Application of Set-Based Decision Methods to Accelerate Acquisition Through Tactics and Technology Exploration and Experimentation (TnTE2)

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Monterey, California. Naval Postgraduate School

SYM-AM-18-095

PROCEEDINGS
OF THE
FIFTEENTH ANNUAL ACQUISITION RESEARCH SYMPOSIUM

THURSDAY SESSIONS
VOLUME II

Acquisition Research:
Creating Synergy for Informed Change

May 9–10, 2018

March 30, 2018

Prepared for the Naval Postgraduate School, Monterey, CA 93943.

ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL

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Abstract

The tactics and technology exploration and experimentation (TnTE2) method has been shown to foster innovation and create speed in responding to high-priority urgent or emerging operational needs. The TnTE2 method rapidly shepherds a balanced team of warfighters and technologists through a series of capability-based rapid prototyping and experimentation cycles, which accelerate complex warfighting concepts and tactics development. Set-based design (SBD) methods enable full exploration of both the warfighting capability and technology trade space. SBD tools and visualizations facilitate complex data analysis and decision-making. TnTE2 methods were synthesized in the recent Ship to Shore Maneuver Exploration and Experimentation (S2ME2) Task Force (TF), where a first-ever Advanced Naval Technology Exercise (ANTX) informed a developing warfighting concept and started associated rapid prototyping projects—all within the standard program

objective memorandum (POM) cycle. The TnTE2 method is open, competitive, and merit-based. Future applications of TnTE2 will be expanded to include the deliberate use of new acquisition authorities, policies, and contracting vehicles, and has the potential to fundamentally change how systems are acquired with agility and speed.

Background

USS *JOHN C. STENNIS*, somewhere in the South China Sea.

Warfare Commanders, War Room, 0330 hours (local time).

Final strike planning …

> *"I can't show protection in this close with these environmentals, boss. As Air Defense Commander, I'm saying … if you launch this morning, we're gonna take losses."*
>
> *"We are going to take losses, Steve. This strike needs to happen now though, this morning, with the sun at our backs. These Alert fives you've had us on are taking a toll on birds AND crews. CAG's down three Hornets as it is, so another 24 hours isn't in the cards. Look, I just need to be here, and quiet, for another hour, okay? Keep working the problem. Rollo, anything new from CHUNG HOON?"*
>
> *"No sir, just the 'POSS-SUB' we told you about earlier, never confirmed. Theater ASW's barrier search will be done at 0430, but buoy data's showing some movement in the sound velocity profile down the threat axis."*
>
> *"Ok. IWC, talk to me about layers, RF and acoustic. I want to be launching in an hour and striking five minutes after sunrise."*
>
> *"Admiral, METOC's loading the 0330 acoustic predictions now. Surface layers have been really close for days, so I'm confident in Rollo's posture for that strike window. Steve's got a problem though. NAVOCEANO launched a new RF modelling format yesterday that is MUCH better, but our NITES system needs a new card to use it. OCEANO's paralleling the old format, but not over GBS, so I can't get it passively. Right now, my best RF prediction is the air search RADAR which is why Steve's Aegis system is being so conservative. TWC and I think we can get NITES back online by 0400 though … right, Melony?"*
>
> *"That's right, Ender. Admiral, I just chatted with Linda Collins and Admiral Beckett in San Diego. They did a rapid prototyping authorization for us, and I expect a file for the new NITES card any minute. It'll take 10 minutes to print and install the card, so NITES should be good to go by 0400."*
>
> *"Alright, good. Port the new RF paths directly to Aegis so Steve can update apportionment for inbounds. I want us all playing off the best sheet of music when we go on this. Everyone stay on your bricks, but keep 'em on Low. We don't need any leakage while our tattletale is enjoying his last hour above the surface. I'll be in TFCC at 0415. Ready, Break."*

This vignette is completely imaginary. The scenario and all characters are fictitious, but they plausibly juxtapose today's strike force leadership and planning with future capabilities envisioned by authors of this paper.

Introduction

Over 30 years ago, the U.S. Navy knew it had to coordinate air, surface, and subsurface warfare in order to maintain superiority over what we then called near-peer competitors. The composite Warfare Commander (WFC) construct helped us achieve that coordination, establishing Air Defense Commanders, (like Steve in the vignette above), Strike Warfare Commanders (CAG), and Sea Combat Commanders (Rollo) to form a team of super teams, each dominant in their domains and each contributing to shared situational awareness of the overall battlespace. This was ahead of its time, actually, and it served us very well until the "knee" of a technology curve began pressing on our chest about five years ago.

For the past three years, we've been working to integrate information warfare (IW) into that composite model (led by IWC, or Ender, in the vignette). We hope IW will help us match our own pace of maneuver and lethality to that of our "informatized" adversary. This force-matching instinct, however, which has been bred over centuries of warfare, approaches a new, information-enabled battlespace as a more complicated but ultimately predictable environment. While IW feels revolutionary, it may have missed a fundamental change in that environment. A technology-fueled explosion of interdependency between tools, operators, and tactics now accelerates naval warfare near a distinct complexity threshold. General Stanley McChrystal found himself on the wrong side of that threshold in 2004 while fighting Al Qaeda in Iraq (McChrystal et al., 2015). There, he discovered an environment of such staggering complexity that prediction and operational efficiency were rendered obsolete by resiliency and adaptability. Since our IW work is largely about efficiently sensing and predicting highly contested battlespaces, maybe we missed the root cause of that heavy feeling in our chest five years ago. Now, as the feeling moves toward our throat, we think it is less about technology and more about interdependencies and speed, about unpredictable complexity.

In 2015, the Chief of Naval Operations (CNO) said that "core attributes" like Integrity, Accountability, Initiative and Toughness must underpin a decentralized command structure (CNO, 2015). To anyone who grew up with "Honor, Courage, & Commitment," the first two items on the CNO's new list were unsurprising. *Initiative* and *Toughness*, however, seemed new, and a little edgy. They sounded a lot, in fact, like McChrystal's resiliency and adaptability. If we mean to use these new attributes against a peer competitor, we should stop prioritizing clever tactics and exquisite tools, which have unknown but probably short shelf lives in a complex battlespace. Instead, we should prioritize a *method* for speedy, coordinated, correct capability fielding, so that we can adapt faster than our adversary in a complex battlespace.

This paper describes a methodology that has been shown to synchronize the development of tactics and technology in response to high-priority and emerging operational needs. The tactics and technology exploration and experimentation (TnTE2) method, pronounced "T-N-T-2," fosters innovation and creates speed by rapidly shepherding a balanced team of warfighters and technologists through a series of capability-based rapid prototyping and experimentation cycles. TnTE2 methods and tools were synthesized through two recent Task Forces that applied the method to rapidly identify highly-valued capabilities, inform developing warfighting concepts, and initiate rapid prototyping lines of effort—all within the standard program objective memorandum (POM) cycle. The recent Task Forces (i.e., Ship to Shore Maneuver Exploration and Experimentation [S2ME2] and Urban Fifth Generation Marine [U5G]), formulated and applied the TnTE2 method with a keen understanding of the nature and politics of major military innovation (Gardiner, 1992; Hayes & Smith, 1994), agile teaming constructs (Rubin, 2013), war room processes

(Burrow, 1997), and set-based design principles, as expanded by the Department of the Navy (DoN) for the Small Surface Combatant Task Force (Garner et al., 2015) and Advanced Combat Vehicle (Burrow et al., 2014). The TnTE2 method and the Task Force strategy collectively enabled the rapid and full exploration of highly complex technical and operational solution spaces and promoted in major naval innovation. The TnTE2 method "bring(s) together technology, doctrine, and policy objectives" (Gardiner, 1992, pp. 10–11) to encourage innovation from within the Naval bureaucracy, promoting "diversity of potential sources of innovation" (Hayes & Smith, 1994, p. 75), and provides a forum for "prototype(s) … (to) demonstrate feasibility … at critical junctures" (Hayes & Smith, 1994, p. 100).

Throughout S2ME2 and U5G Task Force execution, the Assistant Secretary of the Navy for Research, Development and Acquisition (ASN[RD&A]) worked across Congress, the Office of the Secretary of the Defense (OSD), the DoN, and Naval Systems Commands to explore underutilized financing, acquisition, and contracting authorities. This "Fast Lane" effort, further described below, is aimed at effectively scaling up the successful prototyping effort and applying new accelerated acquisition authorities and tools to speed capability to the field.

Unless we think the pace of technology, or that of our peers, will relax, the "knee on our windpipe" must be addressed. Strong efforts to accelerate capability fielding have existed in both the Fleet and the Naval Research and Development Enterprise (NR&DE) for years. In a few recent cases, these efforts have collided like neutrons, releasing tremendous energy in the form of a special, new kind of rapid prototype. These rapid prototypes are distinguished by the fact that their specific capability contribution is valued and fully characterized from both a tactics and technical perspective, allowing one to imagine a future acquisition system where our "technology bench" is expansive, fully characterized, and standing ready to field. Such rapid fieldings of emergent, modified, or adapted technologies to U.S. forces at sea (hypothesized below) might be coordinated, afloat, by a technology warfare commander (TWC, or Melony, in the vignette).

