THE *ZUMWALT*-CLASS DESTROYER

A Technology "Bridge" Shaping the Navy after Next

George V. Galdorisi and Scott C. Truver

The U.S. Navy's decision to truncate procurement of the original fleet of thirty-two guided-missile destroyers of the *Zumwalt* (DDG 1000) class to just three ships does not diminish the value of the program to the United States as a technology bridge to the "Navy after Next." Rarely has the Navy had such an opportunity to do just what the Chief of Naval Operations (CNO), Admiral Gary Roughead, directed in early 2009: "To take advantage of the technologies, to learn from them" and to prepare the Navy for the uncertain "hybrid warfare" strategic environment of the future.[1] Testing, refining, and retesting these technologies and systems in a major surface warship can accelerate the Navy's efforts to provide robust, flexible, and agile forces for tomorrow's roles, missions, and tasks. Indeed, the lead DDG 1000 offers the potential to leverage today's technology investments so as to help shape the characteristics and capabilities of warships yet to come.

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PERSPECTIVE

Ninety years ago, the British military strategist and inventor Major General J. F. C. Fuller understood that "tools, or weapons, if only the right ones can be discovered, form 99 percent of victory. . . . Strategy, command, leadership, courage, discipline, supply, organization and all the moral and physical paraphernalia of war are

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nothing to a high superiority of weapons—at most they go to form the one percent which makes the whole possible."[2]

Having the "right" tools or weapons, as described by Fuller, is important for the United States and its allies and friends as they confront an ambiguous period of both asymmetrical, low-technology warfare and the possibility of high-technology warfare with China, a rejuvenated Russia, or other developing states. However, the link between the invention of a new technology and its impact on warfare is never a straight line. What *has* proved crucial has been the aggressiveness with which nations develop, test, improve, manufacture, and field these technologies as weapons of war. In *Global Trends 2025,* the National Intelligence Council addressed the importance of shepherding new technologies to the point where they transition to the end users, noting, "The pace of technological innovation will be key. Major technologies historically have had an 'adoption lag.'"[3]

As the pace of global technological change has accelerated, the United States has been especially adept at inserting new technology to pace the threat. As Bruce Berkowitz points out in *The New Face of War,* "Recent experience suggests that the right technology, used intelligently, makes sheer numbers irrelevant. The tipping point was the Gulf War in 1991. When the war was over, the United States and its coalition partners had lost just 240 people. Iraq suffered about 10,000 battle deaths, although no one will ever really be sure. The difference was that the Americans could see at night, drive through the featureless desert without getting lost, and put a single smart bomb on target with a 90 percent probability."[4]

Continuous technological innovation, experimentation, and insertion will have a significant impact on the future of warfare, particularly to address the "unknown unknowns" regarding which future technologies will be needed for America's military decades hence. For example, the U.S. Joint Forces Command's *Joint Operating Environment 2008* addressed the issue of technological uncertainty by describing the astounding changes that have taken place in just the last quarter-century alone:

> One might also note how much the economic and technological landscapes outside of the military have changed. . . . On the technological side, the Internet existed only in the Department of Defense; its economic and communications possibilities and implications were not apparent. Cellular phones did not exist. Personal computers were beginning to come into widespread use, but the reliability was terrible. Microsoft was just emerging from Bill Gates' garage, while Google existed only in the wilder writings of science fiction writers. In other words, the revolution in information and communications technologies, taken for granted today, was largely unimaginable in 1983.[5]

The U.S. Navy has a legacy of technology innovation and insertion, embracing both evolutionary and revolutionary changes, tempered by the understanding that a navy's ability to carry out its missions effectively has often depended on who inserts the best technology the fastest and most effectively.[6] As Rear Admiral Jay Cohen, then Chief of Naval Research, noted in 2004, "The Navy/Marine Corps of today and tomorrow are and will remain critically enabled by the power of science and technology put to work for our Sailors and Marines."[7]

In addition to formal research and development programs and the much less formal experimentation along the waterfront, the Navy has at various times in its history taken good advantage of in-service platforms to insert and develop a "bundle" of technologies—many dependent on each other—to test breakthrough, leading-edge capabilities that have the potential to alter the face of naval warfare. For example, the first U.S. surface-to-air missile ships were the eight-inch-gun cruisers *Boston* and *Canberra,* which were converted for the new mission. Likewise, the submarines *Barbero* and *Tunny* were converted to launch Regulus land-attack missiles, making them (as SSG 317 and SSG 282) the world's first operational missile submarines.

