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

Executive Summary

- The Commander, Operational Test and Evaluation Force (COTF) completed a DOT&E-approved operational assessment of the CVN-78 in October 2013.
- It is unlikely that CVN-78 will achieve its Sortie Generation Rate (SGR) (number of aircraft sorties per day) 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 (e.g., to avoid land), and manning shortfalls will not affect flight operations. DOT&E plans to assess CVN-78 performance during IOT&E by comparing to the demonstrated performance of the *Nimitz* class carriers. A demonstrated SGR less than the requirement but equal to or greater than the performance of the *Nimitz* class could potentially be acceptable.
- CVN-78 incorporates newly designed catapults, arresting gear, weapons elevators, and radar, which are all critical for flight operations. The current reliability estimates for the catapult and arresting gear systems are a small fraction of their projected target for the shipboard configuration, and an even smaller fraction of the required reliability. Reliability test data are not available for the radar and the weapons elevators. DOT&E assesses that the poor or unknown reliability of these critical systems will be the most significant risk to CVN-78's successful completion of IOT&E.
- The CVN-78 design is intended to reduce manning. As manning requirements have been further developed, analysis indicates the present design has insufficient berthing for some ranks. The ship will not be delivered with sufficient empty berthing for the CVN-78's Service Life Allowance (SLA). The SLA provides empty bunks to allow for changes in the crew composition over CVN-78's expected 50-year lifespan, as well as ship riders for repairs, assists, and inspections.
- The CVN-78 combat system for self-defense is derived from the combat system on current carriers and is expected to have similar capabilities and limitations.
- The Navy continues to work on integration challenges related to the F-35 Joint Strike Fighter (JSF) and its fleet of aircraft carriers, including CVN-78.
- Although CVN-78 will include a new Heavy underway replenishment (UNREP) system that will transfer cargo loads of up to 12,000 pounds, the Navy's plan to install Heavy UNREP systems on resupply ships beginning in FY16 is unfunded. Heavy UNREP is needed to transfer JSF engines to CVN-78 when it is at-sea.
- The current Test and Evaluation Master Plan (TEMP) does not adequately address integrated platform-level developmental testing, significantly raising the likelihood that platform-level problems will be discovered during IOT&E. The Program Office is said to be addressing the problem and is in the process of refining the post-delivery schedule.
- The Navy began CVN-78 construction in 2008. The schedule to deliver the ship has slipped from September 2015 to March 2016. The Electromagnetic Aircraft Launching System (EMALS), Advanced Arresting Gear (AAG), Dual Band Radar (DBR), and Integrated Warfare System will continue to drive the timeline.
- On June 12, 2012, DOT&E rescinded approval of the alternative LFT&E Management Plan pertaining to the *Gerald R. Ford* (CVN-78) class carrier program. The Navy has not yet addressed the Full Ship Shock Trial (FSST) issue satisfactorily.

System

- The CVN-78 *Gerald R. Ford* class nuclear aircraft carrier program is a new class of nuclear-powered aircraft carriers that replaces the previous CVN-21 program designation. It has the same hull form as the CVN-68 *Nimitz* class, but many ship systems, including the nuclear plant and the flight deck, are new.
- The newly designed nuclear power plant is intended to operate at a reduced manning level that is 50 percent of a CVN-68 class ship and produce significantly more electricity.
- The CVN-78 will incorporate EMALS (electromagnetic, instead of steam-powered), and AAG, and will have a smaller island with a DBR (a phased-array radar which replaces/combines several legacy radars used on current aircraft carriers).
- The Navy intends for the Integrated Warfare System to be adaptable to technology upgrades and varied missions throughout the ship's projected operating life including