Today we face a multi-domain warfighting problem defined by unprecedented complexity. Recent, deployed experience with that complexity tells us that a successful capability-based concept exploration method rooted in Set-Based Design (SBD) can provide a simple but powerful mechanism to prepare for high-end conflict. Only through synchronized discovery and injection of tactics and technology, tailored in iterative and progressive cycles toward specific warfighting capability, can we pace technology and outpace our adversaries.

Prior Work

Our most senior leaders recognize the potential of a deliberate and continuous partnership between the engineering, acquisition, and operational communities in addressing high-end conflict. The Chief of Naval Operations' (CNO) *The Future Navy* was heavily influenced by the pace of technology, and that of our adversaries, speaking often to notions like "rapidly iterative approach[es]" and encouraging us to "simultaneously build and innovate" (Richardson, 2017, p. 7). The CNO told us to optimize requirements via "meaningful discussion[s] [between] industry leaders, technologists, our defense labs, the requirement officers, and our budget people" (Richardson, 2017, p. 7).

On January 7, 2016, Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN [RD&A]), the Honorable Sean Stackley, laid down a marker with Congress, calling for "active and continuous engagement by our Naval Research and Development Establishment (NR&DE) with Fleet forces" (Stackley, 2016, p. 4). The elevation by Stackley of this imperative concept seeded a revolution in acquisition methods,

which has grown strongly in the two years since his call. The 2018 National Defense Strategy (DoD, 2018) also encourages developing operational concepts and technologies together:

> Evolve innovative operational concepts. Modernization is not defined solely by hardware; it requires change in the ways we organize and employ forces. We must anticipate the implications of new technologies on the battlefield, rigorously define the military problems anticipated in future conflict, and foster a culture of experimentation and calculated risk-taking. We must anticipate how competitors and adversaries will employ new operational concepts and technologies to attempt to defeat us, while developing operational concepts to sharpen our competitive advantages and enhance our lethality. (p. 7)

Excellent and recent articles may also be found on experimentation and prototyping. Simmons (2017) compared deliberate practice with deliberate experimentation through an operational lens in his November 2017 article, "Forget the 10,000-Hour Rule; Edison, Bezos, & Zuckerberg Follow the 10,000-Experiment Rule." By drawing his comparisons in operational, albeit commercial, contexts, Simmons offers insight on accelerating technology insertion into capability. He notes that practice alone, while useful in static fields of endeavor, is "next to useless in areas that change rapidly, such as technology" (Simmons, 2017). By contrast, experimentation in large numbers brings the power of odds and large data sets to bear on the problem of non-linear technology acceleration. In fact, the undeniable resemblance of Simmons' experimental success graphic, shown in Figure 1 (Simmons, 2017), to recent portrayals of adversary capability is thought-provoking.

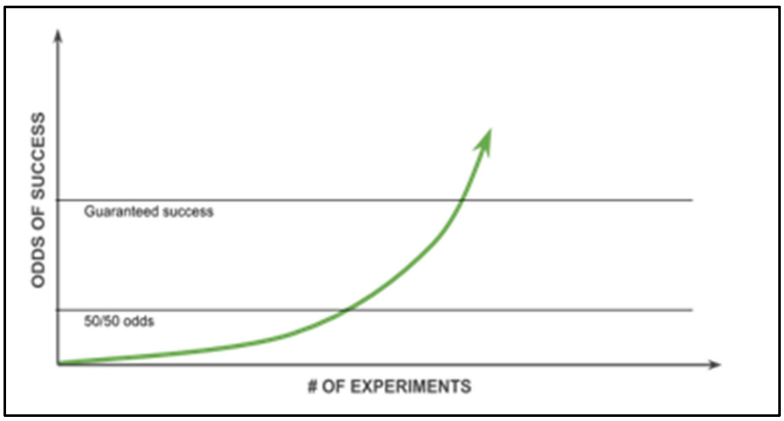


Figure 1. Success Curve
(Simmons, 2017)

The Path to Prototype Warfare (Kozloski, 2017) examines how Cold War industrial and geopolitical environments shaped the DoD's acquisition system in the 1960s and how those environments differ today. Concluding that technology and international relations have invalidated the DoD's acquisition model, Kozloski explores an alternative one based on rapid, mission-targeted, research and prototypes rather than monolithic, unwieldy programs of record. Whereas Cold War strategy intentionally avoided surprise by making large fielding decisions based on assured technology predictions and intelligence, today's strategy must do the opposite. "[Quickly] … equip … with weapons custom designed for a specific … mission," says Kozloski; increase "the number and type of threats a defending force must consider during battle"; and deliver "promising weapon systems … quickly to the operational forces in limited quantities." Kozloski then asks pointed questions about why the military does not act on these ideas and proposes that his questions "be part of a debate on

reforming the acquisition process and designing the future force" (Kozloski, 2017). He even nearly described the TnTE2 method by asserting that "…rapid deployment of unique weapons would demand that the… military… quickly develop… tactics…" (Kozloski, 2017). Even without the final mental leap to integrate TnTE2, this article is bluntly insightful. The assertion that strategic surprise "is viewed often as a tool of the weaker state" (Kozloski, 2017) should not delay our adoption of it, formally, as a defense strategy. After all, the only thing worse than *becoming* the weaker state would be not recognizing it.

Historical Perspective

We recognized the complex, multidomain warfighting problem presented to our nation in World War II (WWII), and we acted on it with a national fervor not approximated in peace or war since. The 1941 attack on Pearl Harbor galvanized our national will, sacrifice, and, innovative spirit, but Naval Forces had been eagerly learning from the embattled British, and from industry, for years before that. The amphibious craft used during America's march across the Pacific evolved from Floridian inventor Daniel Roebling's hurricane floodwater recovery "amphibious tractor" (amtrac), built less than a decade earlier. Historian Henry Shaw, Jr., writes, "When the first production [Landing Vehicle Tracked] (LVT) rolled off Roebling's assembly line … in July 1941, there was already a detachment of Marines at nearby Dunedin learning to … develop tactics for their effective use" (Shaw, 1991). Shaw exactly captured TnTE2's exploratory spirit here, adding that "no sooner did the LVTs make their appearance in significant numbers than the thought occurred that the tractors could be armed and that they could have a role as an assault vehicle, leading assault waves" (Shaw, 1991).

Air power saw tremendous innovation as well. Marine observers from captains to colonels visited British air stations throughout 1941, studying "the weapons and equipment being used and the tactics and techniques being practiced." What we learned about air control and weapons and RADAR, to say nothing of carrier-based aviation in the Pacific, expanded air power's mission from strictly surveillance into an offensive game changer.

Let's not ignore lessons from the other side either. German Blitzkrieg tactics, developed only a generation earlier, had become one of the most effective maneuver methods in history. Small, nimble, lethal units wreaked havoc on Allied troops by moving quickly, aggregating and disaggregating in precise time and space to inflict specific damage. They stayed in touch, and alive, using radios that were simplistic but faster than Allied trucks and horses.

The atomic bomb, infamous for its destructive power, was also an inspiring example of operating force–scientist teaming on a just-in-time, rapid prototyping effort which set the conditions for Japan's surrender and, ultimately, for Allied victory. Richard Rhodes' *Making of the Atomic Bomb* documents this historic operational-technical collaboration in an enjoyable read (Rhodes, 1987; see Figure 2).

Figure 2. Manhattan Project Scientists and Military Personnel Gathered Around the Bomb Pit, Ready to Watch the Little Boy Bomb Being Loaded Into the *Enola Gay*
(Rhodes, 1987)

In the decades following WWII, the U.S. Navy matured into a highly trained, precision firepower, sea-based force. Innovation continued more slowly but no less impressively. Submarine-launched Polaris missiles, nuclear propulsion, modern aircraft carriers, space-based communications, and the Aegis weapon system all capitalized on late 20th-century technology with (Cold) war-winning effect.

Between 1989 and about 2010, we practiced and refined the methods and technology that put us on top despite an increasingly deliberate and laborious defense acquisition system (DAS). Meanwhile, factors like the post–Cold War "Peace Dividend" and a shift in focus from peer competitors to combatant commander hotspots stretched U.S. Naval forces thin. Figure 3, taken from a recent *Strategic Readiness Review*, starkly depicts the reduced force and increased operation tempo of the current Fleet (DoN, 2017).

