Naval War College Review

Volume 37
Number 2 *March-April*

Article 8

1984

The Trident Submarine in Bureaucratic Perspective

Larry Schweikart

D. Douglas Dalgleish

The Trident Submarine in Bureaucratic Perspective

Larry Schweikart
D. Douglas Dalgleish

For several years in the mid-1970s it appeared the Trident submarine program might be the most controversial weapon ever built—it was subjected to widespread reports of "cost overruns," Navy criticisms of Electric Boat Company's construction errors, and threats to build the submarines in other countries. Such did not become a reality, partly because the MX missile absorbed much of the previous criticism of strategic weapons programs and partly because both the Navy and Electric Boat solved many of the problems plaguing the system. Most importantly, however, until the June 1982 retirement of P. Takis Veliotis—who, as general manager of Electric Boat, had fought the Navy as a whole and had clashed individually with Admiral Hyman Rickover, Vice Admiral Earl Fowler, and Secretary of the Navy John Lehman—a process of posturing by both the shipbuilder and the Navy had resulted in an apparently satisfactory working relationship. Veliotis and the Navy each admitted errors and responsibility for faults in the program.

"All things considered, the Trident is to the Polaris what the B1 bomber is to the B-36."

Throughout the controversy, and indeed throughout the submarine's history, the program has been compared to the Polaris program. Often, Polaris was held up as a model for Trident planners and budgeteers. This essay will focus on the Trident submarine in a bureaucratic perspective by specifically comparing and contrasting it with Polaris. Since the Polaris submarine and missile program has received considerable attention in both scholarly and nonscholarly works, it is our goal to highlight the Trident system and to show how it differed from Polaris. We have therefore divided

Professor Dalgleish is on the faculty of Arizona State University and Dr. Schweikart writes widely on financial business history and military affairs.

the discussion into the two critical phases of Trident development and production: the first, 1967 to 1974, laid the groundwork for all the subsequent controversy; and the second, 1974 to 1982, saw the culmination of the problems built into the program at the outset, along with their recent apparent solutions.[1]

1967-1974

Designed as a replacement submarine for the Polaris-Poseidon submarine force that entered operations in the early 1960s, the Trident represented the quietest, fastest, and deadliest ballistic missile submarine (SSBN) in the world. When the Navy initiated purchases of long-lead items for the sub in 1972, the early designs of the vessel roughed out an awesome underwater strategic weapon. Although extensive design completion and modification occurred between the planning and the delivery of the *Ohio* (the first Trident) in November 1981, the finished boat was 560 feet in length and about 18,700 tons submerged displacement, making it the second largest submarine in the world behind the Soviet *Typhoon* at an estimated 25,000 tons. Each Trident's teardrop-shaped 42-foot-diameter pressure hull carries twenty-four Trident I missiles. Each has a range of four thousand nautical miles and enough nuclear warheads (a maximum of 192) for a magazine firing to lay waste to most of the industrialized regions of the Soviet Union, despite some attrition by Russian defensive systems. Besides the substantial increase over the previous class of US submarines in the number, range, and payload of the missiles, the Trident featured scores of technological advances in the fields of quieting techniques, active and passive defense, passive sonar, propulsion, automation, pressure-hull design, communication, operational endurance, navigation, simplified modular maintenance, and crew comfort. In short, it dwarfed all previous US strategic submarines in size and in sophistication of its equipment. To build such a mammoth hull, Electric Boat Company constructed an entirely new frame and cylinder facility at Quonset Point, Rhode Island, and thoroughly revamped its main assembly yard at Groton, Connecticut. Not only was the vessel to be new, but the entire construction process was revolutionized to handle the enormous construction demands posed by the hull size and the Navy's schedule.[2]

Trident emerged from a 1966-1967 study known as Strat-X, in which the Pentagon studied over 125 different missile-basing options in response to the likelihood that the USSR soon would deploy more powerful and accurate intercontinental ballistic missiles (ICBMs) in increasing numbers. Perhaps as a direct result of the experience with Polaris, the ground rules for the Strat-X study required that any suggested new platform be conceptually unique and not simply an upgrading of an existing launching system. Polaris itself had profited from being a straightforward modification of attack submarine designs, which gave it a significant design lead over systems that required

original work. A host of sea-based options were suggested in Strat-X, ultimately posing something of a problem for the winner—Trident, or ULMS (underwater long-range missile system)—in that each option initially was pursued as if it *would be* the winner. Considerable research went into these options. Thus, when Trident proved to be less than an engineering panacea, many observers tended to recall with a nostalgic affection the Polaris precedent and, hence, came to favor other options, forgetting that equivalent problems and complications would not be ruled out just by a preference for other untried alternatives. Polaris, on the other hand, competed with no other sea-based alternatives, except for a brief fling the Navy had with liquid-fueled rockets based on surface ships.[3]