increased self-defense capabilities compared to current aircraft carriers.
- The ship's DBR replaces the myriad radars on *Nimitz* class carriers serving in air traffic control and in ship self-defense.
- The Navy redesigned weapons stowage, handling spaces, and elevators to reduce manning, increase safety, and increase throughput of weapons.
- CVN-78 has design features intended to enhance its ability to launch, recover, and service aircraft, such as a slightly larger flight deck, dedicated weapons handling areas, and increased aircraft refueling stations. The Navy set the SGR requirement for CVN-78 to increase the sortie generation capability of embarked aircraft to 160 sorties per day (12-hour fly day) and to surge to 270 sorties per day (24-hour fly day) as compared to the CVN-68 *Nimitz* class SGR demonstration of 120 sorties per day/240 sorties for 24-hour surge.
- The Consolidated Afloat Networks and Enterprise Services (CANES) program replaces five shipboard legacy network programs to provide a common computing environment for command, control, intelligence, and logistics.
- CVN-78 is intended to support the JSF.
- The Navy plans to declare CVN-78 Initial Operational Capability in FY17 and achieve Full Operational Capability in FY19 (after the ship completes IOT&E and the Type Commander certifies that CVN-78 is Major Combat Operations Ready).

Mission

Carrier Strike Group Commanders will use the CVN-78 to:
- Conduct power projection and strike warfare missions using embarked aircraft
- Provide force protection of friendly units
- 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

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Activity

Test Planning
- The Navy continues to develop the CVN-78 SGR test modeling. The Navy plans to reestablish the SGR working group in early FY14. The ship's SGR requirement is based on a 30-plus-day wartime scenario. The Navy designed a test to demonstrate the SGR with 6 consecutive 12-hour fly days followed by 2 consecutive 24-hour fly days. This live testing will be supplemented with modeling and simulation from the Virtual Carrier (VCVN) model to extrapolate results to the 30-plus-day SGR requirement. DOT&E concurs with this approach.
- The CVN-78 *Gerald R. Ford* class carrier Program Office continues revising the TEMP in an effort to align planned developmental tests with corresponding operational test phases and to identify platform-level developmental testing. The Program Office released an updated Post-Delivery Test and Trials schedule.
- The Navy conducted all operational testing in accordance with a DOT&E-approved test plan.

Operational Assessment
- COTF conducted an operational assessment (OT-B3) from September 2012 through September 2013 to assess the ability of CVN-78 to successfully undergo its IOT&E in 2017. The COTF assessment was a desktop mission-based analysis with specific emphasis on the review of previously identified issues as well as risk assessments of new issues. DOT&E participated in the assessment. DOT&E published an Operational Assessment report in December 2013, which will inform the Defense Acquisition Board decision regarding future procurement of CVN-79.

EMALS
- The EMALS system functional design test site at Joint Base McGuire-Dix-Lakehurst, New Jersey, continues to test the new electromagnetic catapult system. Aircraft compatibility testing continued in 2013. Approximately 400 aircraft launches are being conducted using EA-18G, F/A-18E, F/A-18C, E-2D, T-45, and C-2 aircraft. The Navy has also conducted an additional 1,200 dead-load launches (non-aircraft, weight equivalent, simulated launches). Approximately 55 percent of the EMALS government furnished equipment (GFE) has been delivered to the shipyard.

AAG
- The Navy continues testing the AAG on a jet car track at Joint Base McGuire-Dix-Lakehurst, New Jersey. Testing has prompted design changes for the system's Water Twisters, Cable Shock Absorbers, Mechanical Brake, and Arresting Engine Controller. Performance testing began in April 2013, and approximately 71 dead-load performance tests have been conducted. About 43 percent of the AAG GFE has been delivered to the shipyard.

CANES
- The Navy has scheduled developmental and follow-on operational testing of the force-level CANES configuration used on the *Nimitz* and *Gerald R. Ford* classes for 1Q and 2QFY15. A full system test of the Aegis destroyer configuration occurred this year. Developmental testing and IOT&E of the Aegis destroyer configuration are scheduled for 2Q and 3QFY14.

DBR
- The Navy reactivated the Engineering Development Model of the Volume Search Radar portion of the DBR at the

Surface Combat System Center at Wallops Island, Virginia. The Navy planned to begin testing in January 2013; however, the testing has slipped repeatedly. The first government-led integrated test events began in 1QFY14.