But unlike these examples, in which ships approaching the ends of their service lives have been converted to experiment with new missions, DDG 1000 provides the Navy an opportunity to take emerging technology to sea not in a "test ship" but in a frontline, battle-force, major surface warship.[8] In that regard, the surface warfare community can build on the U.S. submarine force's experience with the USS *Memphis* (SSN 691). In 1989, *Memphis* was designated an experimental submarine to test a variety of technologies and systems, including advanced hull materials and structures, unmanned underwater vehicles, advanced sonars, and bottom-profiler navigation systems. In 1994 the Navy assigned SSN 691 to Submarine Development Squadron 12. But all the while, *Memphis* remained an operational asset—in May 2006 deploying to support Operation Iraqi Freedom—and was included in the active force structure.

Using a new design and not an older ship to "test out" a variety of new technologies provides the Navy opportunity for experimentation on a scale not previously possible. In announcing his decision to truncate the DDG 1000 program at just three ships, CNO chose words that emphasized the importance of this ship as a technology incubator: "That's why I was more interested in truncating than terminating, so we can get a couple of ships out and see what they can do . . . see if the technologies we put on [DDG 1000] are going to pay off for us."[9]

LEVERAGING TECHNOLOGY "BUNDLES"

The "bundle" of technologies embodied in DDG 1000—as well as future technologies that could easily find homes in this ship—represents some of the most cutting-edge and transformational technologies ever adapted for naval uses: the Integrated Power System (IPS); integrated electric drive; a stealthy tumblehome hull and integrated topside (InTop) superstructure design; the 155 mm Advanced Gun System (AGS); the Mark 57 Peripheral Vertical Launching System (PVLS); the Dual-Band Radar (DBR), which includes an S-band Volume Search Radar (VSR) and X-band AN/SPY-3 Multi-Function Radar (MFR); and a host of other advances related to network-centric warfare, stealth, survivability, and dramatically reduced manning levels.

While some have criticized the Navy for embedding too many technologies into DDG 1000, this perceived "weakness" is actually a strength, one that makes this ship a credible host platform for the technologies that will accelerate the leap to the Navy after Next.[10] As DDG 1000 technologies continue to be tested and matured, the ship should serve as the Navy's surface platform—remember *Memphis*—to evolve other advanced technologies as well into new warships.

But though the technologies currently embodied in DDG 1000 are on the cutting edge, it is the ship's potential to host even-farther-future, potentially "game changing," technologies that makes *Zumwalt* important. The fifteen-thousand-ton ship has a 10 percent growth margin, equating to some 1,500 tons of potential increase that would enable the ship to host new sensors and weapons as technologies evolve.[11] Inserting such systems into DDG 1000 throughout the next decades and then improving on them, based on their operational effectiveness and ability to deal with emerging threats, will define what the Navy will look like—and how it can fight—in the future.

For example, as the Office of Naval Research has recognized, "Among the possibilities inherent in all-electric ships are the new weapons that become feasible when virtually unlimited electric power is available on board."[12] *Zumwalt*'s advanced all-electric propulsion plant, generating seventy-eight megawatts of power, allows such weapons as high-powered lasers and electromagnetic rail guns to be used without significantly impacting the ship's electronic surveillance and weapons control systems or speed, a critical operational factor, given the high electrical demands of these on-the-horizon weapons.