During the development of Polaris, the Navy created the Special Projects Office (SPO), within which a small, cohesive group of advocates led by William Rayborn co-opted, incorporated, or otherwise aggrandized organizational power for Polaris. The major exception to SPO's cohesiveness was Vice Admiral Hyman Rickover, who through his position in the Naval Reactors Branch had supplied the Polaris class its nuclear reactors. Although unavoidably any reactor had to come from Rickover, Rayborn's group otherwise "froze" him out. With Trident, however, a completely different situation developed. By the late 1960s, Rickover had increased his personal and organizational power within the Navy to the extent that he could not be ignored and often could not be controlled. Yet, ironically, while he was responsible for the cost growth of Trident as much or more than any other individual, it was for reasons completely different from those normally pointed to by scholars, biographers, and critics of Rickover. Almost unanimously they have agreed that Rickover caused the Trident to be as large as it was by insisting on a huge reactor for its own sake. This conclusion is inaccurate insofar as it misses the crucial sizing factor already in place when the Navy submitted to Rickover requests for reactor designs: the height, diameter, and weight of the proposed D-5 (Trident II) missile. Even the early designs for this 6,000-mile missile showed it to weigh 60 tons and to be 42 feet in length by 7 feet in diameter. Admiral Isaac Kidd, Jr., former Chief of Navy Material, summarized the situation: "The missile sized the submarine."[4]

The other development that gave Rickover influence in the Trident program he had lacked in Polaris was a change in the strategic situation of the United States. During 1971, the Strategic Arms Limitations Talks (SALT-I) had resulted in an interim agreement of short duration. Chief of Naval Operations Admiral Elmo Zumwalt feared the Russians would use its expiration as an opportunity to press ahead with research and development that would dramatically endanger existing US ICBMs and offset the US technological lead in seaborne strategic systems. He therefore joined Rickover to present a united front to the nation's lawmakers, even though he had serious disagreements with Rickover about the size of the reactor and the

design of the ship. This alliance itself would not have subsequently been so crucial had it not given Rickover a hand in the general contract process.[5]

Since Polaris basically utilized existing attack submarine designs adapted to incorporate sixteen submarine-launched ballistic missiles (SLBMs) within a missile-launching section added amidships, Rickover had been unable to play any major role in the contracting process per se. Such contracts were therefore rather conventional, since radical new reactors were not required. This was not the case with Trident. Because the missile required a much larger hull and because Strat-X necessitated the development of new platforms, the Navy had to negotiate for a wholly new kind of contract specifically to build Tridents. Whereas the Department of Defense (DoD) in the fall of 1971 looked at alternatives advocating stretching out the hull life of existing SSBNs, Secretary Melvin Laird rejected these alternatives in favor of replacing the Polaris-Poseidon subs with Tridents and in favor of the rapidest Trident missile deployment possible. The Navy's judgment was that maintenance on the older submarines soon would make them inordinately expensive and perhaps less safe. Yet, it should be noted *all* options, whether they were life system extensions or Trident system replacements, were considered in light of using the C-4 (Trident I) missile—at the time itself still undeveloped—as a temporary measure until the Trident II would become available. Although Admiral Levering Smith of SPO had control over much of the design in the "Development Paper Concept 3b 10c," under which the outline of the Trident program was set, and although Rickover seemed to be sidelined during the 1971-74 period, the latter nevertheless was charged with designing a reactor capable of propelling a colossal hull carrying twenty-four Trident II missiles at high speeds. Still, Rickover's role was scarcely noticed until 1974, when the designs had been completed and the Navy was about to let the contract.[6]

