

Theory and Practice of Integrated Test for Navy Programs

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The role of test and evaluation (T&E) is to provide acquisition program decision makers at all levels with information on a weapon system's effectiveness and suitability. T&E supports validation of the weapon system's capabilities and limitations and their associated concept of operations. T&E is an integral part of the systems engineering process, where contractor test, developmental test, live fire test, and operational test all contribute to design understanding, design iteration, and ultimately design confirmation. T&E results are needed to support the formal Department of Defense (DOD) acquisition decision making process from early phases through life cycle management, to include technology development phase, engineering and manufacturing development phase, production and deployment of system phase, and planned product improvements. T&E is most effective and efficient when it is conducted early in a program with direct assimilation to the systems engineering plan and integrated with related activities. In response to findings and recommendations from past T&E process studies and today's acquisition policy, the U.S. Navy has implemented integrated testing within its weapon systems programs and within its T&E enterprise. Results, although at times difficult to measure, indicate that the benefits in terms of cost avoidance and schedule reductions for Navy programs have been positive. Challenges abound, but lessons learned have been identified and best practices are being shared as discussed in this article.

Key words: Collaboration; combined DT/OT; contractor testing; Navy policy; operational testing.

In accordance with Department of Defense (DOD) and U.S. Navy acquisition instructions, integrated testing is defined as the collaborative planning and collaborative execution of test and evaluation (T&E) phases and events to provide shared data in support of independent analysis, evaluation, and reporting by all stakeholders. This includes the developmental (both contractor and government) and operational T&E communities. Integrated testing leverages early and continuous operational testing (OT) with contractor testing (CT) and developmental testing (DT) to form a cohesive testing continuum that supports an operationally realistic evaluation of the system in development. Navy policy emphasizes early and continuous T&E throughout the acquisition life cycle of a weapon system.

The purpose of T&E is to gain knowledge that can be used to (a) advance system development, (b) make

programmatic acquisition decisions, and (c) inform users about the system's operational characteristics and performance. Preferably, integrated testing efforts need to start during material solutions analysis and requirements development, to allow for test community understanding of objectives, influence the evaluation of technology alternatives and ascertain the use of operationally realistic test environments. Early involvement also allows for early identification and resolution of deficiencies resulting from T&E in a cost effective and timely manner. Integration of efforts also breaks down stovepipe barriers and enhances efficiency in cost, schedule and performance.

Integrating the enterprise

In 2005, the Navy completed a critical study involving a bottom-up review of T&E domain processes, and major cost and schedule drivers that

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impacted Navy acquisition programs. The study was led by Commander, Operational Test and Evaluation Force (COMOPTEVFOR) and included broad participation from the Navy T&E and acquisition community. A consensus by study participants emerged that T&E cost drivers identified in earlier reports were still valid and that prior improvement recommendations were slow in implementation. A critical recommendation was to provide a strategic top-down approach in Navy T&E enterprise management to make change happen and to help coordinate efforts across the T&E domain. For the most part, programs do a good job of coordinating the testing of systems for platforms within their purview. However, the T&E process usually begins and ends within programmatic stovepipes.

The Navy study also found that the enterprise view of T&E was limited in regards to the coordination across the acquisition business enterprise and the diverse weapon system development efforts to address the availability of testing resources, T&E policy and improvement initiatives, development efforts and fleet training. The study identified a need for a single T&E process owner and chartered a T&E task force. That task force evolved into the current Navy Enterprise T&E Board of Directors (BoD) to provide synergy and continuous improvement across the T&E domain in support of acquisition programs.

The 2005 T&E study, amongst other findings and recommendations, concluded that integrated testing should be viewed as an order of magnitude increase in collaboration over traditional DT/OT. The study recommended the conduct of integrated CT/DT/OT, using the program's T&E Working Integrated Product Team (WIPT) to develop, coordinate, and execute DT and OT events through phase specific integrated test plans within the Test and Evaluation Master Plan (TEMP).

Navy T&E Executive

In January 2007, Assistant Secretary of the Navy, Research, Development and Acquisition (ASN[RDA]) in concert with Vice Chief of Naval Operations (VCNO) and the Assistant Commandant of the Marine Corps (ACMC), realigned functions that created the Department of the Navy (DON) T&E Executive. Specifically, CNO (N091), Director, Navy T&E and Technology Requirements, was designated and assigned collateral duties as the DON T&E Executive. For matters pertaining to T&E policy, requirements, and operational test resources, the DON T&E Executive reports to VCNO and ACMC as needed. For matters pertaining to development in acquisition programs, the DON T&E Executive reports to ASN(RDA). The DON T&E Executive