JPALS

- The Navy conducted the Joint Precision Approach and Landing System (JPALS) operational assessment on CVN-77 from May through August 2013. During the assessment, the Navy conducted at-sea requirements verification and collected data to support Navy Data Link Model, Performance Model, and Availability Model Verification, Validation, and Accreditation. A variety of afloat operations with a King Air (simulating the C-2A), MH-60S, and two F/A-18C aircraft were conducted, including about 120 approaches and 20 captures. Associated land-based testing was conducted at the Patuxent River Landing System Test Facility and the St. Inigoes (Maryland) Air Traffic Control Integration Laboratory. Both the afloat and land-based testing was terminated before it was completed because of an anticipated Nunn-McCurdy breach.

JSF

- The Navy is working to address several JSF integration challenges on its aircraft carriers. In general, these issues affect all of the Navy's carriers, not just CVN-78.
- In FY12, a test of the JSF arresting hook identified problems with the design. After failing to engage the arresting cable and demonstrating insufficient load-carrying capacity, the Navy has redesigned the arresting hook system and will test it at Joint Base McGuire-Dix-Lakehurst, New Jersey, in 1QFY14.
- The Navy is redesigning the cooling system in the CVN-78's Jet Blast Deflectors (JBDs). The JBDs deflect engine exhaust during catapult launches. The redesign is needed to handle JSF engine exhaust and will include improvements in side-cooling panels. The Navy will install the redesigned JBDs into CVN-78 after ship delivery.
- CVN-78 will receive the new Heavy UNREP system. To use the Heavy UNREP capability, both the carrier and the resupply ship must be equipped with the system. This new Heavy UNREP system, along with heavy vertical lift aircraft not embarked on carriers, are the only systems currently capable of resupplying the JSF engine and container while the carrier is underway. Today, only one combat logistic ship has Heavy UNREP, USNS *Arctic*. The installation on other Combat Logistic Fleet ships is planned for FY16, but is currently unfunded.
- The JSF engine container was unable to sustain the required sudden drop of 18 inches (4.5 g's) without damage to the power module during shock testing. The Navy is redesigning the container to better protect the engine, which will likely result in an increase in container size and weight. The Navy estimates the new container will be available in late calendar year 2016.
- The Navy is designing separate charging and storage lockers for the lithium-ion batteries required for the JSF. The Navy is also designing a new storage locker for pilot flight equipment as the JSF helmet is larger and more fragile than legacy helmets.
- The Navy has completed JSF cyclic thermal strain testing and concluded that repeated JSF sortie generation at combat rated thrust, i.e., afterburner, will not cause cyclic thermal strain on the CVN-78 flight deck structure.
- The National Security Agency has determined that the JSF Prognostic Health Management (PHM) system downlink poses unacceptable security risks. The PHM reports on the health of the aircraft as it returns from a mission. The Navy has not established a path forward because the JSF Program Office does not have funding to address this issue.
- Unlike current fleet aircraft, the JSF carries ordnance in internal bays. This will require changes to aircraft firefighting techniques for the JSF. The Navy has continued to conduct mock firefighting testing to develop new procedures in the event of a fire on the flight deck near aircraft carrying internal ordnance.
- The JSF Program Office has initiated a tire redesign because of higher than predicted failure rates. The Navy has not yet settled on a strategy for dealing with a possible higher tire storage requirement.

LFT&E

- On June 12, 2012, DOT&E rescinded approval of the alternative LFT&E Management Plan pertaining to the *Gerald R. Ford* class carrier program because the Navy deferred the FSST to CVN-79.

Assessment

Test Planning

- The current state of the VCVN model does not fully provide for an accurate accounting of SGR due to a lack of fidelity regarding manning and equipment/aircraft availability. Spiral development of the VCVN model continues in order to ensure that the required fidelity will be available to support the SGR assessment during IOT&E.
- A new TEMP is under development to address problems with the currently-approved TEMP. The current TEMP does not adequately address platform-level developmental testing. The Program Office has begun to refine the Post Delivery Test and Trials schedule, but that schedule still lacks sufficient details to ensure reasonable developmental testing. Lack of platform-level developmental testing significantly raises the likelihood of the discovery of platform-level problems during IOT&E.
- The Navy plans to deliver CVN-78 in February 2016. The ship's post-shipyard shakedown availability will follow delivery in 2016. During the post-shipyard shakedown availability installations of some systems will be completed. The first at-sea operational test and evaluation of CVN-78 will begin in July 2017.

