Test and evaluation for the US Navy

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As the US Navy develops new designs for its twentieth-century destroyers, submarines, aircraft carriers and amphibious ships, it is relying on its Test and Evaluation programmes to help mitigate the risks and smooth the transition of these ships to the operational forces.

Test and Evaluation (T&E) has a distinct, prominent role in the development of the USA's military systems. Each T&E programme is planned in great detail and executed in a very systematic manner. The results of T&E are reported to the highest levels of the Defense Department, to be used in the key decisions to invest in selected new fighting system capabilities. In fact, T&E results for selected systems accompany the President of the USA's budget when it is submitted to Congress, and are then used at the highest levels of the government's budget formulation process.

T&E has been formalised with a set of well-codified policies and practices such as no other nation has, and perhaps no other nation needs. That formality is driven by many factors, including the facts that the companies in the defence industry are privately owned, that the industry is so large that competition must be a significant factor in government procurements and that there are defined limitations on how close the government's own engineering organisations can work with the industry. This contrasts with the defence industries of other countries where close, interdependent partnerships are the norm, where there is little competition for the developments of many systems and where defence work is sometimes directly subsidised by the government.

The need for new T&E

In recent years, the US Defense Department has been moving towards closer collaborative working relationships with its industry, and has been encouraging industry corporations to do the same among themselves. Nevertheless, while there may be closer collaboration of efforts in T&E, the rigour, thoroughness and objectivity that has characterised it in the past is not expected to wane. In fact, US Navy T&E will be expanded in many ways to cover the new and significantly more complex combat capabilities being developed.

It has been almost three decades since the US Defense Department first instituted the T&E policies to be used by the Army, Navy and Air Force in the acquisition of new systems. The essence of these policies is that systems are to be thoroughly tested, on both engineering and operational criteria, before plans are made to deploy them, and even before commitments are made to produce them. What triggered the policies was that a noticeable gap had appeared: engineering testing by itself was not adequately uncovering, in a timely manner, serious problems that the actual operators and maintainers of these systems would have when they tried to use these systems as tools to perform their missions.

Therefore, it was recognised that a new type of T&E needed to be identified whose requirements were derived not as part of the systems engineering, but from the full spectrum of ways in which systems would actually be used when they were deployed. The new T&E was identified as a category separate from Developmental T&E, and was named Operational T&E. Like the other branches of the military, the Navy has a dedicated organisation whose mission is to plan, conduct and report on operational T&E — the Operational Test and Evaluation Force.

Changes in naval operations

The last decade in particular has seen much growth and expansion in the operational requirements of the US Navy's ships, aircraft, sailors and marines when forward-deployed from seaborne bases. It was noted that it was difficult for ships at sea to discern what was happening on and near land. Strike capabilities from the sea were limited by weapon bulkiness (in relation to the small size of ships) and small magazine capacity, and naval firepower and marine combat forces could be projected only a limited distance onto and over the land. While naval combat in the 1980s had been focused on

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readiness for open-ocean conflict, the threat was changing, and attention now had to be focused on the littorals.

Entering the new century, technological revolutions are rapidly undoing these bounds on naval power. Communications capacity between ships, from sea to land and from air- and space-based assets have increased by several orders of magnitude. Information processing capabilities have expanded concomitantly. Sensor and surveillance systems now provide ship-based forces with unprecedented information about, and insights into, the land environment, and the power, reach and precision of naval strike assets exceed anything previously available in the history of warfare.

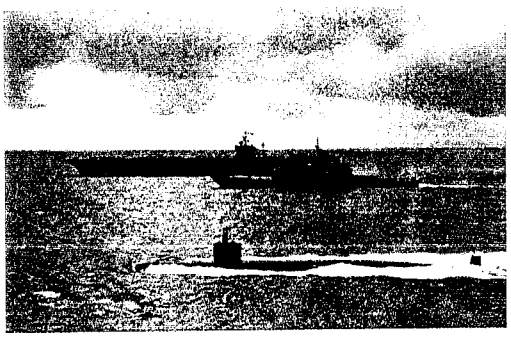
Carrier strike aircraft deliver similarly precise ordnance far inland. When combined with the ability to insert marine forces hundreds of miles from their ships without the need to first build up forces on a beachhead, forces are able to manoeuvre and engage over great land areas, more precisely and more quickly than ever before. Sustainment capacity has grown proportionately. Improved sea-based logistics capabilities and larger, better-outfitted amphibious platforms will facilitate operations of indefinite length and allow land forces to become less dependent on vulnerable, fixed bases or stockpiles.