Space does not permit a treatment of the debates in the Navy and in Congress whose resolution resulted in the final design. Considerable controversy surrounded the size and capabilities of the vessel, but critics often ended up contradicting themselves in trying to attack Trident: for example, whereas some argued that Trident would soon be made obsolete by Soviet ASW advances (thereby admitting that Soviet advances in ASW were real) other critics testified that Trident was unnecessary because the Soviets were well behind in ASW. Ultimately, both the size and capabilities of the submarine were decided by the missile and by considerations of cost effectiveness. Twenty-four missiles per sub were necessary to spread the cost of deploying an adequate number of warheads at sea.[7]

Where Rickover had his greatest impact was in advocating a fixed-price contract over a cost-plus type (straight incentive types were ruled out). Cost-plus contracting had proved common for most lead vessels, although the 617 (*Lafayette* class SSBN), the 637 (*Sturgeon* SSN), the 640 (*Benjamin*

Franklin SSBN), and the 688 (*Los Angeles* SSN), as well as two experimental subs, the 671 (*Narwal*) and the 685 (*Lipscomb*) all were built without cost-plus-incentive contracts. The key to building such a lead vessel without cost-plus contracts is to allow for subsequent submission of contractor claims, to hold out a real incentive of serial production, and to keep the technological advances relatively simple. However, in the case of the first Trident, the *Ohio*, nothing so radical since the *Nautilus* had been attempted, making cost-plus in this case the more reasonable form of contract. Rickover lobbied hard for a fixed-price contract, assuring Capitol Hill that the Trident was "bread and butter shipbuilding." His suspicion towards shipbuilders convinced him a cost-plus contract eventually would engulf the Navy in a sea of "unreasonable" claims. He won support from one Navy group, which also feared that the overall Navy shipbuilding budget for other classes of vessels might be lowered in order to accommodate the anticipated increased costs of the Trident. Admiral Isaac Kidd, Jr., and Rear Admiral Kenneth Woodfin, however, maintained just the opposite: "A cost-plus is the responsible and proper instrument to build a first-of-class ship. The lead Trident is no exception." Still, Woodfin admitted to being under great pressure to use fixed-price contracting.[8]

When the Navy asked two major shipbuilders to submit fixed-price bids to build the *Ohio*, neither responded. Newport News submitted a cost-plus bid, with a projected deadline for delivery in 1981, three years after the Navy's specified date. Electric Boat Company (EB) also submitted a cost-plus, but with the proper date. The Navy instructed EB to submit the bid in fixed-price form, but, while EB changed the date, it still negotiated for a cost-plus. Both the Navy and EB drew up cost estimates, with EB's estimate about $60 million more than that of the Navy. One Navy financial specialist agreed with EB's figures, calling them a more realistic target. After intensive negotiations, Electric Boat and the Navy produced a "marvelously inventive rubber document": a fixed-price with "rather liberal provisions." Woodfin called it "in *reality* a 'cost-type with a ceiling.'" Actually, the contract was so layered as to appear to have a fixed price but with incentives for time and performance at various plateaus. The Navy agreed to share many of the expenses beyond the target costs, however.[9]

Gordon Rule, civilian head of the Navy's Procurement Control and Clearance Division, an office responsible for reviewing contracts prior to their authorization, refused to clear the Trident contract. He claimed it had "built-in overrun" written all over it and was a "flagrant and unforgiveable example" of the Navy knowingly demanding "the wrong type of contract." Before long, Deputy Defense Secretary Bill Clements and Congressman Les Aspin were embroiled in the controversy. Clements approved the contract on 25 July 1974, and Aspin immediately attacked it as a "major screw-up." Contacting the General Accounting Office (GAO) through Charles Bennett,

head of the House Seapower Subcommittee, Aspin received word that Rule had opposed the contract. In fact, Rule sent a letter to Bennett with criticism "so blistering . . . Admiral Kidd forwarded it only with some anguish" under his own cover letter. Several other conflagrations ensued with the GAO pursuing the matter until February 1975, when GAO officials met with Bennett and some Navy representatives. During the meeting, Bennett reduced the question to a thumbs-up-or-down proposition, directed at GAO comptroller general Elmer Staats. Staats summarized his opinion by writing that he did not believe the "choice of contract was wrong." Rule and Aspin blasted the affair as a coverup, but the contract already was in the hands of EB, which continued to be baffled by the Navy's insistence on the fixed-price type. Said William Gourvine, counsel for EB, on the reason for the insistence on the fixed-price contract: "My more-than-belief is that it was Admiral Rickover." Thus, at the outset of construction, Trident was locked into constant controversy and cost overruns were guaranteed because a realistic price never was established.[10]

