes, ship and air wing schedule changes, and resourcing, it was deferred to the second COMPTUEX, now expected to occur in FY25. The Navy plans to apply lessons from the CVN 78 sustained SGR test to the surge SGR test which is currently unscheduled. A *Nimitz*-class COMPTUEX to collect flight operations data to support a *Nimitz*-class SGR M&S suite (part of SSAM) for comparative analysis is planned for FY24. DOT&E approved these deferments in Revision 1 to the IOT&E test plan. The Navy needs to provide an updated test plan prior to conducting these events.

# PERFORMANCE

## » EFFECTIVENESS

Insufficient data are available to determine CVN 78's operational effectiveness due to IOT&E being incomplete. Observations based on testing to date are below.

### Combat System

Self-defense testing against unmanned aerial vehicles (UAVs) and high-speed maneuvering surface targets (small boats) was conducted in July 2022. Details can be found in DOT&E's classified EFR. The Navy is developing fixes to combat system deficiencies identified in DOT&E's classified USS *Gerald R. Ford* (CVN 78) Self-Defense Interim Assessment report dated April 2022. However, to date the fixes remain largely unfunded.

### Sortie Generation

In FY23, CVN 78 conducted almost as many flight operations (as measured by the number of aircraft launch and recoveries) as it had in the previous five years combined since commissioning. From the first arrested landing on CVN 78 in July 2017 until the end of FY22, CVN 78 had conducted 10,826 arrested landings. In FY23 alone, CVN 78 conducted 9,266 arrested landings. The reliability and maintainability of CVN 78's EMALS and AAG continue to adversely affect sortie generation and flight operations, which remains the greatest risk to demonstrating operational effectiveness and suitability in IOT&E. Despite these continuing reliability challenges, DOT&E observed general increases in crew proficiency and decreases in some repair times. While this has improved sortie generation compared to previous years, SGR tests have not been completed yet nor have training sortie rates flown to date approached that of the KPP requirement. CVN 78 earned the flight operations efficiency portion of its Blue Water Certification as part of the Navy's deployment certification process. Observations during COMPTUEX suggests that the *Ford*-class flight deck design improves the efficiency of aircraft turnarounds compared

to that of a *Nimitz*-class flight deck. Additional details on sortie generation effectiveness can be found in DOT&E's classified EFR. Executing the planned SGR testing, as outlined in TEMP Revision E, will be crucial to evaluating the ship's combat effectiveness and accrediting the high-fidelity SSAM which is an essential tool for evaluating the SGR KPP and supporting life-of-class upgrades.

### Electromagnetic Spectrum Compatibility

Developmental testing identified significant electromagnetic radiation hazard and interference problems. The Navy implemented some mitigation measures and conducted follow-on characterization testing during independent steaming events in developmental test, but some operational limitations and restrictions are expected to persist into IOT&E and deployment. The Navy should verify developmental test electromagnetic spectrum compatibility during operational test, particularly when integrated with CSG operations in an advanced electronic attack environment. This will enable capability assessments at differing levels of system use to inform decisions on system employment.

### » SUITABILITY

Insufficient data are available to determine CVN 78's operational suitability. However, the following four new CVN 78 systems have shown low or unproven reliability and are highlighted as

the most significant challenge to flight operations.

### AAG

During FY23, DOT&E observed AAG reliability similar to recent developmental testing (115 mean cycles between operational mission failures [MCBOMF] in FY21 and 460 MCBOMF in FY22). Despite some software and hardware improvements in AAG, reliability has not appreciably changed because the FY23 data reflects many short-duration failures that were unreported in developmental test, as well as system-of-systems degradations, all of which would have prevented landing. Naval Air Systems Command (NAVAIR) delivered hardware updates after early employment and before COMPTUEX, along with a software update before deployment. NAVAIR continues to work on short- and long-term improvements to address AAG reliability degraders.

However, difficulties such as obtaining replacement parts and the reliance on off-ship technical support remain a challenge. The Navy is also using IOT&E to inform the decision of whether to retrofit the fourth AAG engine on *Ford*-class aircraft carriers (as designed, which would make it similar to the arresting gear engine/wire configuration on CVN 76 and CVN 77). The fourth AAG engine was not installed as a cost savings measure. In a 2016 requirements review board, the Navy committed to informing a potential retrofit decision with the results of IOT&E. The criteria on which to base a potential retrofit decision were not specified, and with changes to the IOT&E schedule, more data will be available before the end of IOT&E. The fourth engine would improve the reliability and availability of AAG, improve pilot boarding rate, and restore barricade redundancy. Additional details on AAG suitability can be found in DOT&E's classified EFR.

## EMALS

During FY23, DOT&E observed EMALS reliability remained consistent with recent developmental test (460 MCBOMF in FY21 and 614 MCBOMF in FY22). Despite engineering upgrades to hardware and software, reliability has not appreciably changed from prior years and reliance on off-ship technical support remains a challenge. As part of an effort to provide short- and long-term improvements to address EMALS reliability degraders, NAVAIR delivered a software update and upgraded all catapult position sensor blocks prior to CVN 78's deployment and is continuing development on further improvements. Furthermore, a situational awareness display was added in the EMALS Maintenance Workstation that facilitates troubleshooting during operations. Additional details can be found in DOT&E's classified EFR.

