

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 completed eight Independent Steaming Event (ISE) at-sea periods in support of developmental test and ship certification. Four of these at-sea periods included fixed-wing flight operations for a total of 747 F/A-18E/F launches and arrestments. Mechanical problems forced CVN 78 to return to port early on three of the eight ISE events.
- CVN 78 will probably not 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.
- As of September 30, 2018, the development, installation, and delivery of the Advanced Weapons Elevators (AWE) remains behind schedule. All 11 elevators have been installed, and 2 of the 11 elevators are in government certification testing. The Navy has yet to accept delivery of any elevators due to the shipbuilder's continued development of this first of a kind system without a land-based prototype.
- The Navy previously identified an inability to readily electrically isolate Electromagnetic Aircraft Launching System (EMALS) and Advanced Arresting Gear (AAG) components to perform maintenance. This limitation precludes some types of maintenance during flight operations.
- The Navy continued performance testing of the AAG at the Jet Car Track Site at Joint Base McGuire-Dix-Lakehurst, New Jersey, with 2,230 arrestments completed as of September 30, 2018. Runway Arrested Landing Site (RALS) testing with manned aircraft continues and has completed a total of 928 aircraft arrestments as of September 30, 2018. RALS testing began on E-2 and C-2 on May 24, 2018, with the first propeller aircraft fly-in arrestment occurring on the C-2 on July 18, 2018.
- CVN 78 will likely be short of berthing spaces. Reduced manning requirements drove the design of CVN 78. The berthing capacity is 4,660; more than 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 have required the redesignation of 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 sea-based developmental testing (SBDT) of the ship self-defense combat system aboard CVN 78 from August 2017 through June 2018. The Navy successfully corrected many previously discovered deficiencies. However, the Dual Band Radar's (DBR) false and dual tracks propagation through the integrated combat system affect its performance.
 - 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, EMALS, AAG, DBR, and the Integrated Warfare System will continue to drive the *Gerald R. Ford* timeline as it progresses toward IOT&E.
 - The Navy continued to execute 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.
- According to design, 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 to power electromagnetic catapults (instead of steam) and AAG, both designed to increase reliability and expand the aircraft launch and recover envelopes.

FY18 NAVY PROGRAMS

- CVN 78 also incorporates a phased-array DBR for air traffic control and ship self-defense, which replaced several legacy radars used on current carriers.
- The Navy redesigned weapons elevators, handling spaces, and stowage to reduce manning, improve safety, and increase weapon throughput. AWE utilize linear electrical motors instead of legacy 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. The Navy set a sortie generation requirement for CVN 78 to sustain 160 sorties per 12-hour fly day for 26 days and surge to 270 sorties per 24-hour fly day for 4 days.
- The Navy intends for the ship to have increased self-defense capabilities (hard- and soft-kill), compared to current aircraft carriers. Additionally, the ship includes the following enhanced survivability features:
 - Improved protection for magazines and other vital spaces as well as shock-hardened systems/components
 - Installed and portable damage control, firefighting, and dewatering systems intended to expedite 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 FY19 after successful completion of Post-Shakedown Availability (PSA) and Full Operational Capability in FY22 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

- A Test and Evaluation Master Plan (TEMP) 1610 revision is under development to update the currently approved TEMP 1610, Revision B. The Program Office is in the process of refining the Post Delivery Test and Trials (PDT&T) schedule to further integrate testing and to include the Full Ship Shock Trial (FSST) and SGR assessment.
- The Navy's long-standing, stated intent was to conduct a live test to demonstrate the SGR with 6 consecutive 12-hour fly days followed by 2 consecutive 24-hour fly days. The Navy's current strategy for assessing the SGR Key Performance Parameter during operational test is being reviewed by DOT&E, the Navy Operational Test and Evaluation Force (OPTEVFOR), and the Program Executive Officer for Carriers. OPTEVFOR leads the development of a strategy to assess the sortie generation capability of CVN 78 for inclusion in the upcoming TEMP 1610 revision. All current versions of the proposed strategy include a combination of live flights with modeling using the Navy Seabasing/Seastrike Aviation Model.
- Delays in the Independent Steaming Event (ISE) schedule and an expanded Post Shakedown Availability (PSA) adversely affected the schedule for the at-sea OT&E of CVN 78. The Program Office plans for two back-to-back phases of initial operational testing. The first phase focuses on routine unit-level operations and ship's internal workings (including cyclic flight operations with an embarked Air Wing) and culminates with successful completion of Tailored Ship's Training Availability and Final Evaluation Problem (TSTAFEP). 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 Navy plans to start the first phase of operational testing in FY21 and complete the second phase of operational testing in FY22. To save resources and lower costs, the test phases align with standard carrier training periods required for deployment.

- CVN 78 entered PSA on July 14, 2018.

EMALS

- The Navy conducted 747 F/A-18E/F launches from CVN 78.
- As of September 30, 2018, the program conducted 3,807 dead loads (non-aircraft, weight equivalent sled) and 523 aircraft launches at the land-based test site.

AAG

- The Navy conducted 747 F/A-18E/F arrestments on CVN 78.
- The Navy continues to test the AAG on a jet car track at Joint Base McGuire-Dix-Lakehurst, New Jersey. Earlier testing prompted system design changes that the program is now testing. The jet car track testing examined the F/A-18E/F performance envelope with the new design, and initial E-2C/D and C-2A testing. As of November 3, 2018, land-based jet car track testing accomplished a total of 2,230 dead load arrestments and land-based RALS testing accomplished a total of 456 F/A-18E/F, 65 EA-18G, 226 C-2A, 84 E-2C+, and 140 E-2D aircraft arrestments.

