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

Executive Summary

- DOT&E's assessment of CVN-78 remains consistent with the report DOT&E issued in December 2013, which was based on data obtained during a DOT&E-approved Commander, Operational Test and Evaluation Force (COTF) operational assessment completed in December 2013.
- The Navy submitted the LFT&E Management Plan, Revision B in July 2014. Although the plan was adequate with respect to the Total Ship Survivability Trial (TSST) on CVN-78 and the Analytical Bridge, DOT&E returned the plan to the Navy because it called for the Full Ship Shock Trial (FSST) on CVN-79 instead of CVN-78. The original Alternative Live Fire Strategy prepared by the Navy and approved by DOT&E on December 9, 2008, stated the FSST would be conducted on CVN-78. The Navy unilaterally reneged on the approved strategy on June 18, 2012. The Navy has not submitted an updated Test and Evaluation Master Plan (TEMP) to DOT&E. The last approved TEMP was TEMP 1610 Revision B, which was approved in 2007.
- TEMP 1610 Revision C, which is in revision, improves integrated platform-level developmental testing, reducing the likelihood that platform-level problems will be discovered during IOT&E. In addition, the Program Office is in the process of refining the post-delivery schedule to further integrate testing.
- CVN-78 incorporates newly designed catapults, arresting gear, weapons elevators, and radar, which are all critical for flight operations.
- Reliability for the catapult and arresting gear systems have not been reported on in over a year. Before the Navy stopped tracking/reporting on catapult and arresting gear performance, both systems were performing well below their projected target to achieve 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.
- Testing at the Electromagnetic Aircraft Launching System (EMALS) functional demonstration test site at Joint Base McGuire-Dix-Lakehurst, New Jersey, discovered an excessive EMALS holdback release dynamics during F/A-18E/F and EA-18G catapult launches with wing-mounted 480-gallon external fuel tanks (EFTs). This discovery, if uncorrected, would preclude the Navy from conducting normal operations of the F/A-18E/F and EA-18G from CVN-78. The Navy has no plan to address this discovery in FY15.
- 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 requiring re-designation/redesign of some spaces as a possible solution. The ship will not be delivered with sufficient empty berthing for the CVN-78's Service Life Allowance (SLA). The SLA would provide empty bunks to allow for changes in the crew composition over CVN-78's expected 50-year lifespan, as well as surge capacity, and 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 (F-35) and its fleet of aircraft carriers, including CVN-78.
- 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, and manning shortfalls will not affect flight operations. Discovery of EMALS excessive holdback release dynamics, as well as possible solutions, could significantly limit the carriers' SGR. DOT&E plans to assess CVN-78 performance during IOT&E by comparing to the demonstrated performance of the *Nimitz* class carriers as well as to the SGR requirement.
- 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 plans to install Heavy UNREP systems on resupply ships beginning in FY21 with T-AO(X).
- The Navy began CVN-78 construction in 2008, and the ship was christened November 9, 2013. The schedule to deliver the ship has slipped from September 2015 to March 2016. The development, construction, and testing of EMALS, Advanced Arresting Gear (AAG), Dual Band Radar (DBR), and Integrated Warfare System will continue to drive the timeline.

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 serving in air traffic control and in ship self-defense).
- 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 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 F-35 and future weapons systems over the expected 50-year ship's lifespan.
- The Navy plans to declare CVN-78 Initial Operational Capability in FY17 and achieve Full Operational Capability in FY19 (during IOT&E and after 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 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

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Activity

Test Planning

- The CVN-78 *Gerald R. Ford* class carrier Program Office revised the TEMP 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 continues to develop the CVN-78 SGR test modeling. The Navy is conducting weekly Configuration Review Board meetings to refine requirements for model development through FY17. The ship's SGR requirement is based on a 30-plus-day wartime scenario. The Navy intends to update the 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.

EMALS

- The EMALS functional demonstration test site at Joint Base McGuire-Dix-Lakehurst, New Jersey, continues to test the new electromagnetic catapult system. Aircraft compatibility testing was completed in April 2014. A total of 452 aircraft launches were conducted using EA-18G, F/A-18E, F/A-18C, E-2D, T-45, and C-2A aircraft. The testing discovered excessive EMALS holdback release dynamics during F/A-18E/F and EA-18G catapult launches with wing-mounted 480-gallon EFTs. Aircraft dynamics are considered excessive if they exceed stress limits of the airframe, internal, or external stores. This discovery, if uncorrected, would preclude normal employment of the F/A-18E/F and EA-18G from CVN-78. There is no funding at this time to correct this deficiency.
- The Navy has also conducted over 3,000 dead-load launches (non-aircraft, weight equivalent, and simulated launches). EMALS is currently undergoing laboratory environmental qualification testing and testing of engineering changes to correct observed failures. Shipboard testing began on August 11, 2014, with below decks components. Approximately 94 percent of the EMALS equipment has been delivered to the shipyard. All linear motors are planned to be installed by the end of 1QFY15 to include the main power cables on catapults 1, 2, and 3.