New naval systems

For the new ships, systems and battle forces of the twenty-first century, the Navy is pursuing innovation on all fronts. In the CVN 77, the last of the USS NIMITZ (CVN 68) class nuclear-powered aircraft carriers, the Navy is pursuing major changes to the warfare system to achieve significantly higher levels of systems integration, as well as to reduce the maintenance workload and associated costs.

The first ship of the follow-on class, CVNX-1, will have a completely redesigned power plant that will have sufficient electrical generation capacity to enable applications such as electromagnetic systems for the launching and recovery of aircraft. Such systems will allow for more sortie rates than the carriers of today.

The DD21 class land-attack destroyer will be the first surface combatant ship designed from the keel up based entirely on post-Cold War requirements. It is a multi-mission destroyer that will provide an advanced level of land attack in support of ground campaigns and contribute to battlespace dominance in littoral regions. It will have sensors and weapons, such as an advanced gun system and new land-attack missile, optimised for the littoral environment and the Navy's



Interoperability is critical for ships in a battle group.

network-centric warfare operational concept.

Likewise, the SSN 774 (VIRGINIA) class attack submarine, now under construction, is the first US submarine designed to satisfy the requirements of regional and near-land missions in the post-Cold War era. It will maintain the traditional open-ocean, anti-submarine and anti-surface-ship warfare capabilities, but will have increased capabilities for littoral and regional operations.

These ships will be equipped to perform mining operations, Special Forces insertion and extraction, battle group support, intelligence collection, sea control and land attack. The LPD 17 (SAN ANTONIO) class of amphibious assault ships is being built to be readily adaptable to the full range of Navy-Marine Corps, Joint Service and NATO expeditionary warfare missions. They will be truly multipurpose and capable of supporting the evolving role of the Marine Corps into the twenty-first century.

Expansion of T&E

The specific plans for testing these new combat capabilities will not be known until the actual designs are further along. Clearly, each of the new missions will require rigorous developmental and operational T&E, in realistically stressing operational conditions, against threats or simulated threats that 'fight back'. The sustained sortie rate required of the CVNX carriers will be demonstrated. The surveillance, special warfare and anti-submarine warfare capabilities of the SSN 774 class submarine will be thoroughly tested. The DD21 T&E programme will certainly assess the new organic mine-avoidance capability, as well as all of the ship's signatures that can be detected by enemy sensors.

There are substantial limitations in trying to test the survivability built into the designs of these ships and the predicted vulnerabilities. Nevertheless, the T&E programmes will, at least partially, validate the designed survivability and the design assumptions. With a mandat from the US Congress, significant investments

in live-fire T&E are being made in acquisition programmes to ensure that battle-damage tolerances and damage control will be known and acceptable.

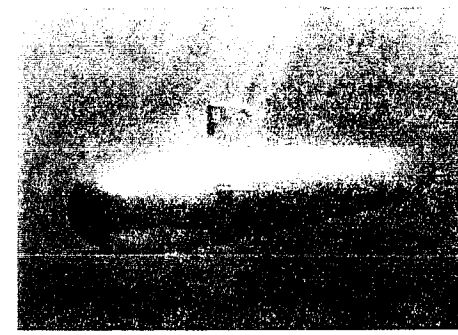
Even though the specifics of these T&E programmes are not yet known, several general points are apparent. First and foremost will be expansion of formal T&E programmes to cover the interoperability among ships in the battle group. To provide the credible forward presence that is the Navy's job, future ships will have multiple missions and will be expected to operate as an integral part of naval joint or combined maritime forces. They will have more than communications connectivity for force coordination. They will rely on the sharing of ship sensors, control networks and weapons systems to optimise their collective capability in today's network-centric warfare environment.