1974-1982

One major problem that progressively influenced congressional and public perception of the Trident—inflation—could not be blamed entirely on the Navy, even though several times congressmen clashed with Navy spokesmen over their estimates for inflation. During the 1974 to 1976 period, when Trident costs actually started to be realized, the Navy figured costs would increase at a rate of 7.9 percent. Such an estimate simply did not take into account prospective post-1976 rates and clearly did not include compound effects.[11]

Inflation, in turn, greatly exacerbated the problem of force levels, about which the Navy was less than candid. It appears a goal of ten vessels was established early in the program, although EB received indications the class would run only to seven. By the end of the decade, it was clear to all involved that a much larger force than ten—somewhere in the neighborhood of twenty-five to twenty-nine boats—would be needed to replace the Polaris-Poseidon fleet. Hence, the Navy missed opportunities for additional economies of scale in the early long-lead contracts in an amount of some $943 million, up to 31 December 1982. Again, neither this problem nor inflation hindered Polaris in any substantial way. First, inflation was much lower during Polaris' construction. Next, construction time itself was much shorter because of its relatively simple design, and the design conversion to incorporate ballistic missiles was much less complicated than dealing with an entire range of new systems, from reactor to sonar.[12]

Trident required something else Polaris had not needed—new basing. The size of the submarine made existing bases obsolete for servicing Tridents and, when combined with the increased range of the Trident I missile, it made all

foreign basing of the sub unnecessary, since all targets would be well within range from near our domestic shores. Consequently, another component of the Trident package was the construction of a new naval base at Bangor, Washington, near Bremerton. Spain somewhat unwittingly contributed to enhancing the global scope of Trident's capability by demanding in the late 1970s that the United States withdraw its Polaris-Poseidon squadron from Rota. Navy planners accordingly took advantage of the Spanish request by asking for authorization to build a Trident base for Atlantic deployment of Tridents at Kings Bay, Georgia.[13]

By 1977, the entire program generally seemed to be running along smoothly. Yet major problems were brewing. Upon receiving the major contract, EB had greatly expanded its work force, going from 11,000 in 1972 to 25,000 by 1977. Those job-hungry trades workers who poured in on the heels of the contract's activation lacked the necessary shipbuilding skills and taxed both the training and supervisory capacities of the yard. According to Stanley Eno, a former labor-relations manager for the shipyard, the firm hired "women, minorities, and the hard-core unemployed." As a result, "drugs, alcoholism, sex and discrimination incidents became a way of life" and "unrest, fights and problems [occurred] as people tried to learn shipbuilding trades." These "growing pains" were "unbelievable." Blame generally rested on the shoulders of Electric Boat's management. A machinists' union official testified that workers were "constantly demeaned, harassed, misdirected and blamed as a smoke-screen for management to cover their [*sic*] accounting manipulations with the Navy." Eno added that the "workers, supervisors and others [were] trying to look busy for 8 hours a day either because of lack of materials or lack of direction by management." Productivity at the shipyard dropped, thanks to an adverse proportion of skilled to nonskilled personnel, which eroded from 62 percent in January 1976, to 55 percent in June 1976, and to 49 percent in 1977. Contributing to the productivity problems was the inexperience of the newly hired supervisory and management force.[14]

P. Takis Veliotis took over the mantle of management from Joseph Pierce in 1977. Veliotis, a former World War II Greek submariner, whose colorful language features a "classical" accent, immediately reorganized the management at Electric Boat. He discharged 3,500 employees, retrained the supervisory force, and set up a program in managerial skills in conjunction with the University of Hartford. By reducing overhead and support functions he eliminated $126 million in costs through 1981. Additional steps taken to improve management involved taking an inventory of the plant and material stocks, computerizing many of the management and control systems, and reviewing what he considered to be unrealistic schedules and budgets. Veliotis also recognized the importance of avoiding future trade strikes, so after the trades council at Electric Boat elected Thomas Kiddy as

its new president, Veliotis opened negotiations on a new contract. When the two reached an agreement in June 1979, it marked the first time in twenty years Electric Boat had reached a settlement without first experiencing a strike.[15]