## Advanced Weapons Elevators (AWEs)

The early employment and COMPTUEX provided CVN 78's first operationally representative opportunities to demonstrate ordnance movement during cyclic flight operations. The AWEs met operational mission needs during these underway periods, but preliminary data suggest AWE is unlikely to meet its operational availability requirement of 99.7 percent. Of note, the crew is reliant on off-ship technical support for correction of hardware and software failures. As of the end of COMPTUEX, the ship had conducted 23,042 total AWE cycles. The Navy has yet to build and transfer ordnance to the flight deck at combat-representative rates. DOT&E expects the SGR tests to be the first operationally representative demonstration of high ordnance throughput. Additional details can be found in DOT&E's classified EFR.

## DBR

During COMPTUEX, DBR availability was observed to be lower than that during developmental testing. This is in part due to the operational expectation of continuous radar coverage. Reliability concerns are amplified due to the one-of-a-kind nature of the DBR. The radar relies on embarked contractor support and there is uncertainty on sourcing replacement parts as the system ages. The Navy should ensure replacement parts are manufactured and available for the life of the system or develop a timeline and strategy for replacing DBR with EASR on CVN 78 to bring it in line with CVN 79's radar configuration. Additional details on DBR suitability can be found in DOT&E's classified EFR.

## Manning and Berthing

Per the Navy's Shipboard Habitability Program, all new ships are required to have a growth allowance of 10 percent of ship's company when the ship delivers. This Service Life Allowance provides both empty bunks to allow for changes in the crew composition over the ship's life and berthing to support crew turnover, visitors, and personnel temporarily assigned to the ship for repairs, inspections, test, and training. However, sufficient berthing is not installed for CVN 78 to conduct combat operations with all hands assigned a bed. While the ship's company manning is reduced from *Nimitz*-class carriers by approximately 500 personnel, the lack of berthing capacity is driven by embarked units. Based on the composition of the ship and embarked units during COMPTUEX and their respective manning documents, if each was at 100 percent manning, the ship would have a shortfall of 159 beds. These berthing shortfalls will affect quality of life onboard and could reduce the Navy's operational flexibility in employing the ship across its full spectrum of missions and logistical support roles for the CSG. Furthermore, there is potential that the berthing shortfalls could increase as the air wing diversifies to include CMV-22, F-35, and MQ-25, none of which are on CVN 78 today. Additional details on manning and berthing can be found in DOT&E's classified EFR.

## » SURVIVABILITY

An adequate survivability assessment of the CVN 78 class depends upon a combination of FSST, TSST, and related modeling of the class supported by component and surrogate testing. To date, the Navy has completed all planned LFT&E, with the exception of TSST, the VARs, and the final survivability assessment.

From June to August 2021, the Navy conducted FSST on CVN 78,

including three shock events of increasing severity. In December 2022, DOT&E published a classified FSST report that details findings from the trial, and in July 2023, the Navy published its own FSST report. Both reports identify deficiencies that, if addressed, will improve the class's survivability against weapon events.

The survivability of CVN 78 in a cyber-contested environment has not yet been fully evaluated. Results from the land-based cyber survivability tests will inform the shipboard cyber survivability tests. Some systems specific to CVN 78 have yet to undergo any operational cyber survivability assessments.

The survivability of CVN 78 in contested and congested electromagnetic spectrum environments has not been evaluated. Discussions on how to evaluate CVN 78 survivability in these environments are ongoing with the Navy.

## RECOMMENDATIONS

The Navy should:

1. Improve the suitability of AAG, EMALS, AWE, and DBR while minimizing the requirement for off-ship and/or contractor technical support.

2. Reevaluate the timeline and better define the criteria for a decision to retrofit the fourth AAG engine.

3. Collect data in accordance with the test plan for the remainder of IOT&E.

4. Resource and execute the testing per Enterprise AW SSD TEMP 1714 and CVN 78 TEMP, including the planned SGR testing, along with completing, verifying, and validating the SGR M&S suite; shipboard cyber survivability testing; and self-defense tests and $P_{RA}$ modeling.

5. Address the recommendations in DOT&E's classified self-defense interim assessment report from April 2022, and the additional recommendations in DOT&E's classified EFR from April 2023.

6. Develop a plan to sustain DBR on CVN 78 or replace it as soon as possible with the EASR configuration on CVN 79 and subsequent *Ford*-class carriers.

7. Re-examine manning and berthing for future ships of the class to ensure sufficient berthing is available and that 10 percent Service Life Allowance is allocated to allow future growth.

8. Submit for DOT&E approval a test plan revision to update the test plan schedule.

9. Continue to develop more robust capabilities to test the cyber survivability of shipboard industrial control systems.

10. Execute the TSST with an embarked air wing in FY24.

11. Prioritize and correct deficiencies identified in DOT&E's classified FSST report of December 2022.

12. Produce a project schedule to complete required updates to the vulnerability modeling and simulation by 4QFY24 to support accurate vulnerability reporting in the CVN 78 final survivability assessment report in 4QFY25.

13. Submit for DOT&E approval in 1QFY25 an update of the CVN 78 TEMP, aligned with the new Enterprise TEMP 1910, that provides the test strategy and test resources to determine operational effectiveness of new and/or upgraded capabilities on CVN 79.

14. Ensure the availability of the capability provided by ex-USS *Paul F. Foster*, the Navy's self-defense test ship, to support combat system testing.

15. To better inform effectiveness and survivability, verify developmental test electromagnetic spectrum compatibility during operational test, particularly when integrated with CSG operations in an advanced electronic attack environment.