Such weapons are classified under the general heading of "directed-energy weapons" (DEW), and they include high-energy lasers, radio-frequency weapons (high-power microwaves or ultra-wideband weapons), and electromagnetic rail guns.[13] They are far from futuristic weapons that may or may not be feasible; the Office of Naval Research is already developing (and working to scale up the power of) free-electron lasers, chemical lasers and their associated beam directors, radio-frequency weapons, and full-scale electromagnetic rail guns capable of launching precision-guided projectiles at hypersonic speeds.[14]

Indeed, independent assessments outside government have concluded that solid-state lasers "are capable of making unique and important contributions to U.S. military effectiveness."[15] The CNO has also directed that his Strategic Studies Group focus its latest deliberations on the impact that hypersonic and directed weapons will generate on the future of naval operations in the 2020–25 time frame, noting that these weapons—both those employed by the U.S. Navy and those of future opponents—have "the potential to profoundly influence future maritime operations."[16]

Modern rail-gun technology has been under development since the early 1980s and is projected to be a reality in the next decade. Ranges greater than two hundred nautical miles are envisioned, using GPS-guided projectiles traveling at six times the speed of sound. The fact that rail guns do not require powders or explosives could free magazine space for strike and other mission areas.[17]

The potential impact of the electromagnetic rail gun on the support of forces ashore likewise could be profound. The power supplied by an all-electric ship like DDG 1000 is sufficient to fire up to twelve electromagnetic projectiles per minute. A twenty-pound projectile could reach a target about three hundred miles away in about six minutes. Initially traveling 8,200 feet per second and striking its target at five thousand feet per second, that twenty-pound rail-gun projectile will penetrate tens of feet of reinforced concrete through its kinetic energy alone.

Directed-energy weapons could also become significant in terms of the way the Navy after Next provides ship and task-force self-defense in the contested littoral. A nation seeking to challenge the United States for control of local seas will probably turn to cruise missiles, because these offer a relatively economical method for conducting sophisticated attacks with a reasonable probability of inflicting damage on enemy ships off a coastline. Used to defeat a cruise missile threat, directed-energy weapons could serve both as high-resolution sensors, adding to capabilities provided by other Navy intelligence and surveillance systems, and as weapons, exploiting the advantages provided by a networked force.[18]

Directed-energy systems provide several mechanisms for cruise missile engagement and destruction. These weapons give the defender a speed advantage of roughly six orders of magnitude, reducing the "time of flight" required to reach an approaching missile. In the two to five seconds required to deposit laser energy on a target, a Mach 4 missile will travel only about 3.5 nautical miles; laser energy could destroy the attacker sixteen to eighteen nautical miles from the defending platform—more than twice the best distance attained with conventional systems.[19] Embarked on mobile Navy warships, DEW could become the weapons of choice for defeating cruise missiles launched at naval formations or for shooting down ballistic missiles launched against naval or other forces.

Swarming attack boats pose another significant challenge to naval ships operating in littoral waters. The severe damage inflicted upon the USS *Cole* (DDG 67) by one small, explosive-laden boat remains fresh in the minds of Navy planners. Directed energy offers the potential to disrupt the sensors of an attacking small craft at the maximum line of sight. Even when fast attacking boats are discernible as threats, engaging them in the vicinity of friendly or neutral forces requires more precision than is typically available with explosive ordnance.[20] The rapid responsiveness of directed-energy weapons makes them particularly useful against high-speed patrol boats or surface-effect craft, which can effectively outmaneuver conventional gun systems. The physical characteristics of directed-energy systems give the defender greater control over the effects generated than does any conventional weapon.[21] Directed-energy weapons like the solid-state laser and the high-power microwave are potentially superior to kinetic weapons against swarming small boats—and the people who man them—for a number of reasons, chief among them the ability to use these weapons in a graduated response mode, where these swarming boats can be warded off with a succession of effects, from nonlethal warning "shots" to lethal, accurate fire.

