Naval War College Review

Volume 58
Number 3 *Summer*

Article 9

2005

The Submarine as a Case Study in Transformation:Implications for Future Investment

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THE SUBMARINE AS A CASE STUDY IN TRANSFORMATION
IMPLICATIONS FOR FUTURE INVESTMENT

James H. Patton, Jr.

It's not the strongest that survive, but the ones most responsive to change.
CHARLES DARWIN

The Department of Defense is sometimes guilty of glomming onto a buzzword or catchy phrase and wearing it thin. "Revolution in Military Affairs," or RMA (a term derived, incidentally, from Soviet military writings concerning a "military-technical revolution") certainly came close to crossing that threshold. Today, the word "transformation"—a marvelously useful and intellectually descriptive word—could similarly be at risk of exhaustion.

When such a phrase represents an apparently desirable property, there exists a tendency to attach that phrase to every conceivable defense system, thereby enhancing the program's attractiveness to senior decision makers. "Transformation," defined by the Department of Defense as a process shaping the way future wars are fought, including elements of concepts, technology, and organizations, clearly also includes the contemporary adoption of the Global Positioning System, precision weapons, and the ballistic missile submarine (SSBN) to guided missile submarine (SSGN) conversions—just as naval aviation and the Blitzkrieg were transformational when they were first introduced.

Though these programs may not be so abrupt or dramatic as to warrant the term "revolutionary," it is important to note that there is also a significant evolution in military affairs under way, in that certain platforms and systems are adapting to changing conditions. Throughout the twentieth century and to the present, the submarine has been a prime example of evolution, largely owing to its inherent flexibility and sometimes unintentional nonmission specificity. For example, many who were not submariners thought that the U.S. submarine force had lost its raison d'être when the Cold War ended, which was not the case. The following will show, therefore, that there has always been a next "most important mission" for these warships.

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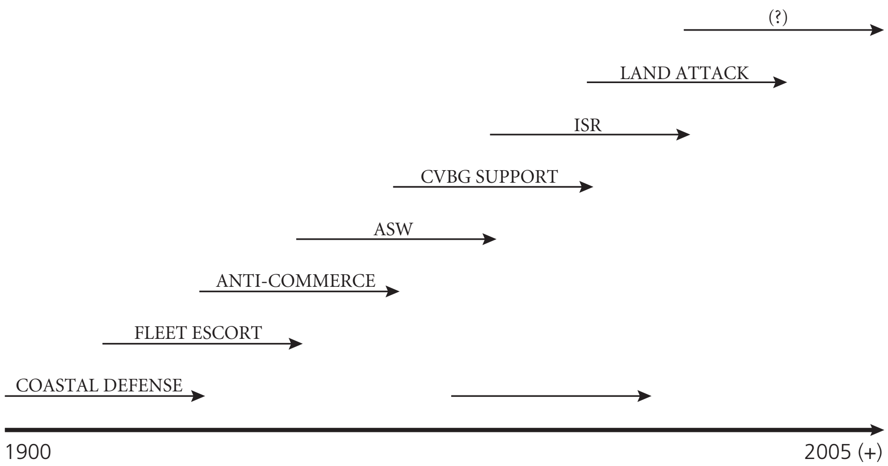
THE SUBMARINE AS A CASE STUDY

The U.S. submarine has a history of adaptation since its incorporation into the fleet in 1900. In a macroscopic sense, the figure below graphically depicts how the submarine's most important missions have continually changed in a hundred years. It is significant that it also alludes to how, at any one time, the submarine was likely to have current missions of high priority, missions of waning importance, and missions of increasing gravity. In almost every case, the time constants of these changes were shorter than the life cycle of the existing platform. To avoid obsolescence, it was sometimes necessary for extreme variant requirements to be made technically (and tactically) during a ship's (and crew's) lifetime. As a result it can be safely said that no U.S. submarine has ever been employed for its designed purpose, and no commanding officer ever performed that for which he was trained.

FIGURE 1
THE "MOST IMPORTANT" SUBMARINE MISSION



A partial list of examples for platform employment:

- S-Boats designed in the 1920s for coastal defense and fleet boats designed in the 1930s as battle-fleet scouts found themselves in 1942 as distantly deployed commerce raiders.
- The *Skipjack* class, designed to provide terminal guidance for nuclear-tipped Regulus cruise missiles fired from a large fleet of *Halibut*-class SSGNs, never materialized because of the advent of the Polaris ballistic missile.
- The *Thresher/Permit*-class SSNs, designed to operate in pairs while firing rocket-propelled nuclear depth charges at distant Soviet subs, never carried out that mission, due to the failure of Sesco, a secure acoustic communications system needed for information exchange and the triangulation of sonar bearings for target localization.