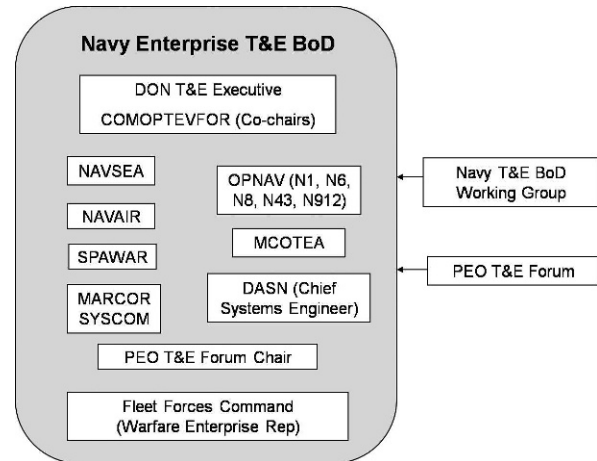


Figure 1. Navy enterprise Test and Evaluation (T&E) Board of Directors (BoD) and participating members.

works with the Principal Military Deputy RDA and all Program Executive Officers (PEOs) and System Commands (SYSCOMs) (i.e., Naval Sea Systems Command [NAVSEA], Naval Air Systems Command [NAVAIR], Space and Naval Warfare Systems Command [SPAWAR], and Marine Corp Systems Command [MARCOR]) to improve the efficiency and effectiveness of T&E enablers across the DON acquisition enterprise.

Navy Enterprise T&E BoD

The Navy Enterprise T&E BoD is unique to the Navy as a Service component. The group was formally established in January 2008 by ASN(RDA) with the authority and responsibility to develop corporate priorities for T&E and to bridge program and domain enablers in support of the Navy warfighting and acquisition enterprises. The group's purpose is to identify and oversee continuous and integrated process improvement to more efficiently and effectively meet the T&E needs of weapon system programs. Because of the group's initial success, a Secretary of the Navy (SECNAV) instruction was issued in May 2009 making the Navy T&E BoD a permanent entity. The DON T&E Executive co-chairs the Navy Enterprise T&E BoD with COMOPTEVFOR. (See *Figure 1*, which shows the other participating members of the board and its support elements.)

Integrating the testing

As noted, integrated testing is being used in support of Navy acquisition programs. However, the specific approach for integrated testing is not mandated because each acquisition system under development is different. As a result, each program determines how best to implement the integrated testing approach for

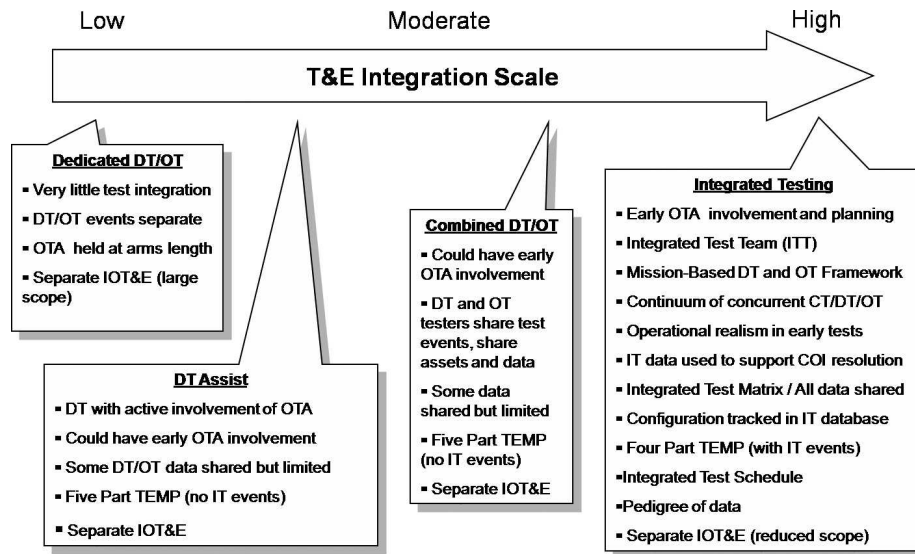


Figure 2. The spectrum of Test and Evaluation (T&E) integration.

its unique acquisition strategy and the technical parameters that need verification. The integrated testing spectrum can span from combined DT/OT events to “full” integrated testing, where specific “integrated test and evaluation” events are called out in the TEMP. Figure 2 provides an overview of the possible spectrum of integrated testing approaches being used and their basic characteristics.

Furthermore, a summary of integrated testing approaches for Navy air and ship system programs is summarized below. Expeditionary warfare, combat systems and command, control, communications, computer, and intelligence (C4I) systems are using a combination of combined DT/OT and enterprise testing approaches, as outlined in their TEMPs and the integrated test program schedules.

Air programs

NAVAIR with affiliated PEOs is aggressively implementing integrated testing in close to 80 percent of its programs. Such programs include Super Hornet Naval Strike Fighter (FA-18E/F), Poseidon Maritime Multi-Mission Air (P-8A), Advanced Hawkeye Airborne Warning and Control System (E-2D), and Growler Electronic Attack Aircraft (EA-18G).