Veliotis most likely believed that by this point his corrective actions had solved the major problems, but deeper damage already had been done. On 12 March 1981, Vice Admiral Earl Fowler presented an indictment of EB's work to the House Seapower Subcommittee, claiming EB had used weldable mild carbon steel that "may not be strong enough for its specific end use" in over "126,000 locations" in four different Trident subs. He also alleged EB had performed deficient welds in some 688 *Los Angeles* class subs and, upon subsequent requests for records, the Navy learned EB lacked inspection records on over 26 percent of the *Ohio*'s welds. Besides blaming EB for faulty painting of the ballast tanks, Fowler concluded by criticizing EB's schedule delays and defended the Navy's habit of sending contract revisions to the shipbuilder.[16]

In fact, quite unlike Polaris—where the goal was to mate the missile with the sub and simply get an existing submarine design to sea with a few major alterations—the Navy was in essence experimenting with everything associated with the Trident. Never before had a submarine carried a crew of over 150 plus on patrols. The Trident was designed to be not only bigger than Poseidon subs but also to have greater speed, more quieting protection, and greater damage resistance. In order to achieve greater at-sea availability, a radical new outfitting concept was devised that used a considerable number of interior fixtures and components of a modular design to facilitate their easy removal, replacement, and dockside repair. Consequently, maintenance and port time would be greatly reduced, not only for each mission and each overhaul, but for the entire lifetime of the program as well.[17]

However, all of these innovations caused standard construction problems—a bolt off by an inch, a pipe that is a foot short—and flooded EB with design revisions. Veliotis estimated at one point they came in at a rate of twenty per day. Although many of the changes involved simple blueprint corrections, some required considerable labor and subcomponent fabrication. Even after January 1980, when the *Ohio* entered its final construction phases, Electric Boat received over 2,900 revisions that "required the performance of physical work in the shipyard—not just paper changes."[18]

Finally, government-furnished equipment (GFEs) proved defective in many cases. Turbines developed cracks and had to be replaced, and the new turbines—approved by the Navy—were not balanced and therefore required extensive corrective work. Complicated and novel valves supplied by the Navy failed, and various sealant plugs rusted, leading to a flooding of the *Ohio*'s engine room. EB workers received 8,000 notices of defective GFEs from the Navy inspectors in 1979 and caught many more themselves. Veliotis

estimated that lost work time amounted to 750,000 man-hours for repairing or correcting problems in GFEs; by 1981 the number dropped (2,856), as had man-hours (195,000), but still they remained significant.[19]

EB's responsibility for its own problems can be traced primarily to the massive manpower buildup from 1972 to 1977, with the welding deficiencies, for example, successfully being addressed by the replacement of poorly skilled workers with reliable, trained welders. Furthermore, the Navy greatly exaggerated the scope of the welding deficiencies by its method of counting and measuring the welds. Virtually no deficient welds were in the pressure-hull or reactor areas. EB willingly admitted responsibility for mislabeling the steel, although Veliotis claimed that even the mislabeled steel was tested at levels above necessary tolerance requirements. The shipbuilder blamed the Navy for the defective paint.

The Navy ultimately conceded to its shortcomings in the GFEs. But admitting its responsibility for the contract revisions brought Rickover's "rubber document" into the limelight again, leading to a bitter confrontation between EB and the Navy over (1) reimbursements for revisions, (2) reimbursements for time added by the revisions, (3) an understanding on the necessary subsequent schedule extension, and (4) provisions for inflation during the time lost by EB to GFE repair and revisions.

A great deal of posturing ensued at this point (1980-81), whereby both Secretary of Defense Caspar Weinberger and Secretary of the Navy John Lehman threatened to build Tridents elsewhere (even in foreign yards!), and EB countered by suggesting there might be a work stoppage. The Navy also awarded three *Los Angeles* submarine contracts to Newport News as a stimulus to make EB take "a more compliant stand on the Navy's demands." Rickover personally got involved, assailing EB's management as "so-and-sos" who did not "care if they manufacture horse turds or submarines."[20]