AAG

- The Navy continues testing the AAG on a jet car track at Joint Base McGuire-Dix-Lakehurst, New Jersey, with 528 arrestments completed by August 2014. Testing has prompted system design changes. A failure in the water twister suspended testing in November 2013; the Navy authorized return-to-test in January 2014. Dead-load testing resumed in May to validate performance of modifications to the mechanical brake. Runway Arrested Landing Site (RALS) preparation began using equipment planned for CVN-78. The Navy de-scoped the number 4 AAG engine, reducing the total arresting gear engines on the ship, including the barricade, to three, and diverted the following equipment to RALS in Lakehurst: the water twisters, electric motors, purchase cable drum assemblies, and cable shock absorbers for the number 4 arresting gear engine. Approximately 94 percent of the remaining AAG equipment 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 2Q and 3QFY15.
- The Navy conducted operational testing in accordance with a DOT&E-approved test plan.
- The Navy conducted integrated testing and IOT&E of the unit-level Aegis destroyer configuration in 3Q and 4QFY14.

DBR

- The Navy installed a production Multi-Function Radar and reactivated the Engineering Development Model of the Volume Search Radar 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, and to date, no live testing with the full production DBR has been completed. The first government-led integrated test events began in 1QFY14. The first developmental testing of DBR began in 4QFY14 at Wallops Island.

Manning

- The Navy conducted CVN-78 Manning War Game III in July 2014 to identify CVN-78 unique Manpower, Personnel, Training, and Education planning and execution concerns. The results of the War Game have not been published.

JPALS

- The Joint Precision Approach and Landing System (JPALS) is no longer funded for CVN-78.
- In June 2014, following a Nunn-McCurdy breach, USD(AT&L) rescinded Milestone B approval for the sea-based Increment 1A of the JPALS land- and sea-based multiple-increment JPALS program. USD(AT&L) directed the Navy to restructure the multiple-increment program into a single increment focusing on sea-based requirements primarily supporting F-35 and future Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) aircraft.
- Under the restructured program, the Navy will complete the development phase for precision approach and landing capability for JPALS-equipped manned aircraft at sea with the addition of risk reduction efforts to prepare for future manned and unmanned auto-land capability. The actual production phase of JPALS will be deferred until it is required for F-35 and UCLASS aircraft. There will be no retrofitting of legacy aircraft with JPALS. The Navy will need to maintain both the legacy approach and landing system and JPALS onboard each ship designated to receive future JPALS-equipped aircraft.

F-35

- The Navy is working to address several F-35 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 F-35 arresting hook system 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. Testing at Joint Base McGuire-Dix-Lakehurst began in April 2014 and completed in September 2014, followed by shipboard trials onboard USS *Nimitz* in 1QFY15. The re-designed hook has been successful in arresting the aircraft. 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 F-35 engine exhaust and will include improvements in cooling flow and eventual addition of side-cooling panels. Until side-cooling panels are installed, the F-35 will be thrust and weight limited for take-off, with associated penalties in payload and/or range. Side cooling panels are expected to be installed on CVNs in the early 2020's.
- 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 F-35 containerized engine while the carrier is underway. Today, only one combat logistic ship has Heavy UNREP, USNS *Arctic*. The Navy plans to have Heavy UNREP systems installed on resupply ships starting with T-AO(X) in FY21. The current acquisition strategy has one T-AO ship delivery every year after that for a total of 17 ships.
- The Navy is designing separate charging and storage lockers for the lithium-ion batteries required for the F-35 and for F-35 weapons loading support equipment. This includes aircraft battery accommodations below decks and ready service lockers for weapons loader batteries on the flight deck. The Navy is also designing a new storage locker for pilot flight equipment as the F-35 helmet is larger and more fragile than legacy helmets.
- The Navy has completed F-35 cyclic thermal strain testing and concluded that repeated F-35 sortie generation at