Reliability

- CVN-78 includes several systems that are new to aircraft carriers; four of these systems stand out as being critical to flight operations: EMALS, AAG, DBR, and the Advanced

Weapons Elevators (AWEs). Overall, the uncertain reliability of these four systems is the most significant risk to the CVN-78 IOT&E. All four of these systems will be tested for the first time in their shipboard configurations aboard CVN-78. Reliability estimates derived from test data are available for EMALS and AAG and are discussed below. For DBR and AWE, estimates based on test data are not available and only engineering reliability estimates are available.

SGR

- It is unlikely that CVN-78 will 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 (e.g., to avoid land), and manning shortfalls will not affect flight operations. DOT&E plans to assess CVN-78 performance during IOT&E by comparing to the demonstrated performance of the *Nimitz* class carriers. A demonstrated SGR less than the requirement but equal to or greater than the performance of the *Nimitz* class could potentially be acceptable.
- During the 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 and that CVN-78 is unlikely to achieve that requirement. There are concerns with the reliability of key systems that support sortie generation on CVN-78. Poor reliability of these critical systems could cause a cascading series of delays during flight operations that would affect CVN-78's ability to generate sorties, make the ship more vulnerable to attack, or create limitations during routine operations. DOT&E assesses the poor or unknown reliability of these critical subsystems will be the most significant risk to CVN-78's successful completion of IOT&E. The analysis also considered the operational implications of a shortfall and concluded that as long as CVN-78 is able to generate sorties comparable to *Nimitz* class carriers, the operational implications of CVN-78 will be similar to that of a *Nimitz* class carrier.

Manning

- Current manning estimates have shortages of bunks for Chief Petty Officers (CPOs) and do not provide the required 10 percent SLA. Per Office of the Chief of Naval Operations Instruction 9640.1B, Shipboard Habitability Program, all new ships are required to have a growth allowance of 10 percent of the ship's company when the ship delivers. The SLA provides empty bunks to allow for changes in the crew composition over CVN-78's expected 50-year lifespan and provides berthing for visitors and Service members temporarily assigned to the ship.

EMALS

- EMALS is one of the four systems critical to flight operations. While testing to date has demonstrated that EMALS should be able to launch aircraft planned for CVN-78's air wing, the system's reliability is uncertain. At the Lakehurst, New Jersey, test site, over 1,967 launches have been conducted and 201 chargeable failures have occurred. Based on available data, the program estimates that EMALS has approximately 240 Mean Cycles Between Critical Failure in the shipboard configuration, where a cycle represents the launch of one aircraft. Based on expected reliability growth, the failure rate is presently five times higher than should be expected.

AAG

- AAG is another system critical to flight operations. Testing to date has demonstrated that AAG should be able to recover aircraft planned for the CVN-78 air wing, but as with EMALS, AAG's reliability is uncertain. At the Lakehurst, New Jersey test site, 71 arrestments were conducted earlier this year and 9 chargeable failures occurred. The Program Office estimates that AAG has approximately 20 Mean Cycles Between Operational Mission Failure in the shipboard configuration, where a cycle represents the recovery of one aircraft. Based on expected reliability growth, the failure rate is presently 248 times higher than should be expected.

DBR

- Previous testing of Navy combat systems similar to CVN-78's revealed numerous integration problems that degrade the performance of the combat system. Many of these problems are expected to exist on CVN-78. The previous results emphasize the necessity of maintaining a DBR/CVN-78 combat system asset at Wallops Island. The Navy is considering long-term plans (i.e., beyond FY15) for testing DBR at Wallops Island, Virginia, but it is not clear if resources and funding will be available. Such plans are critical to delivering a fully-capable combat system and ensuring lifecycle support after CVN-78 delivery in 2016.

JPALS

- The Navy has proposed to the USD(AT&L) Milestone Decision Authority that the program be restructured from its current, land- and sea-based, multiple-increment structure to a single increment focusing on sea-based requirements primarily supporting JSF and future Unmanned Carrier Launched Airborne Surveillance and Strike aircraft. Under this proposed restructuring scheme, there will be no retrofitting of JPALS on legacy aircraft and the Navy will need to maintain both the legacy approach and landing system and JPALS onboard each aircraft-capable ship.