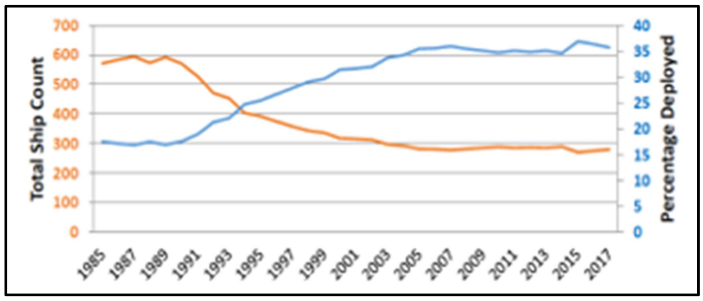


Figure 3. The Dramatic Rise in Percentage of the Total Force Deployed: 1985–Present
(DoN, 2017)

Very recently, in the last three to five years, honest self-assessment and glide slope comparisons with China and Russia have created the sense of urgency captured in the CNO's *The Future Navy* (Richardson, 2017) and the *Marine Corps Operating Concept* (USMC, 2017). Naval component commanders are revamping Concepts of Operation (CONOP), experimenting with new warfighting constructs like Distributed Maritime

Operations (DMO) and Expeditionary Advanced Base Operations (EABO), and prioritizing underutilized mission areas like Information Warfare (IW).

During this time of renewed *operational* innovation, Secretary Stackley's aforementioned Congressional testimony brought clarity and focus to the Navy's renewed focus on *technical* innovation. In that January 2016 testimony, he identified four key enablers to accelerate acquisition (Stackley, 2016). The complete list shown here became the four cornerstones of acquisition reform as we know it today. TnTE2, described in full detail later in this paper, now emerges as the executable method to build on those cornerstones.

> *"We want to 'learn fast' through prototyping—completing projects as rapidly as possible and certainly within 24 months of project selection—to improve follow-on system acquisition decisions before incurring significant costs …*
>
> *Key Enablers:*
>
> 1. *leveraging the breadth and depth of technical talent and facilities from across the Naval Research & Development Establishment (NR&DE)*
> 2. *active and continuous engagement by our NR&DE with fleet forces including the Warfighting Development Centers*
> 3. *designing our major weapon systems for rapid technology insertion*
> 4. *funding expressly for rapid prototyping, experimentation, and demonstration"*
>
> *ASN(RD&A) Testimony on Acquisition Reform: Experimentation and Agility, January 7, 2016*

Figure 4. ASN(RD&A) Testimony on Acquisition Reform
(Stackley, 2016)

Previous acquisition reform efforts, such as the Better Buying Power initiatives, all had the effect of tinkering with the current DAS, adding complexity, rigor, work content, schedule, and cost. In 2016, however, the threat from peer adversaries motivated leaders Capitol Hill, acquisition, and operational communities to pursue "skip-gen" approaches. Prototyping how we do prototyping, the DoN launched a series of dedicated, task-force-like initiatives focused on Smart Mining (SMI), Counter small Unmanned Aerial Systems (CsUAS), Unmanned Systems (UxS), and Advanced Combat Systems Technology (ACST). The creation and branding of the Naval Research and Development Establishment (NR&DE) marshaled the collective and collaborative efforts of the 15 naval labs and warfare centers and the Office of Naval Research (ONR) behind these initiatives in support of Secretary Stackley's accelerated acquisition strategy. Led by the Deputy Assistant Secretary of the Navy for Research, Development, Test and Evaluation (DASN[RDTE]), the NR&DE designed and developed the methodologies and committed dedicated experts to rapidly form the Fleet/Force Engagement Teams (FET), which explored tactics and technology with operational forces.

In parallel with these DoN efforts, the United States Marine Corps (USMC) released the Marine Corps Operating Concept (MOC; USMC, 2017), which articulated a new central warfighting problem: the future operating environment was changing exponentially. Even in 2016, said the Marines, the confluence of a technology explosion, conflicted littorals, complex terrain, adversary use of the information environment and exploitation of

intelligence, surveillance, and reconnaissance systems created increased challenges to naval and littoral maneuver. Recognizing the USMC was at a significant, strategic, inflection point as a service, leadership focused increasingly on challenges and opportunities that would define the future, rethinking the methods, tools, and processes that inform investment decisions. They wanted to accelerate the speed at which USMC develops, integrates, and deploys future systems, and they wanted to co-evolve tactics development and integration. Understanding the complexities of amphibious warfare operating spaces was a daunting task. USMC leadership was searching for new approaches and technologies that would enable real world experimentation and revolutionize warfighting approaches to peer threats. These approaches included artificial intelligence, manned and unmanned teaming, 21st-century combined arms leveraging the information environment, enhanced littoral maneuver and enhanced intelligence, surveillance, and reconnaissance (ISR) and counter ISR. These approaches were applied to five capability concepts:

- Ship to Shore Maneuver: clandestine, overt maneuver from varied distance to support reconnaissance, assault, and heavy material
- Amphibious Fire Support and Effects: finding targets and engaging targets; emphasis on long range precision against moving targets
- Clear Amphibious Assault Lanes: identify and clear mines and obstacles; beach reconnaissance and survey
- Amphibious C4: secure resilient and robust communications; common operational picture; precision navigation and targeting
- Amphibious Information Warfare: corrupt the enemy perception with decoys, electronic support, and attack

S2ME2 Task Force

Having both recognized a strategic transition point, USMC and DoN leaders empowered a task force to accelerate the exploration and experimentation of advanced tactics and technology for 21st-Century Ship to Shore Maneuver warfare. The USMC deputy commandant, Combat Development and Integration (DC CD&I), and DASN(RDT&E) chartered the Ship to Shore Maneuver Exploration and Experimentation (S2ME2) Task Force on August 24, 2016 (DoN, 2016a). This task force applied the TnTE2 methodology, rapidly shepherding a balanced team of warfighters and technologists through an iterative series of capability-focused rapid prototyping and experimentation cycles. Chartering members provided the operational imperative and mission focus, and they empowered an experienced team of warfighters and technologists to set new standards for speed, scale, and rigor.

The establishment and structure of a task force was critical to the overall strategy. The S2ME2 Task Force, simply referred to as the “Task Force” for the remainder of the paper, primarily consisted of operational and technical subject matter experts from DASN(RDT&E), Headquarters Marine Corps Combat Development and Integration (CD&I), Marine Corps Systems Command (MCSC), Marine Corps Warfighting Lab (MCWL), and the labs and warfare centers of the NR&DE.

Naval Technology Exercises

The S2ME2 Task Force expanded upon the concept of an Annual Naval Technology Exercise, which had been pioneered by the Naval Undersea Warfare Center (NUWC) Division Newport in August 2015. NUWC Division Newport leadership leverages their Naval Innovative Science and Engineering (NISE) program to host an annual event that provides government and industry participants access to a collaborative, low-risk environment to demonstrate technologies across NUWC Division Newport labs and ranges. Recognizing the tremendous, unique, intrinsic potential of NR&DE-wide resources and facilities, DASN(RDT&E) subsequently promoted Advanced Naval Technology Exercises (ANTX) as key events in the early exploration phases of TnTE2. Operational Force–championed ANTXs are distinguished by mission focus, team structure, and full employment of TnTE2 methods to evaluate a highly complex tactics and technology trade space. A detailed description of the TnTE2 methods is the focus of the section titled "TnTE2 Within S2ME2." A summary of Annual Naval Technology Exercises and ANTXs that have been executed, or are in planning phases, across the NR&DE labs and warfare centers are included as the appendix.

In just seven months, more than 130 emerging technologies were evaluated, and 52 highly-valued capability prototypes were demonstrated for naval operators, scientists, and engineers during a two-week exploration event at Marine Corps Base Camp Pendleton. This was the first-ever Advanced Naval Technology Exercise (ANTX), and it set benchmarks and best practices for implementing the TnTE2 methodology and ANTX constructs across the entire department and throughout the NR&DE. Unexpected findings included novel concepts such as Proximity: Unmanned Systems can achieve tactically relevant proximity with persistence and low signature. They can effectively maneuver far forward of manned units with very low risk in order to sense and provide effects. A few promising "skip-gen" type technologies were left with operational forces for extended user evaluations. The most extensive integration resulting from S2ME2 ANTX has been the collaboration between ONR's Information Support to Operations office and the 1st Light Armored Reconnaissance Battalion. By October 2017, 14 prototypes, organized around six highly-valued mission threads, were integrated into Fleet/Force Experimentation venues including BOLD ALLIGATOR 17 and DAWN BLITZ 17. S2ME2 Task Force efforts directly initiated more than 30 follow-on rapid prototypes and S&T accelerations, many of which are scheduled to culminate with Fleet/Force experimentation events in fiscal year 2018.