This interoperability is revolutionising how naval systems are designed, tested and operated. In fact, the definition of what is a 'system' is changing. In the 1970s, missile systems and sonars were 'systems'. The next two decades saw the various hardware suites and computer software that performed the detect-to-engage sequences become truly integrated into a single shipboard combat system. For these new twenty-first-century ships, the components of a ship's combat system will be tested individually, as an integrated suite at land-based test sites, and — once installed on a ship — operationally at sea.

However, the T&E programme will no longer stop there, since the boundaries of a 'system' itself will widen. Now the entire battle group will be viewed as a system, and the requirements for battle group-level interoperability are triggering the need for a new level of systems engineering — and of T&E. While thorough testing of the individual ship's sensors, weapons, and command and control systems continues to be necessary, the mix of sensors and weapons in the battle group, the speed and precision of sharing data between ships, the balance of countermeasures among the ships and the full spectrum of signatures of the battle group will be of equal importance — and will be addressed in T&E.

Design modelling and testing

The need for the T&E programmes to verify that these complex 'systems' will adequately perform both technically and operationally is prompting the need for T&E results earlier than before. In effect, in the newest programmes, T&E is being conducted well before the first system is built by the manufacturer or the first steel is laid for the lead ship of the class. Using modern digital modelling and simulation techniques, new ships and systems can be operated and evaluated in a computer, well before most design decisions are finalised. Design decisions themselves can also be evaluated early through computer modelling.



Artist's concept of SSN 774 submarine.

Virtual prototyping is being employed extensively within the new generations of shipbuilding programmes. It supports every major aspect of each programme, including requirements setting, design, logistics planning and T&E. For example, the major product of the next phase of the DD21 class destroyer programme will be a family of models, to be used initially for the evaluation of competing designs. Later in the programme, land-based test sites will be established for purposes of validating the integration of shipboard systems before they are installed in the actual ships. Those sites will be networked for purposes of T&E of battle group interoperability.

T&E throughout construction

Because of the many different types and levels of design and operational requirements, new certifications will be imposed to help maintain systems engineering discipline as the complex and interdependent system developments progress during each programme. Certification procedures will be identified to help ensure that the necessary level of design maturity has been achieved in any specific stage of development, before proceeding to the next stage. As part of recent reforms of the USA's defence acquisition processes, industry is now being given significantly more flexibility than in the past in how it produces designs to achieve systems' requirements. To some extent, this has rendered obsolete previously common methods of management and technical oversight. Certifications strategically placed in the programme schedule and judiciously assigned to the appropriate government and industry organisations will help give timely assurances that the system developments

are on track to achieve operational requirements.

Another thrust in Navy T&E is to systematically conduct in-depth analyses to provide better assurances that the targets, threat simulators, tactics and scenarios are sufficiently representative of actual threats. This ensures that the T&E results can be meaningfully relied upon as good indicators of how well the systems will perform in combat. What is actually known and what is assumed about threat performance, as well as how closely the threat characteristics can be replicated during the T&E events, will be well tracked in each programme. Thus decision-makers and operational forces can be better informed about what level of confidence they can attribute to information about systems' capabilities and limitations provided by T&E results.

T&E during the ship's life

There is one other dimension in which formal T&E will be expanding. T&E will not end when the acquisition programme is complete and the ship class or system has entered the fleet. Inserting rapidly advancing technology has become much more of a continuous activity during the service lives of Navy ships and combat systems. As the US Navy has worked to make its current fleet more interoperable, one of the early lessons learned has been the need for thorough testing and certification of all warfare systems in their battle group configuration prior to deployment. In the last few years, the capability of the existing shore-based testing network has been greatly enhanced to enable systematic interoperability testing and certification ashore, before new systems modifications and computer software upgrades are installed in the fleet.

The role of T&E is progressing from primarily supporting the acquisition of individual ship systems, to that of smoothing the transition to the fleet of the new capabilities that will enable more effective battle force operations. The war fighters will need new tools in this age of information warfare. The US Navy's T&E programmes will help assure that they have the right tools — and that those tools work. **DS**

Biography

Matthew T Reynolds is the director of the Test and Evaluation Office, Naval Sea Systems Command, US Navy Department, a position he has held for 20 years. He is a past president of the International Test and Evaluation Association, and is currently chair of its Strategic Planning Committee. His award-winning book, *Test and Evaluation of Complex Systems*, was published in 1997.