The prospect afforded by directed-energy weapons could represent for the Navy and Marine Corps a potential paradigm shift in how the two services—as well as the joint force—will conduct operations on and from the sea in the twenty-first century. As the only feasible host platform for directed-energy weapons for at least the next decade, DDG 1000 is the ship that will help pull these technologies out of various laboratories and ground test sites and get them deployed to sea, where they could revolutionize warfare at the tactical, operational, and strategic levels.

Hosting these directed-energy technologies on DDG 1000 offers the promise of accelerating the development and refinement of these weapons in the operational environment. So doing will not only identify "the art of the possible" as to what the Navy after Next can look like but also help determine if these technologies can deliver even a portion of their enormous potential. Directed-energy weapons could be most useful in a future missile-defense role. They might be able to target ballistic missiles in all phases of their trajectories—launch, boost phase, and flight—thus helping to restore the odds for the defender. The long range of directed-energy systems and their ability to target the sensitive sensor and guidance systems of ballistic missiles make them particularly useful. If only some of the full range of potential applications of directed-energy systems proves effective, DDG 1000 will still have ably served as the prototype for the high end of any "future surface combatant" family of ships.[22]

THE TECHNOLOGY "BRIDGE"

U.S. military forces will have to operate and fight in a strategic environment comprising a wide array of threats across the spectrum of violence, some of which can only be imagined in 2010. Dealing with such a range of threats requires that the United States avoid the technological surprise that will enable an enemy to exploit military weaknesses and deliver an asymmetric blow that will thwart what this nation seeks to achieve at the strategic, operational, or tactical level. A former Vice Chief of Naval Research, Brigadier General Thomas Waldhauser, U.S. Marine Corps, put this imperative in focus: "Given the current national security challenges our nation faces and those we expect to face in the future, we must keep our focus forward and push innovative technological solutions to address those future threats."[23]

But "pushing" those technologies out to the fleet and Fleet Marine Forces is fraught with organizational and systemic challenges. "Transitioning" is an issue of such concern that the Department of Defense asked the National Research Council (NRC) to investigate the issues surrounding technology transition failures and the concomitant impact on the war fighter and to offer recommendations. The NRC provided a robust list of recommendations, but the title of its final report—*Accelerating Technology Transition: Bridging the Valley of Death for Materials and Processes in Defense Systems*—is a telling indicator of how difficult this prospect remains. Significantly, the NRC concluded, "The adoption and acceptance of a new technology likely depends on the real or perceived impact of that technology on high-level military goals."[24]

The DDG 1000 program could overcome many of these transition challenges, primarily because the ship represents an ideal platform for hosting still-emerging technologies. For example, insertion of DEW technologies into DDG 1000 to support future war-fighting requirements promises an orderly, evolutionary, block-upgrade process, and it is consistent with the Defense Department's emphasis on acquisition reform and with the Navy's desire to exercise more stewardship over its own acquisition programs.

This future has clearly captured the attention of Congress. The fiscal year 2010 National Defense Authorization Act calls for the Navy to develop several plans and road maps, particularly for naval surface fire support—"to address any shortfalls between required naval surface fire support capability and the plan of the Navy to provide that capability"—and a technology road map for future surface combatants and fleet modernization—"a plan to incorporate into surface combatants constructed after 2011, and into fleet modernization programs, the technologies developed for the DDG-1000 and the DDG-51 and CG-47 Aegis ships, including technologies and systems designed to achieve significant manpower savings."[25] DDG 1000 provides important capabilities for these and other requirements.

When the first DDG 1000 is delivered in 2013, the Navy should already have a well developed technology-insertion and experimentation plan in place, if it is to take advantage of this ship's tremendous capabilities. In doing so, the Navy will be able to leverage this ship fully and thereby accelerate the transformation of tomorrow's fleet into the Navy *well after* Next.