Based on inputs from T&E action officers and program managers, the specific examples of efficiencies and performance benefits from integrated testing as seen by the P-8A Poseidon program include the following:

- development and test schedule agility, allowing them to minimize the impact of Boeing’s recent labor strike;

- potential reduction of flight test program from 3,500 hours at program Milestone B to the current 3,100 hours;
- reduction in the number of test aircraft from seven to six;
- volume and pedigree of flight and lab data generated by the integrated test process as well as comprehensive modeling and simulation to allow a program Milestone C without a dedicated flight phase operational assessment;
- potential reduction in initial operational T&E (IOT&E) by 5 months.

Full integration of OT throughout the program development cycle is the number one reason the Littoral Surveillance Radar System (LSRS) program has seen the following benefits:

- schedule shortened by 4.5 months as a result of integrated testing;
- efforts on time and under cost through initial operating capability and predicted the same for full operation capability;
- significant cost avoidance over the 5 years of integrated testing.

Benefits seen to date on both the Growler (EA-18G) program and the Multi-Mission Helicopter (MH-60) Pre-Planned Product Improvement (P3I) program have been reductions in schedule as early performance reviews yielded cost savings and improved performance as the programs track toward IOT&E. Close cooperation in defining and manning test flights has also reduced sortie requirements to date. Integrated testing allowed for compressed development schedules

and provided some cost reductions. The early OT involvement contributed to earlier identification of deficiencies that allowed for design improvements with subsequent system performance improvements that avoided costly corrections late in the schedule.

Ship programs

NAVSEA with affiliated PEOs and their ship acquisition programs are implementing integrated testing but in a variety of approaches. Ship systems must plan for longer design/build/test timelines, complex systems integration, and smaller production quantities. This reflects the way ships are typically contracted, built, and tested (i.e., produced as one or two first ship quantities and tested in distinct stages since major subsystems are incorporated into the ship as separate program elements). At this time, most programs are addressing integrated T&E using combined DT/OT. Newer programs are approaching a fully integrated test concept. As program plans mature and TEMPs are revised, such as for Future Carrier (CVN 78), Zumwalt Class Land Attack Destroyer (DDG 1000), Future Cruiser (CG[X]), and Littoral Combat Ship (LCS), they will move more and more toward the full collaboration of integrated testing. Other programs, such as Virginia Class Submarine program (SSN774) and Ohio Class Conversion program (SSGN), are using combined DT/OT approaches to provide for T&E efficiencies. This is because developmental and production phases were too far along upon implementation of the full integrated testing methodology in DOD/ASN acquisition policy instructions.

Program Executive Office for Integrated Warfare Systems (PEO[IWS]) has historically implemented various levels of integrated testing. To conserve expensive weapons and target assets, PEO(IWS) has expanded collaborative efforts with Aegis combat systems and Ship Self-Defense Air Warfare enterprises by implementing enterprise testing. The enterprise testing approach is well suited for integrated warfare systems (i.e., combat systems and C4I systems) that are employed across multiple classes of ships. Well-defined test scenarios and data collection efforts maximize information needed for all evaluations while minimizing the number of test events that each class of ship must participate in to demonstrate effectiveness and suitability.

Integrated testing best practices

To date, some integrated testing best practices from Navy programs have been collected and are summarized below:

- At program initiation, the integrated testing culture needs the full support of all stakeholders.

- The attitude starts at the program manager level and should filter down.
- The integrated test team (ITT) needs to be formed early to support test planning, modeling and simulation, and CT/DT/OT test execution for each acquisition phase.
 - ITT objectives, procedures, processes, and memorandums of agreement (MOAs) need to be established to build trust between participants.
 - Proprietary data agreements for the ITT should be established as needed and appropriate.
 - Early planning and meetings are needed to set up the ITT for CT/DT/OT collaboration, T&E framework development, and event execution.
- The Operational Test Agency (OTA) should be funded and brought on board early.
 - The number of billets needs to be identified early and funded for a permanent program presence.
- The OTA should be granted wide access to program data and meetings for formal and informal periods of test.
- OTA representatives should be given free access to the production facility, test sites, test articles, and program meetings, as appropriate.
- OTA needs to support requirements reviews and Concept of Operations development.
- To expedite the process, as appropriate, the prime contractor should be incentivized in the design/build contract to address and resolve operational issues and deficiencies identified by the OTA to improve systems design and operation.
- The program should plan and budget for resolution of deficiencies identified during T&E, since they will undoubtedly occur.