- Escorting carrier battle groups was the justification for the high speed of the *Los Angeles* class in the late 1960s. Even though submarines were used in direct support of battle groups in a 1977 Pacific Fleet exercise (RIMPAC), and a Navy warfare publication was published in 1980 based on further experimentation in RIMPACs 1978 and 1979, this mission was not routinely assigned until after the Cold War ended, when many of the class were being decommissioned.

With this sort of historical precedent, one can appreciate the wisdom behind the decision to widen the mission range of the *Virginia* class so that it could be somewhat better acclimated to joint operations in shallow coastal waters rather than, as some had insisted, optimized as *specifically* a "littoral combat submarine." There have been few failures in U.S. submarine design, but the designs that did fail were those that were overoptimized for a narrow mission set, thereby losing their intrinsic adaptability.

A traditional approach to the kind of anti-access (AA) and area-denial (AD) scenario likely to be encountered by U.S. naval forces in the littorals would be an "outside-in rollback" of these maritime AA/AD networks.[1] However, when a key element of the forces is entirely capable of passing directly through (over/under) these networks, much as F-117s and B-2s have routinely gone "right downtown" before air defenses have been degraded, it makes enormous sense to do just that. Stealthy aircraft were and are *technologically* transformational, but it is *tactically* transformational to employ a characteristic of an existing system (i.e., a submarine's intrinsic ability to covertly penetrate AA/AD defenses) for a different reason. In a previous life, submarines penetrated AA/AD defenses to collect intelligence or engage "bastioned" Soviet SSBNs. They can now do it actively, to take down AA/AD measures from the inside out, enabling other forces to enter the contested area. Here once again, the submarine has adapted to a different set of tasks than those for which it was originally created.

There are many factors that go into creating a long-lived weapon system capable of such unexpected adaptations. There is certainly the importance of selecting flexible, intelligent, and innovative personnel to man it, and there is the indispensable requirement to instill early in its crew a solid baseline of training that includes a "common culture" and provide continuous training as newer employments and missions evolve. Internal hardware, electronics, and software can, of course, be upgraded, facilitated by incorporating into the initial design considerable "space and weight reserved," but there is a limit to just how much something like a nuclear submarine (built now with fuel to last more than thirty years) can be "reinvented" during its lifetime. Certain attributes, stealth being a primary example, must be engineered in at the beginning and therefore have

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historically appeared initially to be far in excess of that which was considered adequate. However, continual component improvement and evolution of superior maintenance procedures can not only maintain "as-built" levels of emissions controls but actually improve upon them. For example, submarines decommissioned over the last decade or so left service significantly quieter than when they first sailed a quarter-century earlier.

Sometimes pure serendipity has enabled submarine platforms to age and adapt gracefully. When, in the 1930s, it was desired to design a submarine to operate with and scout for the main battle fleet, it had to make economically at least eighteen knots on the surface. Since maximum surface speed ultimately dictates the length of a ship's hull, by the laws of hydrodynamics, this resulted in a nearly three-hundred-foot behemoth (for its time) displacing 1,800 tons. By comparison, the then-existing "gold standard" of submarines—the German Type VIIC, which did so much damage early in World War II—displaced only about seven hundred tons. The U.S. *Gato*-class fleet boat was able easily to carry enough diesel fuel to traverse the Pacific and have significant time on station, while the Type VIIC literally had to carry fuel in its bilges and conduct hazardous at-sea refuelings if it was to operate in the western Atlantic. Perhaps even more importantly, the fleet boat had room onboard to incorporate equipment developments and improvements in radar, sonar, and electronic intercept equipment while the small U-boat did not, significantly contributing to its rapid obsolescence and high loss rates. It was not until 1943 that Germany rectified the U-boat's shortcomings and began design and construction of the Type XXI—a marvelous submarine that set the standard for postwar U.S. and Soviet designs. However, it did not arrive in numbers soon enough to have an appreciable effect on the war.

Similar design imbalances were seen between U.S. and Soviet submarines. Greater concern about radiation and other safety issues made American nuclear submarines far more reliable than their Soviet counterparts, with less radiation exposure. Marginal thermodynamic considerations and assumptions that these subs would always be operated in cold arctic waters made Soviet Type 2 nuclear submarines (e.g., Charlies, Victors) virtually inoperable in areas such as the Arabian Sea or Persian Gulf, while the engineering plants of *all* classes of U.S. SSNs operated superbly in waters of very high temperatures as well as in cold climates.

