

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

Executive Summary

- The DOT&E assessment of CVN 78 remains consistent with previous assessments. Poor or unknown reliability of systems critical for flight operations, including newly designed catapults, arresting gear, weapons elevators, and radar, could affect the ability of CVN 78 to generate sorties. Reliability of these critical subsystems poses the most significant risk to the CVN 78 IOT&E timeline.
- CVN 78 entered the shipyard for a Post-Shakedown Availability (PSA)/Selected Restricted Availability (SRA) in July 2018 after completing eight Independent Steaming Event at-sea periods. The Navy originally planned a 1-year PSA, but extended it by 3 months to effect repairs until October 2019. The delays are due to the volume of work in the PSA, repairs and changes made to the propulsion plant based on lessons learned during sea trials, and acceptance delays for the Advanced Weapons Elevators (AWE).
- CVN 78 is unlikely to achieve the Sortie Generation Rate (SGR) (number of aircraft sorties per day) requirement. Unrealistic assumptions underpin the SGR threshold requirement. These assumptions ignore the effects of weather, aircraft emergencies, ship maneuvers, and current Air Wing composition on flight operations. DOT&E plans to assess CVN 78 performance during IOT&E by comparing it to the demonstrated performance of the *Nimitz*-class carriers, as well as to the SGR requirement.
- Because CVN 78 has been in the shipyard for PSA, the Navy does not have additional data from shipboard operations. Consequently, the Navy has not updated the reliability estimates for the catapults, arresting gear, radar, or weapons elevators.
- CVN 78 will likely be short of berthing spaces. Reduced manning requirements drove the design of CVN 78. The berthing capacity is 4,660; 1,100 fewer than *Nimitz*-class carriers. Manning requirements for new technologies, such as catapults, arresting gear, radar, and elevators are not well understood. Some of these concerns required redesignating some berthing areas and may require altering standard manpower strategies to achieve mission accomplishment. Recent estimates of expected combined manning of CVN 78, its Air Wing, embarked staffs, and detachments range from 4,656 to 4,758. The estimates do not include Service Life Allowance for future crew growth.
- The Navy conducted developmental and operational tests on the Self-Defense Test Ship (SDTS) that revealed combat system deficiencies and limitations associated with the SLQ-32(V)6 electronic warfare system, the SPY-3 Multi-Function Radar (MFR), and the Cooperative Engagement Capability (CEC). These deficiencies and limitations reduce the overall self-defense capability of the ship. The Navy has conducted only one of the four planned



- CVN 78 SDTS operational test events and has not resourced the remaining testing. If the Navy does not conduct all of the remaining events, testing will not be adequate to assess the operational effectiveness of the CVN 78 combat system.
- CVN 78 exhibits more electromagnetic compatibility problems than other Navy ships. The Navy continues to characterize the problems and develop mitigation plans.
- The development and testing of AWE, Electromagnetic Aircraft Launch System (EMALS), Advanced Arresting Gear (AAG), Dual Band Radar (DBR), and the Integrated Warfare System will continue to drive the CVN 78 timeline as it progresses toward IOT&E.
- The Navy continues to conduct the LFT&E program to provide the data and analyses required for the evaluation of the survivability of the ship to operationally significant threats.

System

- The CVN 78 *Gerald R. Ford*-class aircraft carrier program introduces a new class of nuclear-powered aircraft carriers. It uses the same hull form as the CVN 68 *Nimitz*-class but introduces a multitude of new ship systems.
- The new nuclear power plant reduces manning levels by 50 percent compared to a *Nimitz*-class ship and produces significantly more electricity. CVN 78 uses the increased electricity (instead of steam) to power electromagnetic catapults and AAG, both designed to increase reliability and expand the aircraft launch and recovery envelopes.
- The Navy redesigned weapons elevators, handling spaces, and stowage to reduce manning, improve safety, and increase weapon throughput. Weapon elevators utilize electromagnetic linear induction motors instead of cable driven systems.
- CVN 78 incorporates a more efficient flight deck layout, dedicated weapons handling areas, and an increased number of aircraft refueling stations designed to enhance its ability to launch, recover, and service aircraft.