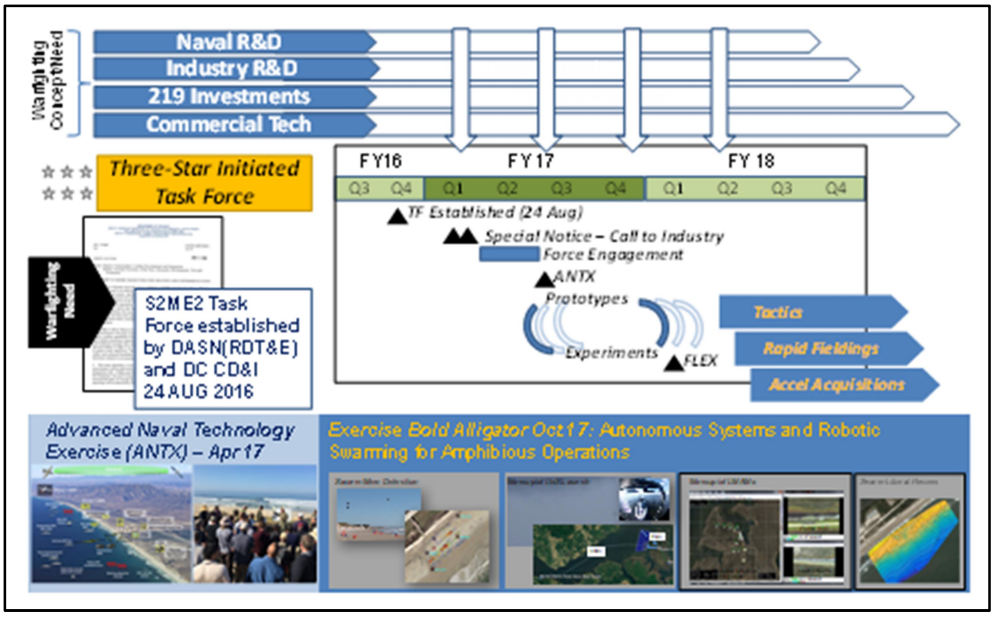


Figure 5. S2ME2 Task Force Strategy

The complexity of the solution space and the speed at which leadership demanded execution and recommendations required a synchronized effort from warfighters *and* technologists. The complexity of the solution space was generally defined by the following:

- **Tightly coupled and multi-domain operating environments—**requires our most innovative operators and planners to explore warfighting capabilities and alternate tactics
- **Technology options are significant in number and diversity—**requires our most innovative scientists and engineers to explore the applicability and limitations of emerging technologies
- **Technology and tactics pairings are significant in number and diversity—**requires BOTH our most innovative operators and technologists to rapidly explore, iterate, and assess technology and tactics pairings

The S2ME2 Task Force employed TnTE2 methods through a series of capability-based workshops, which led up to field demonstrations, exercises, and experiments. Throughout the course of these rapid iterations, the operational and technical experts explored the solution space together, assessing emerging capabilities from their respective areas of expertise. The method effectively unleashed the intrinsic ingenuity of our practicing operators, planners, scientists, engineers, and industry partners, and it leveraged the full potential of our Naval laboratory infrastructure to "reestablish agile experimentation at appropriate levels (seen as) critical to achieving a strategic innovation advantage" (DoN, 2015).

S2ME2's operational team contributed expertise in the specific emerging concept of operations, scenarios, and related tactics of interest. "Delivering capability at the speed of relevance" (DoD, 2018, p.10) demanded mission focus and expertise from the operators. These operators were "current" and empowered by leadership to advance tactics for the high end fight. For S2ME2, the Operational Champion was a senior general officer with sufficient experience and authority to set priorities. This is considered a critical element for all TnTE2 implementation.

S2ME2's technical team of practicing scientists and engineers provided expertise related to the specific technologies and their potential applicability and limitations in the relevant environment. While the S2ME2 Task Force did not require long-term reassignment, it established a core team and prioritized the efforts of an extended team of experts for the duration of the Task Force. For example, expertise was resourced from across the NR&DE and USMC commands for dedicated periods of time for Force Valuation workshops, planning workshops, ANTXs, and Fleet/Force experiments.

The underlying thesis for S2ME2 was that mature and emerging technologies from the DoD, the DoN, and industry had been largely untapped. Many mature prototypes inspired better and/or alternate tactics for amphibious ship to shore maneuver. By studying and in many cases, leveraging significant prior S&T and R&D investments, the Task Force quickly and cost-effectively characterized the tactics and technology trade space and informed:

- S&T, R&D, and rapid prototyping investments
- Industry and NR&DE internal investments
- Concept and requirements development
- Acquisition plans

Extensive participation by small, large, traditional, and non-traditional DoD and industry partners was encouraged by a Special Notice promulgated on the Federal Business Opportunities website (https://www.fbo.gov/) and socialized through various public websites and industry forums. Overall, more than 48 R&D organizations participated in S2ME2 ANTX through their current contracts or new cooperative research and development agreements (CRADA) with the appropriate NR&DE lab or center. More than 75 operational assessors from over 10 Fleet and Force organizations participated in the Force Valuation workshops, planning, and ANTX and FLEX events, providing more than 760 technical and operational assessments that informed leadership decisions.

The S2ME2 Task Force has fostered innovation and accelerated development of complex warfighting capability in ways that informed the tactics as much as the systems that were prototyped. The Task Force directly informed the development of the Marine Corps Operating Concept (MOC; USMC, 2017) and emerging Ship to Shore Maneuver concept of operations. USMC leadership recognized the potential of TnTE2 as an innovative process to integrate tactics and technology evaluation, initiate follow-on prototyping for experimentation, further technology development, and inform decisions to move into rapid fielding. USMC leadership also considers S2ME2 as a rapid prototyping, experimentation, and demonstration (RPED) project and will continue employing these methods to accelerate capability development and acquisitions (DoN, 2016b).

Throughout S2ME2 execution, DASN (RDT&E) worked with Congress, the Office of the Secretary of the Defense (OSD), the DoN, and Naval Systems Commands to explore underutilized financing, acquisition, and contracting authorities. This "Fast Lane" effort, further described below, is aimed at effectively scaling up the successful prototyping effort and applying new accelerated acquisition authorities and tools to speed capability to the field. Another iteration of TnTE2, focused on the "Urban 5th Generation (U5G) Marine" is in progress at the time of this writing, and planning has begun for a third iteration focused on Expeditionary Advanced Base Operations (EABO) and Information Warfare.

At present, in early 2018, the authors sense a tipping point, either just ahead or just behind us, beyond which our most senior leadership view accelerated acquisition, based on TnTE2, as an executable method of preparing Naval and Joint forces for high-end conflict.

Recent guidance from the 2018 National Defense Strategy reinforces the authors' belief that such combined action between the Fleet/Force and the NR&DE is not only desired, but essential to delivering "a more lethal, resilient, and rapidly innovating Joint Force" (DoD, 2018, p. 1).

It is believed the strategy and methods synthesized by the S2ME2 Task Force constitute the first comprehensive response to recent DoD and DoN calls for faster capability fielding. The remainder of this paper will describe TnTE2 in detail, including specific S2ME2 implementations, how it has evolved since 2017, and remaining work. We will also describe additional, "Fast Lane," Accelerated Acquisition (AA) work, both planned and in progress, and suggest ways for readers to get involved.

TnTE2 Within S2ME2

TnTE2 methods, as applied during the S2ME2 and U5G Task Forces, have proven successful in rapidly identifying highly-valued capabilities, informing developing warfighting concepts, and initiating rapid prototyping lines of effort. Set-based design (SBD) principles and decision methodologies, as expanded by the DoN for the Small Surface Combatant Task Force (Garner et al., 2015) and Advanced Combat Vehicle (ACV; Burrow et al., 2014), allowed for the full exploration of complex technical *and* operational solution spaces.

The TnTE2 method can be generalized into four interrelated major elements, as shown in Figure 6.

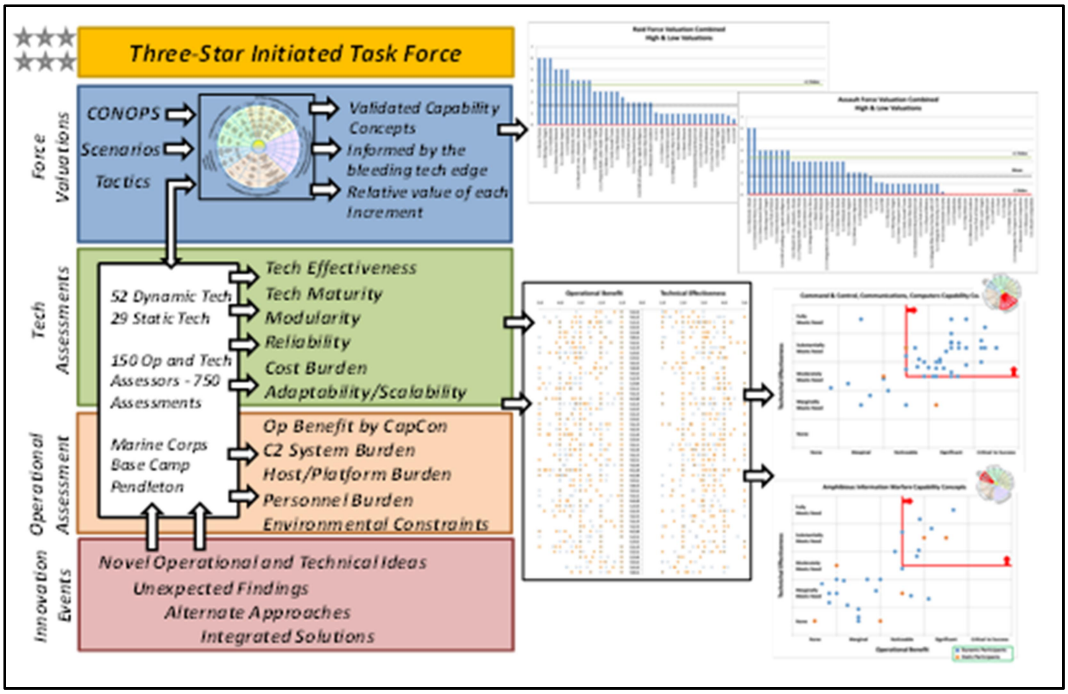


Figure 6. Tactics and Technology Exploration and Experimentation (TnTE2) Method

It is important to note that the metrics and data depicted in Figure 6 were captured at a specific point during the S2ME2 ANTX. The method and major elements are applied iteratively throughout the TnTE2 process. Leadership is continuously informed by additional and more quantitative data gathered throughout the assessment process, (i.e., capability

increments, “tech bank,” assessment results, databases, systems engineering artifacts, architectures, cost estimates), which increases fidelity and confidence in decision-making.