Clearly, the margin of superiority demonstrated by U.S. submarines over their Soviet counterparts played a key role in the winning of the Cold War. As recently as the late 1990s the Defense Science Board called the SSN the "crown jewel" of the U.S. armed forces. This prompted a two-year "Submarine Payload and Sensors" program by the Defense Advanced Research Projects Agency to investigate what adaptations would be necessary to maintain that prestigious title through the next two decades. A finding of this program was that the new *Virginia* class currently being built would need to be "modular" in its payload options and that the magnitude of such payloads would probably increase by a factor of ten. In this sense, the soon-to-be *Ohio*-class SSGNs (converted from SSBNs in excess of Cold War requirements) can be viewed as "bridges" to what fully developed *Virginia*s will become.

Now that the largest class of U.S. nuclear submarines (the *Los Angeles* and its sisters) is drawing toward its end, it is instructional to review some of the good and not so good elements of their initial design. Built to accompany carrier battle groups, they needed to be fast, and they were, through a doubling of the shaft horsepower of their predecessors. Each successive class (after the first multiple-ship class [*Skate*]) improved access and habitability over its predecessor with resulting improvements in morale and reliability not easily measured in the initial investment. The engineering spaces of the *Los Angeles* class were well designed for easy access to equipment. Significant free-flooding volume forward of the pressure hull permitted installation in later units of the dramatically successful twelve-tube *Tomahawk* vertical launch system. However, to enhance speed by reducing hydrodynamic drag, the sail of the ship was made relatively small. As a result, it had fewer masts and antennas and was not "ice hardened," reducing its value as an information systems research (ISR) collection platform and sacrificing ability to perform some arctic missions. Because of the much larger engineering spaces, the "front end" of the ship was actually smaller than that of the class it replaced, to keep overall length reasonable, reducing habitability and somewhat constraining systems growth potential (although this was fortunately counterbalanced by dramatic improvements in computer capacity per unit volume). Also, the hydrodynamics of the ship are such that the ship is not easy to control at speeds of one to three knots, making it difficult to deploy and recover special operation forces (SOF)—which has become an increasingly important mission.[2] All shortcomings have been addressed in the *Virginia* design.

While a brighter future is foreseen for better and even more flexible multimission submarines, the reality of force structure is out of phase with this vision by 180 degrees. From a Cold War level of one hundred or so attack submarines, the present level is about fifty and is falling—in spite of the fact that SSN taskings by fleet and national commanders have essentially doubled. Because of this submarine shortage, existing ships must now transit at much higher sustained speeds than originally planned, which threatens the life span of their reactors. During the last decade, the SSN has become the Tomahawk land-attack cruise-missile launch platform of choice. In Operation DESERT STORM, SSNs launched 5 percent of the missiles, while during IRAQI FREEDOM the number was more than 30 percent. This is not to argue that the sheer number of platforms is the critical variable. As Rear Admiral Jerry Holland, USN (Retired),

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(Holland served on CNO staff as director for Strategic and Theater Nuclear Weapons, as Deputy Director for Space Command and Control, and as Deputy Director for Operations, Joint Staff) pointed out regarding the *Skate*-class SSN of the late 1950s, an "economy-sized" *Nautilus* follow-on was operationally disappointing and difficult to maintain.[3] It is true that "quantity does have a quality all its own," but in order to adapt and to transform there must be a nontrivial level of quality, robust design, and architectural flexibility resident in the initial version of a major weapons system.

By virtue of what history may note as remarkable speed and adroitness, the submarine and its crew once again have adapted to a different set of operational requirements. From essentially a "lone wolf" a decade ago, the submarine is now nearly universally accepted as a key node within network-centric warfare, the purveyor of "undersea dominance," and an essential element of Sea Power 21. Disbelievers need only review the capabilities tested and demonstrated in exercise GIANT SHADOW of early 2003, where an operational SSBN, USS *Florida* (SSBN 728), simulating an SSGN on counterterrorist and counter–weapons of mass destruction (WMD) operations, launched a large autonomous undersea vehicle (AUV) to plot a minefield, landed and supported special operation forces, exploited ISR from a small unmanned aerial vehicle (UAV), analyzed soil samples returned by SOF on the AUV, and launched two Tomahawk missiles to simulate the destruction of a terrorist WMD facility. An additional exercise, SILENT HAMMER, more fully developed and demonstrated SSGN potential by employing USS *Georgia* (SSBN 729).