NOTES

1. "Momentum for Building DDG-51's Remains, despite Young's Objection," *Inside the Pentagon,* 12 February 2009.
2. Max Boot, *War Made New: Technology, Warfare, and the Course of History 1500 to Today* (New York: Gotham Books, 2006).
3. *Global Trends 2025: A Transformed World* (Washington, D.C.: National Intelligence Council, November 2008), p. viii, available at www.dni.gov.nic/.
4. Bruce Berkowitz, *The New Face of War: How War Will Be Fought in the 21st Century* (New York: Free Press, 2003), pp. 2–3. Berkowitz does not restrict his examples to just one conflict, noting further, "The same thing happened when the United States fought Yugoslavia in 1999 and the Taliban regime in Afghanistan in 2001. Each time experts feared the worst; each time U.S. forces won a lopsided victory."
5. *Joint Operating Environment 2008: Challenges and Implications for the Future Joint Force* (Suffolk, Va.: U.S. Joint Forces Command, 2008), available at us.jfcom.mil/. This publication, commonly referred to as "The JOE," serves as the "problem statement" regarding what challenges the U.S. military and its coalition partners will face in the future and informs all subsidiary joint publications, beginning with the *Capstone Concept for Joint Operations.*
6. Boot, *War Made New,* pp. 1–473. Boot does not present technology as the only element determining victory or defeat, giving full acknowledgment to a host of other factors—from geography to demography, to economics, to culture, to leadership. However, he is firm in his contention of technology's huge impact, noting, "Some analysts may discount the importance of technology in determining the outcome of battles, but there is no denying the central importance of advanced weaponry in the rise of the West. . . . The way to gain military advantage, therefore, is not necessarily to be the first to produce a new tool or weapon. Often it is to figure out better than anyone else how to utilize a widely available tool or weapon."
7. *Science and Technology for the 21st Century Warfighter* (Washington, D.C.: Office of Naval Research [ONR], 2004).
8. While some have questioned whether DDG 1000 will deploy, the CNO has been unambiguous in stating this ship will be a deployed asset. See, for example, Geoff Fein, "DDG-1000 Will Deploy, CNO Says," *Defense Daily,* 28 April 2009.
9. Ibid.
10. See, for example, Ronald O'Rourke, *Navy DDG-1000 and DDG-51 Destroyer Programs: Background and Issues for Congress,* CRS Report for Congress RL32109 (Washington, D.C.: Congressional Research Service, 23 December 2009), available at www.fas.org/; and U.S. Government Accountability Office, *Defense Acquisitions:* Zumwalt-*Class Destroyer Program Emblematic of Challenges Facing Navy Shipbuilding,* Statement of Paul Francis, Director Acquisition and Sourcing Management, Testimony before the Subcommittee on Seapower and Expeditionary Forces, Committee on Armed Services, House of Representatives, GAO-08-1061T (Washington, D.C.: 31 July 2008). This GAO report addresses the challenges of embedding so many

technologies in one ship, noting, "Rather than introducing three or four new technologies (as is the case on previous surface combatants), DDG 1000 plans to use a revolutionary hull form and employ 11 cutting-edge technologies, including an array of weapons, highly capable sensors integrated into the sides of a deckhouse made primarily of composite material—not steel, and a power system designed for advanced propulsion as well as high-powered combat systems and ship service loads. This level of sophistication has necessitated a large software development effort—14 million to 16 million lines of code."