Major Element: Force Valuations and the Capability-Based Framework

The development of a capability-based framework is foundational to the TnTE2 method. The Capability Concept Wheel (CCW) is the capability-based framework that translates concepts of operations into capability areas and then into increments of capability. Increments of capability include definitions and sufficient parameterization such that an operator can assess the relative value of discrete capability increments and a technologist can identify specific technology solutions. The CCW is a shared framework that must be developed, acknowledged, and maintained by both the operational and engineering community. It becomes the primary communications tool used throughout wargaming, tactics development, and the series of iterative and progressive rapid prototyping, experimentation, and demonstrations that ensue.

The CCW is essentially a table that includes underlying definitions and parameters. It is typically presented as a wheel with increments of capability of increasing complexity along the radial axes. Capability increments can be cumulative or exclusive, and differences are typically denoted with asterisks to guide the user. Joint publications are typically referenced, but in cases of multi-domain or joint efforts where lexicon differs among warfighter communities, the framework establishes a common lexicon and definitions that are agreed upon for the duration of the Task Force’s efforts. The S2ME2 CCW was developed over the course of two four-day workshops and validated during a Force Valuation dry run. Helpful hints are provided to operational and technical subject matter experts throughout the efforts of a Task Force. Hints specific to CCW development are shown in Table 1.

Table 1. Hints for Capability Concept Wheel Development

Transform Emerging Warfighting Concepts *into* Capability Areas *and then into* Increments of Capabilities
Helpful Hints: • Thinking dominated by needs and capabilities • Stay clear of discussing proposed solutions • Any solution discussions should be limited to refining increments of capabilities • Multiple solutions and combinations of solutions will be developed and analyzed

The major capability areas of the S2ME2 CCW are shown in Figure 7.

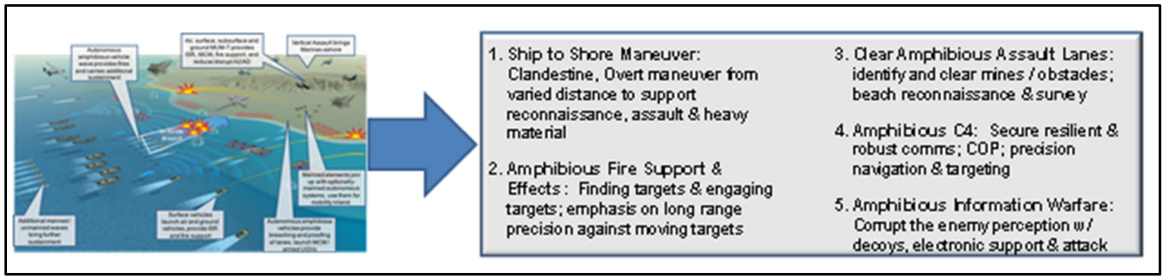


Figure 7. S2ME2 Capability Areas

It is imperative that a CCW provide coverage for the entire trade space of tactics and technology options. Initial workshops to develop the CCW are a mix of facilitated brainstorming and wargaming sessions where operators are asked to articulate capabilities a planner or operator would employ during specific scenarios. In the context of TnTE2, a capability must be technology or solution agnostic and *strictly* defined as the ability to perform or achieve certain actions or outcomes. Capability examples might include abilities like: sensing the spectrum, where increments of capability span frequencies and/or ranges; or engaging kinetically, where increments of capability span ranges and/or effects. Allowing capabilities and/or increments to be limited to a specific technology or solution will stifle innovation, as there may be more than one technical approach to achieving a specific capability.

Force Valuation workshops are typically executed over the course of a week where teams of planners and operators play a series of scenario-based tabletop wargames that provide insights into which capabilities the operators value most for a given scenario and mission. Care must be taken when scripting scenarios, so as to not limit tactical creativity or preordain solutions. Multiple scenarios may be “played” to learn more about capabilities unique to specific areas of responsibility (AORs) and/or phases of conflict.

Each team “plays” a given scenario multiple times (i.e., Game 1, 2, … n) and with decreasing resources, as shown in Figure 8. Operators are asked to place their resources on the specific increment of capability they value most in executing the mission. “Pulling rank” is discouraged, and teams must collaborate to converge on a single set of capabilities required to execute a mission plan. Each team is carefully manned with planners and operators of various experience and expertise. Discussions regarding specific technologies may aid in developing the CCW and during the Force Valuations, but the fact that the CCW is entirely capability-based is critically important. Teams may be shuffled and scenarios and games repeated to provide more fidelity to the capability valuations. Plays are captured with “chips” or “thumbtacks” on the CCW, and statistical analysis provides a summary capture of the results for leadership review and validation.

Flag or general officers should validate the results from these valuations because these results directly inform the ensuing prototyping and experimentation campaign and S&T investments. Data gathered from Force Valuation workshops provide decision-makers with insight into the relative value of each increment of capability for a given mission and scenario. If results are anticipated to vary significantly between theaters, then multiple Force Valuation Workshops may be conducted. Results may be normalized, but retaining the ability to visualize unique insights from different phases, scenarios, and AORs is important.