Combat System

- The Navy conducted five sea-based developmental test (SBDT) events onboard CVN 78 between August 2017 and June 2018. The Navy intended to use these events to determine the CVN 78 integrated combat system (ICS) baseline performance with respect to DBR, Ship Self-Defense System (SSDS), and Cooperative Engagement Capability (CEC) track management and support for Rolling Airframe Missile (RAM) and Evolved Seasparrow Missile (ESSM) engagements. The Navy plans to start the first phase of air warfare operational testing in 3QFY19 by conducting several missile events on the unmanned, remote-controlled self-defense test ship (SDTS).

DBR

- The radar consists of fixed array antennas both in the X- and S-bands. The X-band radar is the Multi-Function Radar and the S-band radar is the Volume Search Radar.
- The Navy completed testing of DBR at Wallops Island, Virginia, and over the course of the last year tested the system during SBDT. Multi-Function Radar testing on the SDTS began in late 2018.

Propulsion

- Propulsion issues caused the ship to return to port early from three ISE at-sea events. Main reduction gear thrust bearing problems cut short two of the ISE events and another propulsion system failure caused the third. The Navy is addressing the problems with the manufacturer.

Electromagnetic Compatibility

- Preliminary electromagnetic interference (EMI) and radiation hazard testing has been conducted by Naval Surface Warfare Center, Dahlgren Division and Naval Air Systems Command. Further testing and mitigation are planned both at sea and in port throughout PDT&T.

Live Fire Test & Evaluation

- In FY18, the Navy resumed the planning of CVN 78 FSST, which included shock trial logistics, environmental requirements, instrumentation, and related analyses. The Navy is on track to support the execution of the FSST in CY20.
- The Navy delivered two draft volumes of their latest vulnerability assessment report in August 2018. This report updates earlier (2007) survivability analyses to account for ship design maturation.

Assessment

- The delays in the ship development and initial trials pushed both phases of initial operational testing until FY21 and FY22. The delay in the ship's delivery and development added approximately 2 years to the timeline. As noted in previous annual reports, the CVN 78 test schedule has been aggressive, and the development of EMALS, AAG, AWE, DBR, and the Integrated Warfare System delayed the ship's first deployment to FY22.

Reliability

- Four of CVN 78's new systems stand out as being critical to flight operations: EMALS, AAG, DBR, and AWEs.

Overall, the poor reliability demonstrated by AAG and EMALS and the uncertain reliability of DBR and AWEs could delay CVN 78 IOT&E. The Navy continues to test all four of these systems in their shipboard configurations aboard CVN 78. Reliability estimates derived from test data for EMALS and AAG are discussed in following subsections. For DBR and AWE, only engineering reliability estimates have been provided.

EMALS

- Testing to date involved 747 shipboard launches and demonstrated EMALS capability to launch aircraft planned for the CVN 78 Air Wing.
- Through the first 747 shipboard launches, EMALS suffered 10 critical failures. This is well below the requirement of 4,166 Mean Cycles Between Critical Failures, where a cycle represents the launch of one aircraft.
- 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 onboard 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

- Testing to date included 763 attempted shipboard landings and demonstrated AAG capability to recover aircraft planned for the CVN 78 air wing.
- The Program Office redesigned major components that did not meet system specifications during land-based testing. Through the first 763 attempted shipboard landings, AAG suffered 10 operational mission failures (which includes one failure of the barricade system). This reliability estimate falls well below the re-baselined reliability growth curve and well below the requirement of 16,500 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

- Results of SBDT events indicate good SSDS performance in scheduling and launching simulated RAMs and ESSMs, as well as scheduling DBR directives for ESSM acquisition and target illumination. Insufficient interoperability testing with a CEC network and Link 16 prevents an estimate of performance in this area. It is unknown if the integration problems between SSDS and Surface Electronic Warfare Improvement Program (SEWIP) Block 2 identified during engineering testing at Wallops Island have been resolved because SEWIP Block 2 was not installed on the ship during these SBDT events.

- CVN 78's combat system testing on the SDTS is at risk due to schedule constraints, lack of funding, and insufficient planned developmental testing.

DBR

- Throughout the five CVN 78 SBDTs, DBR was plagued by extraneous false and close-in dual tracks adversely affecting its performance.
- Integration of the DBR electronic protection capabilities remains incomplete and unfunded. With modern threats, a lack of electronic protection places the ship in a high-risk scenario if deployed to combat.
- The Navy analysis noted that DBR performance needs to be improved to support carrier air traffic control center certification.

Sortie Generation Rate

- 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 EMI and radiation hazard 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 vulnerability of CVN 78's many new critical systems to underwater threat-induced shock is unknown. The program plans to complete shock testing on EMALS, AAG, and the AWE components during CY19, but because of a scarcity of systems, shock testing of DBR components lags and will likely not be completed before the FSSTs.
- The Vulnerability Assessment Report provides 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 FY19, 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. Provide schedule, funding, and an execution strategy for assessing SGR. This strategy should specify which testing will be accomplished live, a process for accrediting the Seabasing/Seastrike Aviation Model for operational testing, and a method for comparing CVN 78 performance with that of the *Nimitz* class.
2. Continue to characterize the electromagnetic environment onboard 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.
3. Develop and implement DBR electronic protection to enhance ship survivability against modern threats.
4. Submit an updated TEMP.