FY19 NAVY PROGRAMS

- The CVN 78 combat system incorporates changes intended to improve upon the legacy *Nimitz*-class combat system. It consists of:
 - A phased-array DBR comprised of the SPY-4 Volume Search Radar and the SPY-3 MFR. The DBR replaced several legacy radars used on current carriers for self-defense and air traffic control.
 - Ship Self-Defense System (SSDS) Mark 2 command decision system
 - CEC tracking and data fusion and distribution system
 - Surface Electronic Warfare Improvement Program (SEWIP) Block 2-equipped SLQ-32(V)6 electronic surveillance system
 - Rolling Airframe Missile (RAM) Block 2 and Evolved Sea Sparrow Missile (ESSM) Block 1
 - Phalanx Close-In Weapon System
- The ship includes the following enhanced survivability features:
 - Improved protection for magazines and other vital spaces
 - Shock-hardened mission systems/components
 - Installed and portable damage control, firefighting, and dewatering systems intended to expedite response to and recovery from peacetime 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. Currently, only one supply ship, the USNS *Arctic*, has the Heavy replenishment system installed. The Navy has no current plans to include the system on other ships.
- The Navy intends to achieve CVN 78 Initial Operational Capability in FY21 prior to the start of Full Ship Shock Trial (FSST) and Full Operational Capability in FY24 after successful completion of IOT&E and Type Commander certification.

Mission

Carrier Strike Group Commanders will use CVN 78 to:

- Conduct power projection and strike warfare missions using embarked aircraft
- Provide force and area protection
- Provide a sea base as both a command and control platform and an air-capable unit

Major Contractor

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

Activity

- The Navy updated the Test and Evaluation Master Plan (TEMP) 1610 and it is currently in the Navy approval chain. This TEMP continues two back-to-back phases of initial operational testing described in previous annual reports. The first phase focuses on routine unit-level operations and the ship's internal workings (including cyclic flight operations with an embarked Air Wing) and culminates with successful completion of Composite Training Unit Exercise. Phase two focuses on more complex evolutions, including tests of the integrated combat system in self-defense scenarios, and includes integrated operations with an embarked Air Wing, Destroyer Squadron, and Carrier Strike Group staffs during the Composite Training Unit Exercise (COMPTUEX) at-sea period.
- The development, installation, and delivery of the AWE remains behind schedule. As of October 2019, CVN 78 has all 11 elevators installed but the Navy has only accepted 4.

EMALS

- The Navy expects to complete the EMALS Aircraft Launch Bulletins (ALB), required for shipboard operations, for the C-2A, E-2C/D, F/A-18E/F, E/A-18G, and T-45C by the end of October 2019.

AAG

- Aircraft Recovery Bulletins (ARB) for C-2A, E-2C/D, F/A-18E/F, and E/A-18G were released August 2, 2019. These bulletins are required for shipboard flight operations with fleet aircraft.
- The Navy expects to complete the remaining AAG ARB, required for shipboard operations, by the end of

December 2019. The Barricade ARB completed October 4, 2019, and will be released with the T-45C ARB, which will be completed by the end of December 2019.

Combat System

- In June 2019, the Navy conducted one of the four planned CVN 78 operational tests planned for FY19 on the SDTS. However, the remaining three tests are unlikely to be conducted in accordance with the DOT&E-approved CVN 78 data collection plan, the DOT&E-approved Capstone Enterprise Air Warfare Ship Self-Defense TEMP, and the DOT&E-approved SSDS TEMP. The Navy canceled one test event because they did not incorporate software changes required to conduct the test on the SDTS and the event was not resourced. The Navy delayed another test event due to poor SLQ-32(V)6 performance in developmental testing. The final, most challenging test event planned for 2QFY20 is not currently funded. The Navy may have to cancel the remaining delayed/unfunded events if they are not conducted before the MFR is removed from the SDTS; this removal is currently planned for the end of 2QFY20. If the Navy does not conduct all of the remaining events, testing will not be adequate to assess the operational effectiveness of the CVN 78 combat system.
- The Navy has not resourced combat system testing on the lead ship or the modeling and simulation (M&S) required to support evaluation of the ship's Probability of Raid Annihilation (PRA) requirement.