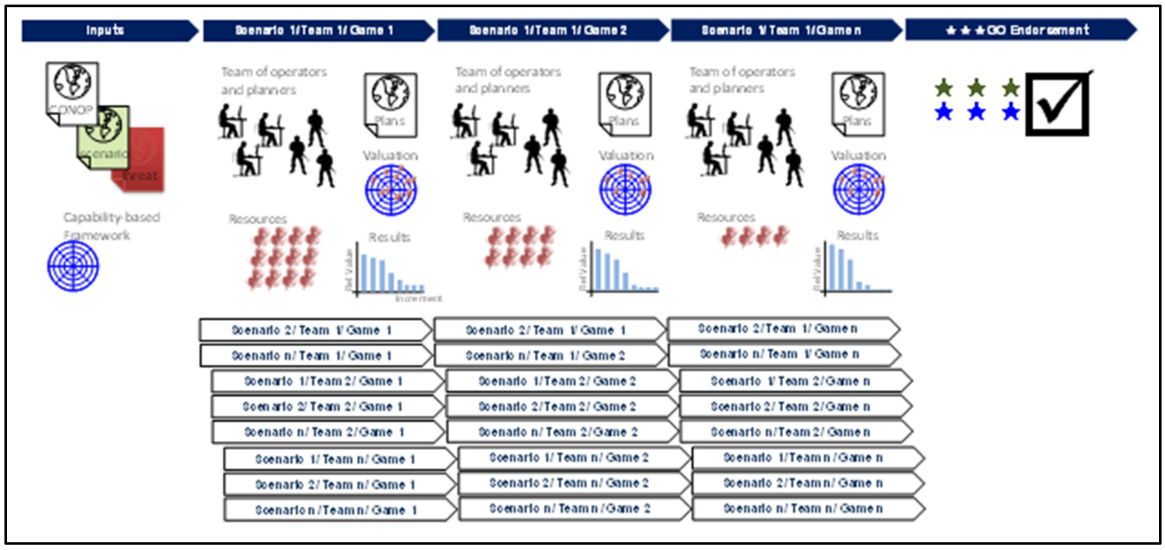


Figure 8. Force Valuation Process

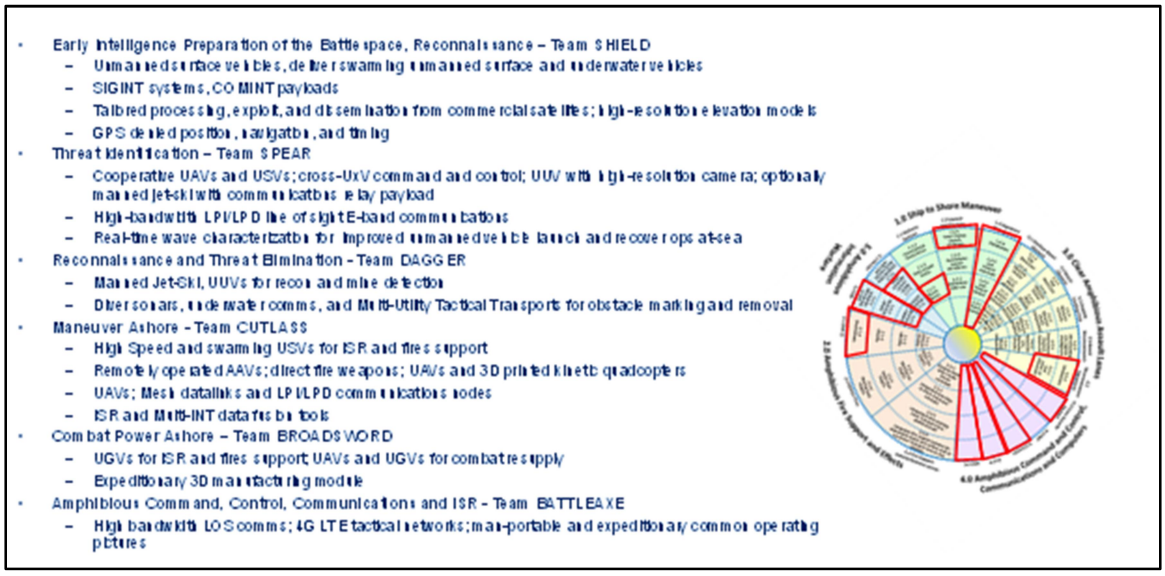
Force Valuation workshop outputs are typically visualized as histograms that show Capability Increments ranked according to their relative value in the relevant mission scenarios. A typical set of mission scenarios, selected by the operational leadership, includes "most stressing" and "most likely" scenarios at a minimum. For S2ME2, these two scenarios were "amphibious raid" and "amphibious assault." In general, S2ME2 Force Valuation findings demonstrated that capabilities required to plan and execute an amphibious raid differed greatly from those required in amphibious assault. This prompted a leadership decision to focus the majority of S2ME2 ANTX mission-threads on evaluating alternate tactics and technology pairings to help advance the raid forces. Force valuation results also demonstrated that operators and planners employed many diverse capability sets. No single capability would completely enable the emerging tactics. These discoveries further justified the need for a deliberate, low-barrier-to-entry, exploration phase that was loosely scripted to allow for rapid iterations of tactics and technology pairings.

Major Element: Technical and Operational Assessments

Simultaneous to the execution of the Force Valuation workshop, a "Special Notice" was posted to the Federal Business Opportunities website and distributed through other various public websites and industry forums. The S2ME2 CCW formed the basis of a call to industry, academia, and government labs for emerging technologies and/or engineering innovations. The capability areas, increments, and sample metrics were fully articulated in Section III of the Special Notice (SPAWAR Systems Command, 2016), which emphasized a desire for responses offering mature and emerging technologies that could be fielded within 18 to 24 months. Submitters were asked to identify the specific increment, or increments, of capability that a particular technology was capable of providing. Submissions were maintained in a government-owned relational database known as the "Tech Bank." Scientists, engineers, and subject matter experts then binned the technologies into the CCW increments and conducted technical assessments against categories that included technical maturity, integration readiness, reliability, standardization, etc. Operators, planners, and subject matter experts then assessed the technologies against categories, which included operational relevance, personnel burden, environmental constraints, etc. It should be noted that assessments and/or weighting criteria used to evaluate offerors' technologies will vary depending on the urgency and/or specifics of the operational imperative, which will vary with different study areas.

More than 130 emerging technologies or engineering innovations were submitted in response to the S2ME2 Special Notice, providing a variety of technology solutions for the majority of the capability increments. Ensuring the CCW was wholly capability-based reduced the urge to presuppose technical areas and solution spaces and preserved the entire trade space. For example, both swarming UUVs and post-processed surface search radar returns were able to provide bathymetry predictions in an amphibious environment. In fact, at the time of the Force Engagement Team (FET) workshop, only one of the highly-valued capability increments had less than two technology options. In general, highly valued increments of capability that garner few to zero submissions are typically fed back into the S&T and/or R&D communities for action.

Technical and operational assessments during S2ME2 were iterative and repeated to gather more detailed and quantitative data as the Task Force progressed through the series of workshops, exercises, and experimentation events. Leadership was continuously informed by additional quantitative data gathered throughout the assessment process. Sample outputs from more than 50 dynamic and almost 30 static technologies assessed at S2ME2 ANTX are depicted above in Figure 6. During the ANTX, each technology was grouped into one or more of six exercise teams. Teams Shield, Spear, Dagger, Cutlass, Broadsword, and Battleaxe were formed around mission threads shown in Figure 9. Team Battleaxe, the sixth team, focused on the persistent aspects of amphibious command, control, communications, and ISR that could be applicable to both raid and assault scenarios.



Note. Team Broadsword's "capability concept" is highlighted in red.

Figure 9. S2ME2 Teams by Mission-Threads

A "capability concept" is the combination of a valued set of capability increments *and* an associated concept of operations. A capability concept is solution agnostic and may include many different technology options, and permutations thereof. Team Broadsword's associated capability concept is highlighted in red in Figure 9. Force Valuations, described above, provide insight into the highest valued increments of capability. Technical and operational assessments provide insight into the most promising emerging technologies. The combination of this data is used to prioritize exploration efforts and inform near-term rapid prototyping investments. It should be noted that a capability concept is not intended to

fully define a system, or systems, as in the form of a "detailed specification." Once technologies are identified for follow-on rapid prototyping and experimentation efforts, systems engineering effort and expertise are required to fully decompose the system of systems required for end-to-end integration of a given capability concept.

Major Element: Innovation Events

Innovation is fostered throughout the life of the Task Force, enabled primarily through the expansive characterization of a capability-based trade space where technology and tactics are fully characterized *and* the direct and continuous interaction between our Fleet/Force operators and planners and practicing scientists and engineers. This second element is so foundational to our strategy and to our methods that it was highlighted as the second key enabler of acquisition reform through experimentation and agility (Stackley, 2016).

Fleet/Force operators and planners, like those from our warfighting development centers and current or recent deployers, must be "current" on advanced tactics, and they must be empowered by an Operational Champion to develop them within specific missions and scenarios. Practicing scientists and engineers should be experts in the "state of the art" with a solid grasp of technical capabilities and limitations of the "bleeding" technological edge. Helpful hints specific to promoting innovation throughout the various phases of effort are provided in Table 2. For example, during a FET workshop, experts are asked to articulate new and innovative capabilities and technological solutions. During an ANTX, experts are provided a loosely scripted event where new and innovative technology/tactics pairings are captured and assessed. Facilitating these "direct and continuous interactions between our scientists and engineers and the Sailors and Marines they support will drive innovation and more importantly, align technical ideas with operational needs at the earliest stages in prototype development and experimentation" (Stackley, 2015, p. 5).

Table 2. Hints for Promoting Innovation

Helpful Hints:
▪ Thinking dominated by new and innovative views of needs, capabilities and solutions
▪ Think deep throws through incremental experimentation plans
▪ Seek vignettes that apply to many CapCons
▪ Develop and analyze multiple solutions and combinations of solutions

SBD principles are applied to the decision-making that occurs throughout the TnTE2 continuum.

- Full exploration of the trade space is enabled by the capability-based framework and full and open calls to government and industry partners.
- Progressive and iterative series of prototyping and experimentation events are used to gather more qualitative and quantitative information.
- Expansive consideration of technology/tactical pairings are characterized and evaluated prior to making decisions to proceed to the next phase.

SBD principles and decision-making methodologies are applied to ensure that trade spaces are fully characterized with dense and diverse sets of tactics and technology pairings. Force valuations, technical and operational assessments, and visualization tools

provide leadership with the ability to make rapid data-driven decisions. The TnTE2 continuum is shown Figure 10. The TnTE2 continuum includes exploration, rapid prototyping, Fleet/Force experimentation, and rapid fielding phases. The CCW, or the "framework," is continuously matured and developed, informed throughout the continuum by innovations in tactics and/or disruptive technologies. Even as initial decisions are made, the framework and solution trade space can be updated and reemployed as technologies, threats, and budgets change.