Most of the controversy was resolved in spring 1981, negotiations in which EB received a contract for the ninth Trident in return for an agreement to pay 50 percent on all cost overruns and for a promise to refrain from submitting claims on contractor-caused deficiencies. The Navy already had settled an earlier claims battle involving the 688s to EB's partial satisfaction. All sides engaged in adroit political maneuvering during the controversy, but the bottom line was that EB had the *only* equipment capable of building Tridents in the world—a $540 million capital investment—and gradually both the Navy and EB were working the "bugs" out of the new design. Partly due to the Navy's pressure, partly due to Veliotis's management, and partly due to a GAO audit, the shipbuilder delivered six attack subs and the *Ohio* in 1981, and would deliver two more Tridents in 1982. It continued to push ahead virtually all of its schedules so that by 1983 it had really lost only the time spent sorting out problems on the lead vessel.[21]

However, the theme of "cost overruns" has not disappeared. Typical reports include *Time* magazine "40 percent over the original budget," *U.S. News & World Report* "Trident Budget to Run Further in the Red," government publications "severe cost overruns," *Congressional Issue Brief,* and even sympathetic journals such as *Armed Forces Journal* "Blunted Trident." Polaris escaped such attacks for several reasons: its platform already was basically designed, its hard-core group of advocates often exceeded their administrative authority, they occasionally "hid" funds, and they did not have the fixed-price contract as "divine law" by which they were held accountable. Indeed, when one allows for inflation, the Trident has not been exceedingly costly, and when viewed in light of the capabilities per system, Trident and Polaris simply are not comparable, even on a proportional basis. The Navy could have gained greater credibility by using a cost-plus contract at the outset. Combined with a more gradual and careful buildup at EB, many of the subsequent construction difficulties and much of the media attention to costs could have been averted. But SALT-I and its constraints made a replacement of the Polaris-Poseidon force imperative, and Laird's acceleration order forced EB to aim for a deadline that, in the end, proved impossible to meet.[22]

Ultimately, Trident's costs vis-à-vis Polaris are measured only in its effectiveness as a deterrent, and to this extent Polaris evidently has been worth every penny expended during its life span. In more traditional measurements, however, the final bill for Trident probably is both greater than most people suspect and yet reasonable. When the cost of the bases, auxiliary facilities, related research on subsystems, and the unclaimed costs are counted, Trident is the single most expensive weapon currently deployed. If, however, the effects of inflation are wrung out, and if one measures the additional security gained by US basing, the Trident's costs are better put in perspective. Most important, however, are the possibilities the Trident hull offers with its amazing size and diving capabilities. Eventually it may serve as the model for new underwater tankers, may become the next great freighter series, or may perform a number of military uses just now being contemplated. All things considered, the Trident is to the Polaris what the B-1 bomber is to the B-36.[23]

Notes

1. This paper was prepared from material in the authors' book, *Trident* (Carbondale: Southern Illinois University Press, 1984). For procurement comparisons with other programs, see Robert Art, *The TFX Decision: McNamara and the Military* (Boston: Little, Brown, 1968); Robert Coulam, *Illusions of Choice: The F-111 and the Problems of Weapons Acquisition Reform* (Princeton, N.J.: Princeton University Press, 1977); Ingemar Dörfer, *System 37 Viggen: Arms Technology and the Domestication of Glory* (Oslo: Universitetsforlaget, 1973); Robert Kaufman, *The War Profiteers* (New York: Bobbs-Merrill, 1970). For descriptions of the Trident, see *The Trident System* (Washington: Navy Department, Trident System Project Office, 1977); Norman Polmar, "The U.S. Navy: Strategic Missile Submarines," US Naval Institute *Proceedings*, March 1980, pp. 141–42. For Polaris, see Harvey Sapolsky, *The Polaris System Development: Bureaucratic and*

Programmatic Process in Government (Cambridge, Mass.: Harvard University Press, 1972); J.J. DiCerto, *Missile Base Beneath the Sea: The Story of Polaris* (New York: St. Martin's Press, 1967); Baar and William Howard, *Polaris!* (New York: Harcourt, Brace & World, 1960). For general developments in the postwar Navy, see Richard Hewlett and Francis Duncan, *Nuclear Navy* (Chicago: University of Chicago Press, 1974), and Norman Polmar and Thomas Allen, *Rickover: Controversy and Genius* (New York: Simon & Schuster, 1982).

2. *Trident System*, passim; Interviews with P. Takis Veliotis, various dates, 1981-1982.