Live Fire Test & Evaluation

- The Navy continued planning of the CVN 78 Full Ship Shock Trial (FSST), including shock trial logistics, environmental requirements, instrumentation, and related analyses. Due to the extended PSA, the Navy intends to conduct the FSST in FY21.
- The Navy continues work on survivability assessments of the CVN 78 design against weapon threats using M&S-based vulnerability analysis and scenario-based recoverability assessments.

Assessment

- As noted in previous annual reports, the test schedule has been aggressive. This year, the planned schedule slipped over a year. The recent extension in Planned Ship Availability delayed both phases of initial operational testing until FY22, and pushed the ship's first deployment to FY23.

Reliability

- Four of CVN 78's new systems stand out as being critical to flight operations: EMALS, AAG, DBR, and AWE. Overall, the poor reliability demonstrated by AAG and EMALS and the uncertain reliability of DBR and AWE could further delay CVN 78 IOT&E. Reliability estimates derived from test data for EMALS and AAG are discussed in following subsections. Since CVN 78 spent FY19 in the shipyard for PSA, the Navy has not conducted additional aircraft launches or recoveries from the ship. For DBR and AWE, only engineering reliability estimates have been provided.

EMALS

- Through the first 747 shipboard launches, EMALS suffered 10 critical failures. This is well below the requirement for Mean Cycles Between Critical Failures, where a cycle represents the launch of one aircraft. The Navy identified 9 unique Incident Reports (IRs) that resulted in the 10 critical failures for EMALS. Of the nine IRs, one fix was installed during PSA and is in place to support flight operations during CVN 78's Post Delivery Test and Trials (PDT&T). Four IRs will be corrected commencing in late FY20. The four remaining IRs occurred only once during pre-PSA operations, are deemed low priority, and will be monitored during future flight operations.
- The reliability concerns are exacerbated by the fact that the crew cannot readily electrically isolate EMALS components during flight operations due to the shared nature of the Energy Storage Groups and Power Conversion Subsystem inverters on board CVN 78. The process for electrically isolating equipment is time-consuming; spinning down the EMALS motor/generators takes 1.5 hours by itself. The inability to readily electrically isolate equipment precludes EMALS maintenance during flight operations.

AAG

- The Program Office redesigned major components that did not meet system specifications during land-based testing. Through the first 747 attempted shipboard landings, AAG suffered 10 operational mission failures, including one

incident to the engine that supports the barricade. The Navy identified 7 unique IRs that caused the 10 operational mission failures for AAG. Of the seven, six fixes have been installed and will be in place to support flight operations during CVN 78's PDT&T. The one remaining IR occurred once, is deemed low priority, and will be monitored during future flight operations.

- This reliability estimate falls well below the re-baselined reliability growth curve and well below the requirement for Mean Cycles Between Operational Mission Failures, where a cycle represents the recovery of one aircraft.
- The reliability concerns are magnified by the current AAG design that does not allow electrical isolation of the Power Conditioning Subsystem equipment from high power buses, limiting corrective maintenance on below-deck equipment during flight operations.