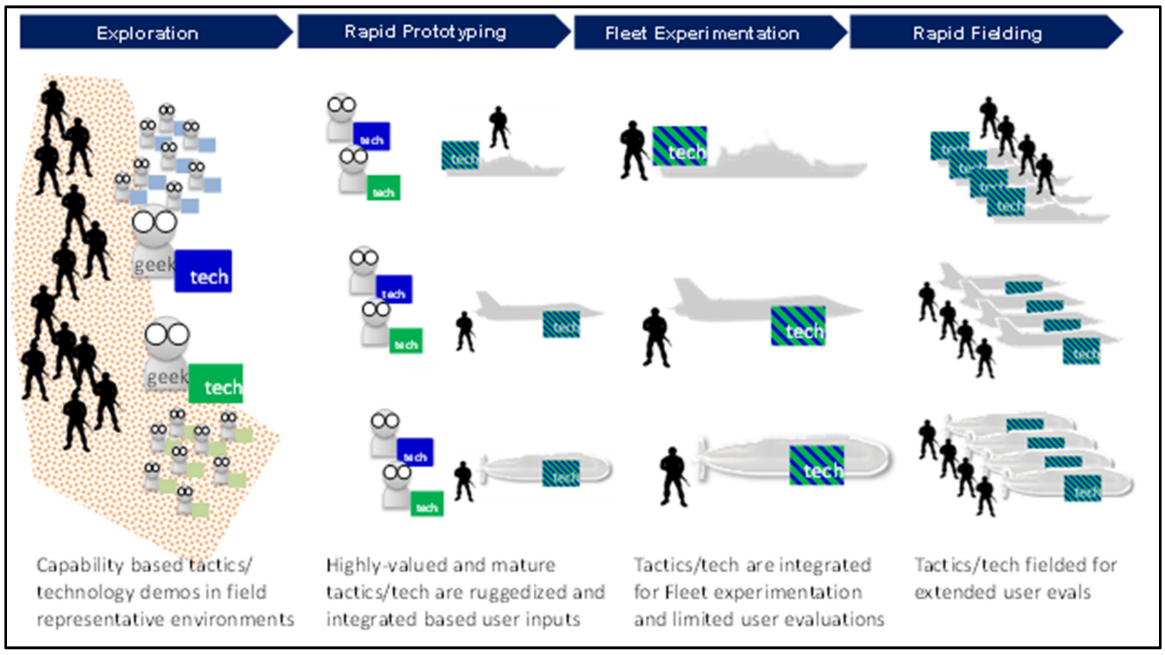


Figure 10. TnTE2 Continuum

For S2ME2, the exploration phase was realized through the first-ever TnTE2 ANTX event. As described above, ANTXs are a very low-barrier-to-entry event where technologists demonstrate their technologies with operator participation and observation in a field or simulated environment. Speed and scope are prioritized; full integration is of lower priority. Technologies are demonstrated to operators in choreographed mission threads to help them assess the potential impact of the technology on advanced tactics. In many cases, advanced sensors or algorithms are demonstrated on COTS platforms that are not intended for fielding or acquisition. In these cases, the analysis and assessment must remain focused on the contribution of the specific emerging technology, not the platform. Even throughout these early stages, balanced and focused partnership with operational experts is critical. Emerging concepts of operations and tactics must be informed by the technological art of the possible, and technological solutions must be informed by emerging concepts of operations. S2ME2 Task Force findings confirmed observations from *The Politics of Naval Innovation* that a single, "new technology has not revolutionized naval warfare. … It was the final integration of several technologies," most already existing that were simply applied in new ways that included: "1) synthesis—new combinations of existing technologies, 2) a keystone—a missing link for a new ensemble of technologies, or 3) tactical innovation—new uses for existing forces" (Lautenschlager, 1983, p. 50).

TnTE2 methods and an exploration phase of significant scope and scale, such as realized through ANTXs, are the catalysts that ignite an extensive campaign of rapid prototyping, rapid fielding, and accelerated acquisitions. Highly-valued technologies are

selected to proceed to rapid prototyping, experimentation, and fielding phases for extended user evaluations. Concepts of employment are continuously evolved throughout the process and tested during these phases. Operators refine the concepts of employment and inform technology refinement while technologists are documenting top-level requirements, interface requirements, architectures, and cost data. Tight integration of operational and technical experts, documentation, and learning is paramount. The S2ME2 Task Force focused "on testing out ideas and concepts first and getting fast feedback through rapid prototyping" (DoN, 2016). USMC and ASN(RD&A) are embracing these methods as the new paradigm for rapidly identifying and integrating new technologies into military tactics, informing Naval Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF) solutions, and guiding future Navy and/or Marine Corps acquisitions.

Remaining Work

TnTE2 tools and methods continue to be refined, and planning has begun for future initiatives and Task Forces focused on other Navy and Marine Corps mission priorities. The areas provided below have been identified as opportunities to expand the impact of TnTE2 methods and to ensure more confident transitions.

- Funding expressly identified to support rapid prototyping, experimentation, and demonstration efforts which may be allocated within budget execution years based on data provided by open, merit-based methods such as TnTE2
- Direct and deliberate implementation of alternate financing vehicles, such as prize challenges, multi-award contracts, Other Transactions (OTs; DAU, 2017), throughout the TnTE2 continuum to enable rapid financing actions at the various decision points
- Improvements in NR&DE and DoN processes and databases such that the framework and solution trade space, aka the "Tech Bank," can be updated and reemployed as technologies, threats, and budgets change.
- Automation and improved visualization of the technical and operational assessments made during ANTXs to enable even greater decision speed
- Strategies and methods for rapid security classification of many-to-many technology and tactics pairings
- Direct and deliberate use of TnTE2 methods in other wargame series, such as USN and USMC Title 10 wargames
- Improvements to the NR&DE live, virtual, and constructive (LVC) ranges for concept exploration through experimentation events
- Efforts to expedite integration and installation of prototypes into Fleet/Force tactical systems
- Direct and deliberate integration of TnTE2 with acquisition and POM planning efforts

The authors continue to seek opportunities to expand and apply TnTE2 methods to high-priority, emerging, and complex warfighting areas, where the technology and tactics trade space are inherently complex. Planning efforts are underway for the first-ever tri-chartered ANTX with direct involvement of an operational Fleet command. Planned for December 2018, the next ANTX will focus on Information Warfare as it applies to the emerging concept of Expeditionary Advanced Base Operations (EABO).

Evolving Accelerated Acquisition

Since 2015, NR&DE's FET-led efforts like SMI, CsUAS, UxS, and ACST and more recent S2ME2 and U5G Task Forces have laid important groundwork for TnTE2. S2ME2 and U5G Task Forces embraced the full potential of a unified partnership between operators and technologists. As a result of these recent Task Forces, TnTE2 methods identified impactful, mature technology candidates and initiated several rapid fieldings. While the DoN was leaning forward with TnTE2 methods and agile teaming constructs, Congress initiated the largest acquisition reform since the 1986 Goldwater–Nichols Act. Although our traditional defense acquisition system will continue to guide most major defense platform acquisition, the 2016 and 2017 NDAAs authorize alternate pathways to accelerate urgent and component-level acquisition (USG, 2016, 2017).

Middle-Tier Acquisition (Section 804) and Acquisition Agility (Section 806) pathways are depicted in Figure 11. These new authorities recognize that increased use of rapid prototype development and experimentation early in a program's formulation are fundamental to improving acquisition outcomes (Dougherty, 2018; GAO, 2017). Additionally, they allow for agile methods and approaches, such as TnTE2, to be applied throughout the problem identification and definition phases, limited trials, and decision points.

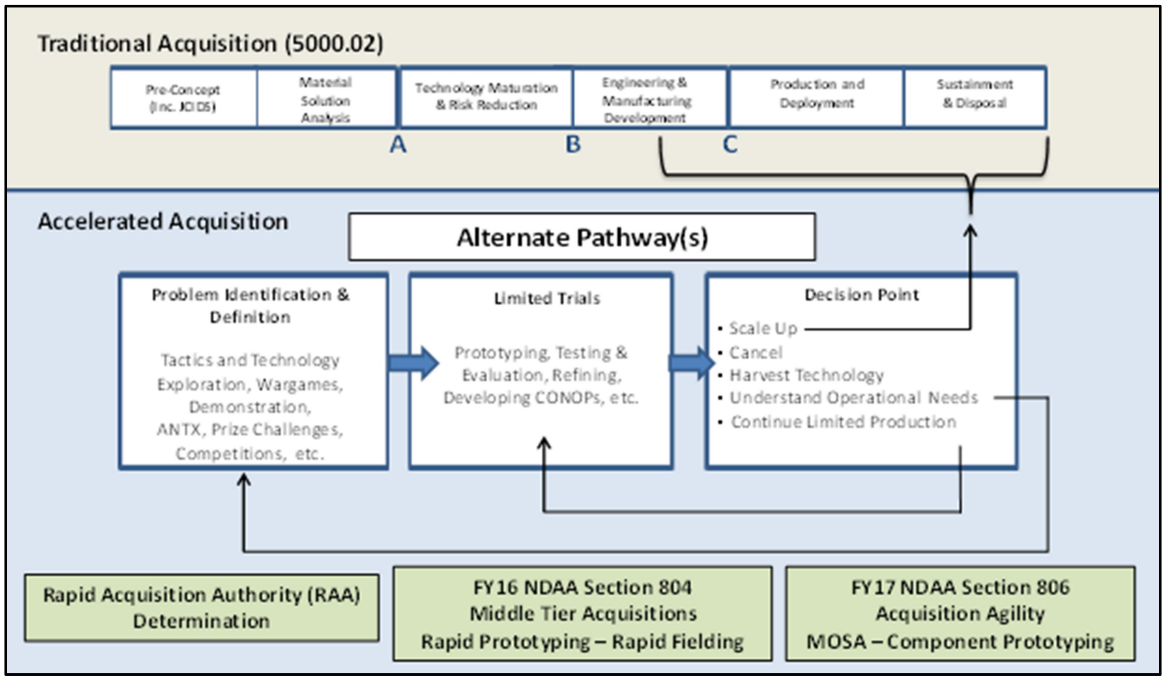


Figure 11. Alternate Acquisition Pathways

Specifically, Middle Tier Acquisition introduced authorities that release certain service urgent programs from constraints in the Department of Defense (DoD) Instructions and the Joint Capabilities Integration and Development System (JCIDS) process. In addition, Middle Tier Acquisitions allow the services to establish a flexible rapid prototyping fund to accelerate programs within the Planning, Programming, Budgeting, and Execution (PPBE) cycles. Acquisition Agility introduced authorities to acquire incremental capabilities by separating "component /technology acquisition" from "platform acquisition" for Major Defense Acquisition Programs (MDAP). This component acquisition allows components and their underlying technologies to be developed through an agile framework. Their host platform(s) requiring substantial investment will remain in the inventory for decades and will