3. Polmar and Allen, pp. 564-66; James Canan, *The Superwarriors: The Fantastic World of Pentagon Superweapons* (New York: Weybright & Talley, 1975); Morton Mintz, "Depth Charge," *Washington Post*, 4 October 1981; William Whitmore, "The Origin of Polaris," US Naval Institute *Proceedings*, March 1980, pp. 56-59.

4. Sapolsky, pp. 11, 41-48; Mintz; *Senate Hearings*, Armed Services Committee, Subcommittee on Research and Development, 95th Cong., 1st Sess., 5 April 1977, statements of Admirals Don Harvey, Albert Kelln, and J.C. Metzel, p. 6660; Polmar and Allen, pp. 566-67.

5. Polmar and Allen, pp. 566-67; Elmo Zumwalt, *On Watch* (New York: Quadrangle Books, 1976), pp. 156-57.

6. *House Hearings*, Armed Services Committee, Subcommittee on Research and Development, 92d Cong., 2d Sess., 1 March 1972, statements of Admirals H.E. Lyon and Robert Kaufman, p. 2636; *Senate Hearings*, Armed Services Committee, Ad Hoc Committee on Research and Development, 92d Cong., 2d Sess., statements of Admirals Beshany and Kaufman, 22 March 1972, pp. 2651-60.

7. For examples of opponents' arguments, see *House Hearings*, 1972, pp. 2642-47 and Fiscal Year 1973 R.D.T. & E., N Program Data—Submarine System; Dr. Morton Halpern, "Sea Power Comes Back into Its Own," quoted in *Senate Hearings*, Armed Services Committee, 92d Cong., 2d Sess., 1972, p. 2649; *Senate Hearings*, Armed Services Committee, Ad Hoc Subcommittee on Research and Development, 22 March 1972, statement of Admiral Kaufman, p. 3192; *Congressional Quarterly*, 5 August 1972, p. 1964; *Ibid.*, 31 March 1973, pp. 712-13; *Senate Hearings*, Armed Services Committee, 92d Cong., 2d Sess., 9 March 1972, statement of Dr. Herbert Scoville.

8. Mintz; Jacques Gansler, *The Defense Industry* (Cambridge, Mass.: M.I.T. Press, 1980), pp. 84, 138-39; J.R. Hiller and R.D. Tollison, "Incentive vs. Cost-Plus Contracts in Defense Procurement," *Journal of Industrial Economics*, 26: (1973) 239-48.

9. Mintz; Interviews with P. Takis Veliotis, various dates, 1981-82; Interviews with O.B. Nelson, varions dates, 1981-82.

10. Mintz; Polmar and Allen, pp. 570-71.

11. *House Hearings*, Armed Services Committee, Research and Development Subcommittee, 13 March 1975, statements of H. Tyler Marcy, Assistant Secretary of the Navy for Research and Development, and Admiral John Nicholson, p. 4570; *House Hearings*, Armed Services Committee, Subcommittee on Research and Development, 26 February 1976, pp. 857-859, statements of Admirals Albert Kelln and J.C. Metzel.

12. *House Hearings*, Armed Services Committee, Subcommittee on Research and Development, 94th Cong., 2d Sess., 26 February 1976, statement of Rear Admiral Kelln, pp. 857-58; *House Hearings*, Armed Services Committee, Subcommittee on Research and Development, 94th Cong., 1st Sess., statement of H. Tyler Marcy, p. 4570; *Department of Defense Annual Report, 1975*, Table 1. One way to determine the additional cost is to use a formula for compound inflation (.08) for the cost of raw materials for the three additional boats purchased. Thus (3 x $343.8 million) (.08) = $91.2 million times 10 years = $912 million (*Trident*, chap. 4). Of course, the figure of 8.85 percent for compound inflation is somewhat subjective, and the debate over what constitutes true inflation rages on.

13. For a discussion of Trident's bases, see *Trident System*, p. 7; *Congressional Quarterly*, 31 March 1973, p. 713; *House Hearings*, Armed Services Committee, Subcommittee on Military Installations and Facilities, 94th Cong., 1st Sess., 12 May 1975, statement of Admiral H.E. Lyon, pp. 410-16; *Senate Hearings*, Armed Services Committee, 95th Cong., 1st Sess., 22 March 1975; statements of Admirals J.C. Metzel, A.L. Kelln, and A.R. Marschall, p. 687; *House Hearings*, Armed Services Committee, Subcommittee on Military Installations and Facilities, 94th Cong., 2d Sess., 25 February 1976, statements of Admiral Marschall, and Admiral Metzel, pp. 309-33, 856.