JSF

- The arresting hook system remains an integration risk as the JSF development schedule leaves no time for discovering new problems. The redesigned tail hook has an increased downward force as well as sharper design that may induce greater than anticipated wear on the flight deck.
- JSF noise levels remain moderate to high risk in JSF integration and will require modified carrier flight deck procedures.
  - Flight operations normally locate some flight deck personnel in areas where double hearing protection

would be insufficient during F-35 operations. To partially mitigate noise concerns, the Navy will procure new hearing protection with active noise reduction for flight deck personnel.
  - Projected noise levels one level below the flight deck (03 level), which includes mission planning spaces, will require at least single hearing protection that will make mission planning difficult. The Navy is working to mitigate the effects of the increased noise levels adjacent to the flight deck.
- Storage of the JSF engine is limited to the hangar bay, which will affect hangar bay operations. The impact on the JSF logistics footprint is not yet known.
- Lightning protection of JSF aircraft while on the flight deck will require the Navy to modify nitrogen carts to increase their capacity. Nitrogen is used to fill fuel tank cavities while aircraft are on the flight deck.
- JSF remains unable to share battle damage assessment and non-traditional Intelligence, Surveillance, and Reconnaissance information captured on the aircraft portable memory device or cockpit voice recorder in real-time. In addition, the CVN-78 remains unable to receive and display imagery transmitted through Link 16 because of bandwidth limitations. These capability gaps were identified in DOT&E's FY12 Annual Report. The Combatant Commanders have requested these capabilities to enhance decision-making.

LFT&E

- While the Navy has made substantial effort in component and surrogate testing, this work does not obviate the need to conduct the FSST to gain the critical empirical data that past testing has repeatedly demonstrated are required to rigorously evaluate the ship's ability to withstand shock and survive in combat. Shock Trials conducted on both the *Nimitz* class aircraft carrier and the *San Antonio* class Amphibious Transport Dock demonstrated the need for and substantial value of conducting the FSST. Postponing the FSST until CVN-79 would cause a five- to seven-year delay in obtaining the data critical to evaluating the survivability of the CVN-78 and would preclude timely modification of subsequent ships of this class to assure their survivability.
- CVN-78 has many new critical systems that have not undergone shock trials on other platforms. Unlike past tests on other new classes of ships with legacy systems, the performance of CVN-78's new critical systems under test is unknown.
- The Navy proposes delaying the shock trial by five to seven years because of the approximately four- to six-month delay required to perform the FSST. The benefit of having test data to affect the design of future carriers in the class outweighs the delay in delivery of CVN-78 to the fleet to conduct this test. The delay is not a sufficient reason to postpone the shock trial.

Recommendations

- Status of Previous Recommendations. The Navy should continue to address the seven remaining FY10 and FY11 recommendations.
  1. Adequately test and address integration challenges with JSF; specifically:
     - Logistics (unique concerns for storage and transportation)
     - Changes required to JBDs
     - Changes to flight deck procedures due to heat and noise
     - Autonomic Logistics Information System integration
  2. Finalize plans that address CVN-78 Integrated Warfare System engineering and ship's self-defense system discrepancies prior to the start of IOT&E.
  3. Continue aggressive EMALS and AAG risk-reduction efforts to maximize opportunity for successful system design and test completion in time to meet required in-yard dates for shipboard installation of components.
  4. Continue development of a realistic model for determining CVN-78's SGR, while utilizing realistic assumptions regarding equipment availability, manning, and weather conditions for use in the IOT&E.
  5. Provide scheduling, funding, and execution plans to DOT&E for the live SGR test event during the IOT&E.
  6. Continue to work with the Navy's Bureau of Personnel to achieve adequate depth and breadth of required personnel to sufficiently meet Navy Enlisted Classification fit/fill manning requirements of CVN-78.
  7. Conduct system-of-systems developmental testing to preclude discovery of deficiencies during IOT&E.
- FY13 Recommendations. The Navy should:
  1. Address the uncertain reliability of EMALS, AAG, DBR, and AWE. These systems are critical to CVN-78 flight operations, and are the largest risk to the program.
  2. Conduct fully integrated, robust, end-to-end testing of the proposed JPALS, to include operations in neutral and potentially hostile electronic warfare environments.