Integrated testing challenges

A summary of challenges and lessons learned identified to date from Navy programs implementing integrated testing are provided below:

- Increased T&E planning efforts are required upfront to plan and execute an integrated testing approach.
- Earlier funding for the T&E workforce (involves CT, DT, and OT workforce) will be needed.
- The T&E effort needs to be engaged for program life to support P3I and capability block upgrades.
- Data management and transparency of the system under test must be carefully managed. During

periods of integrated testing where the design/build contractor and the OTA are involved, contractor data rights or proprietary issues may come into play.

- Pedigree of the test data must be managed and maintained in order to fully understand its validity in resolution of critical operational issues by the OTA.
- The early involvement by T&E stakeholders will impact staffing at SYSCOM/PEOs, Naval Warfare Centers, and OTA and may require reexamination to ensure support can meet program requirements.

Integrated testing pathfinders

To further promote integrated testing and continuous process improvement, the Navy is implementing pathfinder(s) to further identify the lessons learned and best practices. An approach to implementing a pathfinder program is to

1. identify a suitable program (warfare domain area of interest);
2. solicit SYSCOM/PEO/Program Office/OTA concurrences to proceed;
3. implement integrated testing best practices and lessons learned to date;
4. implement a forward-fit test integration effort vice a back-fit effort;
5. start integrated testing efforts early in the program, for best results;
6. determine the extent that certain warfare area acquisition programs are, or are not, suited for integrated testing; and
7. determine the impediments, collect lessons learned, identify challenges and policy changes, if needed.

Summary

At the strategic level, to help improve the effectiveness and efficiency of T&E for acquisition programs, the Navy aligns and governs the T&E enterprise using the DON T&E Executive and Navy T&E enterprise BoD. This process is unique to the Navy and is working well. To improve effectiveness and efficiency in T&E for programs, the Navy has adopted integrated testing. The specific approach is not dictated and is achieved in a number of different ways that suit individual programs. Each program T&E WIPT defines the specific approach to be followed for that program. The basic principle of integration and enhanced communications between organizational elements sets the stage for improved planning and

execution of test events. This provides for and has shown to provide testing efficiencies that result in cost and schedule reductions.

Integrated testing does not eliminate the requirement for an independent IOT&E event by an OTA. Independent activity test data are needed by statute to support a full rate production decision. However, the expectation (and results seen to date) is that the IOT&E period will be less in scope and time due to the early involvement of operational testers throughout the entire continuum of system development. Integrated testing entails a significant departure from the legacy DT and OT methodology and encompasses an additional planning paradigm. Early coordination and collaboration between both DT and OT teams in the integrated test planning process provide an earlier-than-normal sharing of data that continues throughout the development and test periods. This sharing will support the monitoring and assessment of system capabilities, attributes, performance parameters, and measures of effectiveness and suitability in order to support resolution of critical operational issues upon completion of IOT&E.

Conclusions

The anonymous quote "First a thing is impossible, then it's difficult, then it's done" applies to integrated testing for a complex weapon system program. Robust testing and early involvement by test activities allow discovery to take place at the front end of the program where it is far less expensive to implement design changes. IOT&E can then be used to confirm what is already known. The integrated testing culture needs to be implanted early in a program to provide the greatest benefit. Cost is reduced by sharing of resources, elimination of duplicative testing, and the early identification and correction of deficiencies. Schedule is shortened by combined versus serial events and the sharing of high demand test assets. □

MICHAEL SAID, Office of the Assistant Secretary of the Navy, Research, Development and Acquisition (ASN[RDA]), Test and Evaluation (T&E), is on staff to provide direct support to the Principal Military Deputy, Deputy ASNs (DASNs), DASN Action Officers, SYSCOMs, PEOs, and Navy acquisition programs in the area of T&E. His role is to coordinate efforts closely with CNO (N912). He also provides coordination with OSD(ATL), Director, Operational Test & Evaluation (DOT&E); COMOP-TEVFOR; Marine Corps Operational Test & Evaluation Activity (MCOTEA); Defense Test Resource Management Center (DTRMC); other CNO codes; other Service components and industry on issues, policies, and acquisition

reform to achieve efficiency and effectiveness in T&E of warfare system programs. E-mail: michael.o.said@navy.mil

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Dr. Foulkes is responsible for the planning and assessment of the adequacy of the Major Range and Test Facility Base to provide adequate testing in support of development, acquisition, fielding, and sustainment of defense systems. The TRMC also maintains an awareness of other test and evaluation (T&E) facilities and resources, within and outside the Department, and their impact on DoD requirements.

Featured Speaker: Michael D. Crisp

Deputy Director Air Warfare, Operational Test and Evaluation, Office of the Secretary of Defense

Mr. Crisp is directly responsible for the adequacy of operational test and evaluation for air systems within the Department of Defense. His responsibilities include oversight for the conduct of major weapons systems assessments that are reported to the Secretary of Defense and Congress, and to support the participation of the Director, OT&E on the Defense Acquisition Board and in the Defense Acquisition Executive Summary process.

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