11. O'Rourke, *Navy DDG-1000 and DDG-51 Destroyer Programs.* See also National Defense Business Institute, *The U.S. Navy's Destroyer Acquisition Plan: Examining Options for Acquiring DDG-1000 and DDG-51 Destroyers to Meet Maritime Capability Requirements* (Knoxville: Univ. of Tennessee, 2009). This study noted the large growth potential of DDG 1000.
12. *Science and Technology for the 21st Century Warfighter,* p. 25.
13. George Galdorisi and Lynn Pullen, *Leveraging Directed-Energy Weapons to Accelerate Naval Transformation: Prospects and Issues* (Arlington, Va.: Center for Security Strategies and Operations, December 2004), p. 15.
14. *Science and Technology for the 21st Century Warfighter,* pp. 25–26. See also Galdorisi and Pullen, *Leveraging Directed-Energy Weapons to Accelerate Naval Transformation;* and William McCarthy, *Directed Energy and Fleet Defense: Implications for Naval Warfare* (Maxwell Air Force Base, Ala.: Air War College Press, May 2000). The fact that directed-energy weapons have not been written about extensively in the defense media over the past several years can be traced directly to the uncertainties surrounding DDG 1000 *Zumwalt*-class program. Without a "host" platform having an integrated power system and integrated electric drive, directed-energy weapons will remain land-bound.
15. Thomas Ehrhard, Andrew Krepinevich, and Barry Watts, "Near-Term Prospects for Battlefield Directed-Energy Weapons," *CSBA Backgrounder* (January 2009), available at www.CSBAonline.org. The authors note, among other findings, that "lasers have long been considered a technology that could give rise to a new [revolution in military affairs]. As a December 2007 Defense Science Board on directed-energy weapons (DEW) observed, lasers promise to be a transformational 'game changer' in military operations. Recent advances in solid-state laser (SSL) technologies suggest, however, that directed-energy weapons in the 100-kilowatt (kW) range with power sources dense enough to provide 'deep' magazines could be fielded in the near future. . . . In sum, the technical challenges that have long delayed the fielding of directed-energy weapons for battlefield use finally appear to be giving way to technical and engineering progress." See also Andrew Krepinevich, Tom Ehrhard, and Barry Watts, "Solid-State Laser Weapon Systems: Bridging the Gap—or a Bridge Too Far?" Center for Strategic & Budgetary Assessments (CSBA) briefing, 20 May 2009. The briefers, all highly respected defense experts who authored the study cited here, conclude that the key impediments to the development of solid-state lasers are not technical but cultural and institutional.
16. Chief of Naval Operations, memorandum for Director, Strategic Studies Group, 23 September 2009.
17. H. G. Ulrich and Mark Edwards, "The Next Revolution at Sea," U.S. Naval Institute *Proceedings* (October 2003). See also Scott Truver, "Naval Warfare at the Speed of Light," *Jane's Navy International* (July/August 2003), p. 27.
18. Andrew Koch, "Sea Power 21 to Change Face of US Navy," *Jane's Defense Weekly,* 19 June 2002.
19. Air Force Scientific Advisory Board, Directed Energy Volume, New World Vistas: Air and Space Power for the 21st Century (Washington, D.C.: 18 June 1996), p. 67.
20. *Report of the Defense Science Board Task Force on High Energy Laser Weapon System Applications* (Washington, D.C.: Defense Science Board, Department of Defense, June 2001), p. 86.
21. McCarthy, *Directed Energy and Fleet Defense,* p. 27. See also Claude Berube, "The Post Oceanic Navy, the New Shadow Zones, and the U.S. Navy's Force Structure Challenge,"

Small Wars Journal, 16 April 2009, www.smallwarsjournal.com.

22. *Science and Technology for the 21st Century Warfighter,* p. 25. This now-five-year-old ONR report was prescient in recognizing the potential of the DDG 1000 *Zumwalt*-class destroyer as the lead ship for the Navy after Next, noting, "IPS and electric drive will revolutionize surface ship and submarine warfighting capabilities by increasing combat effectiveness and agility while reducing ownership costs, space requirements, vulnerability, and crew size. Indeed, IPS is critical to the future development of the 'all-electric Navy.'"

23. Ibid., p. 2.

24. The National Research Council is a part of the National Academies consortium, comprising the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council. This report, *Accelerating Technology Transition: Bridging the Valley of Death for Materials and Processes in Defense Systems* (Washington, D.C.: National Academies Press, 2004), available at www.nap.edu, notes, "Accelerating the transition of new technologies into defense systems will be crucial to achieving military transformation. . . . Historical precedents for the transition of new technologies into defense systems have been neither fast nor efficient."

25. *National Defense Authorization Act for Fiscal Year 2010,* Public Law 111-84, U.S. Statutes at Large 123 (2009): 2190, sec. 125, Procurement Programs for Future Naval Surface Combatants.