be acquired through the established, deliberate, acquisition process. Using these new pathways depends on the services' ability to prototype, experiment, and integrate components seamlessly into host platforms. These authorities could fundamentally alter how we execute MDAPs and provide alternative acquisition strategies to programs leveraging new methods, like TnTE2, which embrace open, competitive, merit-based, and fast acquisition as the rule vice the exception.

The implementing policies for these alternate acquisition authorities are being developed by DoN leadership and experts in the Accelerated Acquisition "War Room," located in Crystal City, VA. The following have been identified as the key enablers to accelerating acquisitions:

- **Organizational Constructs**, which recognize and are comfortable employing new acquisition authorities, pathways, and tools aimed at agility and responsiveness
- **Technical Authority** culture and process change to embrace speed to capability, risk, and uncertainty as sources of resiliency
- Innovative **Contract and Agreement Strategies** to leverage inherent authorities and employ new tools applied to the appropriate level of service
- Innovative **Financing Constructs**, which leverage DoD, national, and global investments in technology
- Modern **Systems Development and Engineering Methods**, such as "agile" and "DevOps" that accelerate and streamline development, test, and deployment
- **Financial Management Methods and Benchmarks**, which encourage agility and nimble financial decisions, obligations, and expenditures within a budget cycle
- **Cost Accounting Regulations and Practices** aligned to the spirit of the Acquisition Agility Act, which are capable of monitoring Platform affordability without limiting incremental increases in capability
- Expanded availability and access to **Fleet/Force Experiments** for extended user evaluation periods
- Strategies and organizational alignment for rapid **Security Classification** determinations
- **Delegation of Authority** to the lowest possible level
- Flexible and agile **Requirements Development** methods that provide acquisition professionals the trade space to deliver technically and tactically relevant capability

Acquisition professionals with expertise in one, or more, of these transition-enabling subject areas are strongly encouraged to visit the Accelerated Acquisition War Room to explore opportunities to contribute to this DoN Strategic Initiative.

A Future Perspective

"Deliver performance at the speed of relevance. Success no longer goes to the country that develops a new technology first, but rather to the one that better integrates it and adapts its way of fighting." (DoD, 2018, p. 10)

While this paper is about a method proven for rapid prototyping and capability development, we must acknowledge the inextricable linkage between operators and the technical and acquisition workforce necessary to institutionalize our ability to deliver capability at the speed of relevance. General McChrystal's experience in Iraq, described in his excellent book, *Team of Teams: New Rules of Engagement for a Complex World* (McChrystal et al., 2015), describes a transformation of linear thinking and organizational charts into a new interwoven structure enabling parallel plans and execution, not at the squad level but across the enterprise. The general's foe bore little resemblance to our peer naval competitors, but the Internet-enabled, shape-shifting environment he encountered has clear parallels to the contested maritime and uncertain fiscal environments we face. If the fight goes to the side who best understands and exploits the environment, and it usually does, then the environment is our "Rosetta Stone." In increasingly complex warfighting environments, adaptability, not control, reigns supreme. It follows that an adaptable structure should form the basis of our acquisition system and strategy. OPNAV strategic planner CDR Frank Goertner recently observed that Russia and China "both appear intent on being first to learn early and learn fast in the operating environment" (Goertner, 2018). Second place has little value in that race.

As technology, peer capability, and the rapidly changing interdependency between them proliferate, how will naval research, development, and acquisition change its structure to pace technology and outpace our adversaries? Taking full advantage of Congressional authorities is just the first step. If accelerating new system fieldings from 10 years to one year satisfies us today, what should satisfy us in the future, and how will that change over time? It takes both experience and imagination to answer that question. It means blending enduring ideas, like deterrence and combined arms maneuver, with new trans-regional complexities like Information Warfare. It requires conceptually refreshing and refitting how we deploy and sustain highly agile, lethal, expeditionary formations, and *that* requires faster decision-making. Faster decisions, at the Enterprise level, require flat, dynamic reporting chains, shared situational awareness, and trust, which can only be developed deliberately and systemically by the *many*, versus accidentally or episodically by the *few*.

Looking ahead, we imagine the ability to download, print, or otherwise create new warfighting capability in the thick of a fight, in minutes or seconds, or fractions of sections. That kind of responsiveness certainly requires some new technology, but it may also require methods like TnTE2, alternate acquisition mechanisms, and agile teaming constructs. Scientists and engineers from across the NR&DE have already begun forming that team with our warfighters and acquisition professionals. Our methods unify developers and operators in the same way that the DevOps culture unified software developers and software operators in commercial industry. The only difference is that our developers know that a mistake, or a delay, can cost the life of an operator, a crew, or a fleet. Scientists and engineers will be critical shipmates in future conflicts because of the rapid pace of technological development.

We are not guided here by what we can prove or plan exquisitely, but simply by what is necessary. Put another way,

> Until one is committed, there is hesitancy, the chance to draw back. Concerning all acts of initiative (and creation), there is one elementary truth, the ignorance of which kills countless ideas and splendid plans: that the moment one definitely commits oneself, then Providence moves too. All sorts of things occur to help one that would never otherwise have occurred. A whole stream of events issues from the decision, raising in one's favor all manner of unforeseen incidents and meetings and material assistance, which no man could have dreamed would have come his way. … "Whatever you can do, or dream you can do, begin it. Boldness has genius, power, and magic in it" [Goethe]. (Hutchinson, 1951)

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Appendix: Annual Naval Technology Exercises and ANTX Summary

- 13 August 2015. NUWC Division Newport hosted the inaugural Annual Naval Technology Exercise. Undersea Constellation technology was demonstrated.
- 16–18 August 2016. Cross Domain Communications and Command & Control Above, On, and Under the Sea Annual Naval Technology Exercise hosted by NUWC Division Newport. Exercise focused on cross-domain collaboration for maritime superiority.
- ★ **15–29 April 2017. DASN RDT&E/Marine Corps DC, CD&I Task Force led Ship to Shore Maneuver Exploration and Experimentation (S2ME2). ANTX focused on evaluating technology and tactics parings that enable high speed and agility in order to rapidly deploy combat capabilities from the sea.**
- 15–16 August 2017. Battlespace Preparation in a Contested Environment hosted by NUWC Newport/Keyport & NSWC Panama City. Exercise focused on battlespace preparation in a contested environment.
- 21 August–1 September 2017. ANTX Innovation and Sensor Fusion Experimentation Exhibit (ISFEE) hosted by NSWC Crane. Experiment focused on networked sensors, weapons, data fusion, data diffusion, processing, exploitation and dissemination and a Counter-UAS scenario.
- 13–14 September 2017. Surface Warfare Distributed Lethality in the Littoral hosted by NSWC Dahlgren. Demonstration focused on improving air/surface warfighting through unmanned system integration.
- ★ **15—23 March 2018. DASN RDT&E/Marine Corps DC, CD&I Task Force led Urban 5th Generation (U5G) Marine ANTX. ANTX focused on assessing technology and tactics pairings that enable situational awareness, counter-reconnaissance, maneuver, fires, and C4I operations within and among the populations resident in the urban littorals.**
- 21–25 May 2018. Coastal Trident 2018 to be hosted by NSWC Port Hueneme Division. Demonstration will focus on leveraging new and emerging technology to address operational and technical challenges presented by asymmetric threats in port and coastal regions.
- 29–31 August 2018. Human-Machine Optimization and Integrated Targeting in the Maritime Environment to be hosted by NUWC Division Newport and Commander, Naval Meteorology and Oceanography Command (CNMOC). Exercise will focus on human-machine Optimization and Integrated Targeting in Maritime Environments.
- ★ **TBD December 2018. Information Warfare ANTX to be hosted by SSC Pacific and TBD Operational Force/Fleet champion.**

Note: Operational Force championed ANTXs denoted by ★.

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