Combat System

- The CVN 78 SDTS events revealed good performance of the SSDS Mark 2 command decision system due to its ability to manage the combat system tracks, manage and apply the ship's engagement doctrine, and schedule intercepts and launch missiles against incoming subsonic anti-ship cruise missile (ASCM) surrogates.
- In the most recent CVN 78 SDTS developmental test event, the MFR and CEC failed to maintain detections and tracks for one of the threat surrogates in the multi-target raid; however, that raid presented a scenario that was more challenging to the combat system than originally planned.
- In developmental testing on SDTS, the SLQ-32(V)6 electronic surveillance system demonstrated poor performance that prompted the Navy to delay additional operational tests until those problems could be corrected. Similar problems were previously reported in DOT&E's September 2016 SLQ-32(V)6 SEWIP Block 2 IOT&E Report.
- The Navy continues to address known deficiencies with the DBR Air Traffic Control (ATC), but the resolution of those problems will not be known until CVN 78 returns to sea. In at-sea testing before the PSA, DBR was plagued by extraneous false and close-in dual tracks adversely affecting ATC performance, and Navy analysis noted that DBR performance needs to be improved to support carrier ATC center certification.

SGR

- CVN 78 is unlikely to achieve its SGR requirement. The target threshold is based on unrealistic assumptions including fair weather and unlimited visibility, and that aircraft emergencies, failures of shipboard equipment, ship maneuvers, and manning shortfalls will not affect flight operations. During the 2013 operational assessment, DOT&E conducted an analysis of past aircraft carrier operations in major conflicts. The analysis concludes that the CVN 78 SGR requirement is well above historical levels.
- DOT&E plans to assess CVN 78 performance during IOT&E by comparing it to the SGR requirement, as well

as to the demonstrated performance of the *Nimitz*-class carriers.

- Poor reliability of key systems that support sortie generation on CVN 78 could cause a cascading series of delays during flight operations that would affect CVN 78's ability to generate sorties. The poor or unknown reliability of these critical subsystems represents the most risk to the successful completion of CVN 78 IOT&E.

Manning

- Based on current expected manning, the berthing capacity for officers and enlisted will be exceeded by approximately 100 personnel with some variability in the estimates. This also leaves no room for extra personnel during inspections, exercises, or routine face-to-face turnovers.
- Planned ship manning requires filling 100 percent of the billets. This is not the Navy's standard practice on other ships, and the personnel and training systems may not be able to support 100 percent manning. Additionally, workload estimates for the many new technologies, such as catapults, arresting gear, radar, and weapons and aircraft elevators are not yet well understood.

Electromagnetic Compatibility

- Developmental testing identified significant electromagnetic radiation hazard and interference problems. The Navy continues to characterize and develop mitigation plans for the problems, but some operational limitations and restrictions are expected to persist into IOT&E and deployment. The Navy will need to develop capability assessments at differing levels of system utilization in order for commanders to make informed decisions on system employment.

Live Fire Test & Evaluation

- The potential vulnerability of CVN 78's new critical systems to underwater threat-induced shock has not yet

been fully characterized. The program continued shock testing on EMALS, AAG, and the AWE components during CY19 but because of a scarcity of systems, alternatives to component shock testing of DBR components are being pursued and shock testing will likely not be completed before the FSST. The Vulnerability Assessment Reports delivered to date provide an assessment of the ship's survivability to air-delivered threat engagements. The classified findings in the report identify the specific equipment that most frequently would lead to mission capability loss. In FY20, the Navy is scheduled to deliver additional report volumes that will assess vulnerability to underwater threats and compliance with Operational Requirements Document survivability criteria.

Recommendations

The Navy should:

1. Continue to characterize the electromagnetic environment on board CVN 78 and develop operating procedures to maximize system effectiveness and maintain safety. As applicable, the Navy should utilize the lessons learned from CVN 78 to inform design modifications for CVN 79 and future carriers.
2. Fund all remaining SDTS events and explore the possibility of leaving the MFR on the SDTS past 2QFY20 to allow for completion of the CVN 78 self-defense test program.
3. Fund the CVN 78 lead ship combat system operational testing and the M&S required to support assessment of the CVN 78 PRA requirement.
4. Implement the required software updates to multiple combat system elements to allow cueing from external sources necessary to conduct one of the SDTS test events.