combat rated thrust, i.e., afterburner, will not cause cyclic thermal strain on the CVN-78 flight deck structure.
- Unlike current fleet aircraft, the F-35 carries ordnance in internal bays. This will require changes to aircraft firefighting techniques for the F-35. The Navy is developing new firefighting equipment to attach to existing hose nozzles, including a tow-bar mounted spray device for open bay firefighting, and a penetrating device to punch through the aircraft skin for closed bay scenarios.
- The F-35 Joint Program Office has initiated a tire redesign for the F-35B due to higher than predicted wear rates. The Navy has not yet settled on a strategy for dealing with a possible higher tire storage requirement.
- The F-35 is very loud aircraft. The noise level in some operating envelopes is presently being tested on the flight deck. The Navy has determined the problem of aircraft noise on the flight deck is significantly worse than they originally thought. This may require the installation of noise abatement material below the flight deck to allow for conversational speech in work spaces located on the O3 level. The Navy plans to investigate noise levels during shipboard trials in 1QFY15 to help determine a solution.
- The F-35 ejection seat has a higher center of gravity than legacy seats, requiring additional tie downs for heavy seas when installed in the maintenance dolly. The F-35 program is planning to use the Navy Aircrew Common Ejection Seat (NACES) Seat Dolly and will provide an adaptor for its seat. The Navy and F-35 Program Office will assess the need for changes to the seat shop when the drawings for the adaptor are completed. The use of the NACES Seat Dolly is anticipated to eliminate the need to change the seat shop. The Navy is currently determining what modifications this will require for the seat shop.

LFT&E
- The Navy submitted the LFT&E Management Plan, Revision B in July 2014. Although the plan was adequate with respect to the TSST on CVN-78 and the Analytical Bridge, DOT&E returned the plan to the Navy because it called for the FSST on CVN-79 instead of CVN-78 as stipulated in the original Alternate Live Fire Strategy approved on December 9, 2008.

Assessment

Test Planning
- A new TEMP is under development to address problems with the currently-approved TEMP. The TEMP in the approval process improves integrated platform-level developmental testing, reducing the likelihood that platform-level problems will be discovered during IOT&E. In addition, the Program Office is in the process of refining the post-delivery schedule to further integrate testing.
- 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.
- The Navy plans to take delivery CVN-78 in March 2016. The ship's post-shipyard shakedown availability will follow delivery in late 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 September 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 were provided last year for EMALS and AAG and are discussed below. The Navy has stated that in the last year, they did not assess EMALS and AAG reliability due to systems' redesign and investigative and developmental testing. For DBR and AWE, estimates based on test data are not available and only engineering reliability estimates are available.

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, present limitations on F/A-18E/F and EA-18G configurations as well as the system's reliability remains uncertain. As of December 2013, at the Lakehurst, New Jersey, test site, over 1,967 launches had been conducted with 201 chargeable failures. At that time, 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 for the last reported Mean Cycles Between Critical Failure was five times higher than should have been expected. As of August 2014, the Navy has reported that over 3,017 launches have been conducted at the Lakehurst test site, but have not provided DOT&E with an update of failures. The Navy intends to provide DOT&E an update of failures in December 2014.

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 test site, 71 arrestments were conducted early in 2013 and 9 chargeable failures occurred. The Program Office last provided reliability data in December 2013 and estimated that AAG had approximately 20 Mean Cycles Between Operational Mission Failure in the shipboard configuration, where a cycle represents the recovery of

one aircraft. Following these tests, the Navy modified the system and has yet to score reliability of AAG. Based on expected reliability growth as of 2013, the failure rate was 248 times higher than should have been 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, 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 life-cycle support after CVN-78 delivery in 2016.

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, and manning shortfalls will not affect flight operations. 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.
- 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 for all berthing. The Navy plans to re-designate/design some officer rooms as CPO berthing spaces. Per the 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.

JPALS

- As the Navy reformulates the JPALS Test and Evaluation Master Plan, it faces significant challenges in defining how it will demonstrate the operational effectiveness and operational suitability of the restructured system without a representative aircraft platform.

F-35

- The arresting hook system remains an integration risk as the F-35 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.
- F-35 noise levels remain moderate to high risk in F-35 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 F-35 engine is limited to the hangar bay, which will affect hangar bay operations. The impact on the F-35 logistics footprint is not yet known.
- Lightning protection of F-35 aircraft while on the flight deck will require the Navy to modify nitrogen carts to increase their capacity. Nitrogen is filled in fuel tank cavities while aircraft are on the flight deck or hangar bay.
- F-35 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; this problem is not unique to F-35. 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

- The Navy has made substantial progress on defining the scope of the TSST and the Analytical Bridge task. While these portions of the LFT&E Management Plan were adequately defined in the Revision B document, DOT&E returned the LFT&E Management Plan to the Navy solely on the basis of the FSST on CVN 79 verses CVN-78.

- CVN-78 has many new critical systems, such as EMALS, AAG, and DBR, 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 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 eight remaining FY10, FY11, and FY13 recommendations.
  1. Adequately test and address integration challenges with F-35; 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.
  8. 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.
- FY14 Recommendations. The Navy should:
  1. Aggressively fund and address a solution for the excessive EMALS holdback release dynamics during F/A-18E/F and EA-18G catapult launches with wing-mounted 480-gallon EFTs.
  2. Plan for fully integrated, robust, end-to-end testing of the restructured JPALS onboard both manned high-performance and unmanned aircraft, including operations in neutral and potentially hostile electronic warfare environments.