One of the less publicized capabilities of the SSGN will exploit the virtually unlimited electrical power and air conditioning capability of all nuclear submarines, coupled with extensive space and manpower, to provide an extensive capability to absorb and process huge amounts of data from on- and off-board sensors and ISR platforms (such as Global Hawk, HAIRY BUFFALO, joint surveillance and target attack radar system, etc.). This data will be processed and fused within the ship to produce manageable quantities of information, analyzed onboard by humans, then distilled into *knowledge*. This grapes-to-wine-to-brandy process will permit an SSGN with the proper interfaces, such as the Distributed Common Ground System–Navy (DCGS-N), to become a vital theater node, transforming vast quantities of downloaded data from multiple sources into small nuggets of knowledge that are easily distributed (through a vastly smaller diameter "pipe") via Secret Internet Protocol Router Network (SIPRNET) to other users globally. It should also be clear, to those who think deeply about such matters, that the SSGN program is far more than just a way to extend the operational viability of declining SSBNs; it is a pilot program to investigate just what the *Virginia* class should become when it has fully evolved in ten years.

However, with the world situation becoming increasingly unstable, there are more than one or two places where a credible, actual, or virtual U.S. presence must be claimed or maintained. Therefore, to sustain *persistently* unseen assets around the world, there is a force-level number that must be maintained. This number is significantly more than thirty, the level resulting from a one-per-year build rate of thirty three-year-design-life hulls, when operating tempos, maintenance, and transits are factored in. All post–Cold War submarine force level studies by several agencies indicate an enduring need for numbers of SSNs far in excess of what can be sustained by a one-per-year build rate.

IMPLICATIONS FOR INVESTMENT

An SSN is unique. Not only does just one submarine represent a credible military force, but it is also capable of surviving and operating independently anywhere in the world, including ocean areas as shallow as twenty fathoms, to which access has been restricted or denied to other platforms. Two or so weeks out of home port and an SSN can be anywhere in the world. These operational traits truly make it a desirable asset for multimission tasking, but even more important are the top-level characteristics and design specifications that have allowed it to demonstrate repeatedly that degree of adaptability. These specifications have included reserving space and weight that permits yet-unenvisioned equipment to be installed to counter now unimagined situations, and an insistence that core enabling characteristics such as stealth never be compromised.[4] Other essential steps being taken to enhance flexibility are an expansion into other combat system areas of the extremely successful Acoustic Rapid COTS Insertion (ARCI) program, in which dramatic improvements are routinely and affordably incorporated into sonar systems, and a push toward weapon system modularity for the *Virginia* class, the SSGN, and subsequent classes.

Similarly, since reduced levels of detection, tracking, and weapons homing resulting from incorporation of low observable or very low observable technologies and techniques have shown to enhance dramatically the survivability of aircraft and surface ships, a reduction in design requirements of subsequent platforms should be imposed only with the greatest trepidation. Whatever new mission or tasking received will certainly be better accomplished, and the platform will be more survivable, with improved mitigation or control of its signatures.

Other mentioned submarine traits should also be objectively examined for possible applicability and incorporation into what one would wish to be inherently adaptable in the future. Are margins to grow, ability to gain access, and

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persistent presence desirable attributes of the CVN-21 carrier, the DDX destroyer, Global Hawk, joint unarmed combat air system, and various space vehicles and other intelligence systems? The question should certainly be asked.

Platforms, procedures, or even people do not have to be revolutionary to be transformational. Perhaps a different word using the same semantic root better captures the intent—that these things be *transformationable*—designed, built, and maintained so as to be readily adaptable to inevitable changes. If this is properly done, survival will be enhanced not only in present and future budget wars but in present and future shooting wars.

NOTES

1. Andrew Krepinevich, Barry Watts, and Robert Work, *Meeting the Anti-Access and Area-Denial Challenge* (Washington, D.C.: Center for Strategic and Budgetary Assessments, 2003), p. 60.
2. See J. H. Patton, Jr., "Slow Speed Controllability," *Submarine Review* (January 2004), pp. 68–72.
3. W. J. Holland, "Really New SSNs," *Submarine Review* (January 2004), pp. 60–62.
4. For example, when it became clear that the superb, Cold War–inspired *Seawolf* class was too expensive and in some regards overqualified for post–Cold War needs, the cheaper *Virginia* class traded off speed, depth, and magazine size, but not one decibel of the extraordinarily quiet levels of radiated noise achieved by the *Seawolf* design effort.