14. Jim Davis, "Building the Trident's Home," US Naval Institute *Proceedings*, March 1979, pp. 62-73; *House Hearings*, Appropriations Committee, 97th Cong., 1st Sess., 25 March 1981, statement of P. Takis Veliotis, pp. 1-4; *House Hearings*, Appropriations Committee, 97th Cong., 1st Sess., 5 May 1981, statements of Admiral Hyman Rickover, pp. 9-11, 90, 130, 133, 159, 169; "Sub Cost Overruns Blamed on Drugs, Sex, and Booze," *Boston Globe*, 20 May 1978.

15. *House Hearings*, Appropriations Committee, 97th Cong., 1st Sess., 25 May 1981, statement of P. Takis Veliotis, pp. 1-4.

16. *House Hearings*, Armed Services Committee, Subcommittee on Seapower and Strategic and Critical Material, 97th Cong., 1st Sess., 12 March 1981, statement of Vice Admiral Earl Fowler, pp. 2-17. Fowler produced the following chart for the committee:

Ship	Original Contractor Delivery Date	EB Estimate Feb. 1978	EB Estimate* Aug. 1980	Navy Estimate
726	4/30/79	11/80	6/81	12/81
727	4/30/80	11/81	11/81	9/82
728	12/30/80	7/82	7/82	9/83
729	8/31/81	3/83	3/83	5/84
730	4/30/82	11/83	11/83	1/85
731	12/31/82	7/84	7/84	9/85
732	8/31/83	3/85	3/85	5/86
733	5/31/86			1/87

*Electric Boat advised the Navy in October 1980 that these dates were under review (p. 17).

17. These construction techniques are discussed at length in the authors' *Trident*, chap. 5. Also see Gerard Burke, "To Build Trident," US Naval Institute *Proceedings*, October 1979, pp. 117-20; "Nuclear Submarines" (pamphlet by Electric Boat); "Quonset Point Facility" (pamphlet by Electric Boat). The authors received considerable information on Trident construction from William Bennet, vice-president of the Quonset Point facility (June 1982) and P. Takis Veliotis (various dates).

18. *House Hearings*, Appropriations Committee, 97th Cong., 1st Sess., 25 March 1981, statement of P. Takis Veliotis, pp. 9-13 (figs. 9-15).

19. *Ibid.*

20. A report prepared by the GAO for Congress place the conflicting claims side by side ("Vice Admiral Fowler and P. Takis Veliotis, Side-by-Side," 5 May 1981, in authors' possession); "Navy Says General Dynamics Must Settle Its Claims to Get More Trident Contracts," *Wall Street Journal*, 16 September 1981; "General Dynamics Won't Ask Navy to Pay Costs on Flawed Subs, Wins Chance at Bid," *Wall Street Journal*, 17 September 1981; "Navy, General Dynamics Reconcile Feud," *Wall Street Journal*, 23 October 1981.

21. "Navy, General Dynamics Reconcile Feud;" Representative Charles Bennett to Milton Socolar, acting comptroller general of the United States, 6 April 1982 (in authors' possession); Socolar to Bennett, 19 April 1982, *ibid.*; Statement of Electric Boat Company, A.M. Barton to W.H. Sheley, 24 February 1982, *ibid.*

22. "How to Spend a Trillion: Arming for the '80s," *Time*, 27 July 1981, pp. 6-21; "Inside Story of the Trident Debacle," *U.S. News & World Report*, 12 December 1977, p. 37; "Navy's Trident Sub: One More Massive Miscalculation," *U.S. News & World Report*, 12 December 1977, p. 37; Benjamin Schemmer, "A Blunted Trident," *Armed Forces Journal International*, June 1979, p. 42, and retraction, "All Wet About a Blunted Trident," *Armed Forces Journal International*, April 1980, pp. 36-37, 61-62; Congressional Research Service, *U.S. Defense Industrial Preparedness Issue Brief #IB81109* (Washington: Congressional Research Service, 8 June 1982), p. 5.

23. Alternative uses of the hull are discussed in *Trident*, chap. 12. For example, one Trident could carry at least 200 cruise missiles, could serve as a laser anti-cruise-missile picket ship, or could serve as a particle-beam ABM system.