From Technical Solution to Managerial Transformation: PERT and the Polaris Missile Program in the 1950s [1]

Evelyn R. Chao
Founder and President, PM Ready Inc.

Abstract

In the late 1950s, the U.S. Navy launched the Polaris Program to create the first solid-fueled, nuclear-armed submarine-launched ballistic missile system. Confronting immature technologies and intense schedule pressure, the Navy's Special Projects Office collaborated with civilian contractors and created the Program Evaluation and Review Technique (PERT) as a statistical, network-based method for planning and controlling complex research and development projects. PERT did more than accelerate the Polaris schedule; it became a defining tool of modern project management following Polaris's success. The story of PERT in Polaris highlights several management lessons for contemporary project professionals. PERT's lasting value was not only technical but managerial - it created a shared language for uncertainty. Complex projects require transparent information flows, disciplined review rhythms, and probabilistic thinking. At the same time, PERT's limitations show that management systems remain dependent on human judgment. These lessons are especially relevant in the age of artificial intelligence. Like PERT, AI helps project teams manage uncertainty; however, it should augment, not replace, managerial judgment. The history of PERT reminds project professionals that successful innovation depends not only on new tools, but also on the governance, culture, and trust that make those tools effective.

Keywords: *Project Management; Risk management; PERT; Polaris Missile Program; U.S. Navy*

Introduction

In the late 1950s, the U.S. initiated the Polaris Program to develop the first solid-fueled, nuclear-armed submarine-launched ballistic missile (SLBM). This program involved unfamiliar engineering challenges, intense schedule pressure, and complex contractor networks. To manage

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this pioneering program, the U.S. Navy's Special Projects Office developed the Program Evaluation and Review Technique (PERT) - a network-based managerial method for planning large research and development programs. By drawing from a range of primary sources, including archives from the Navy's Special Projects Office, oral histories, newspaper articles, and other contemporary documents, this paper explores how PERT evolved from a technical solution for Polaris in the 1950s to a revolution that shaped the project management field. The technical innovation of PERT accelerated the delivery of the Polaris Program, transformed how the program managed time, interdependence, and risks, and came to symbolize professionalism and modernity in project management.

Origins of the Polaris Program

In the 1950s, the U.S. adopted a strategy of deterrence against the Soviet Union. National security experts warned that early deterrent forces, such as strategic bombers and land-based missiles, became increasingly vulnerable to a first strike. The 1950 U.S. National Security Council report to the President stated that "It is estimated that, within the next four years, the USSR will attain the capability of seriously damaging vital centers of the U.S." (U.S. National Security Council, 1950). A 1955 report from the Technological Capabilities Panel of the Science Advisory Committee also emphasized the need to meet the threat of surprise attack, noting that "They [the Soviets] might be so tempted to attack before we achieve a large multimegaton capability." (U.S. Department of State, 1955, p. 43). Both reports alerted that U.S. bomber bases were increasingly vulnerable to surprise attack and drove the shift toward missile-based deterrence.

These strategic concerns drove the Eisenhower administration to seek a quickly deployable second-strike capability. In 1956, the U.S. Navy began formal studies for a submarine-launched ballistic missile. This effort unfolded alongside parallel missile programs in the Army and the Air Force. Admiral Arleigh A. Burke (1901-1996), Chief of Naval Operations (1955-1961), reinforced the political pressure behind Polaris in a 1972 interview with Dr. John T. Mason Jr., the Director of Oral History at the U.S. Naval Institute. He stated that ballistic missiles were going to "replace aircraft for the delivery of large quantities of nuclear weapons." (Burke, 1972, p. 5). The studies quickly translated into organizational action. On November 8, 1955, Burke directed the creation of the Special Projects Office (SPO) and assigned it the full responsibility of developing the Polaris submarine weapons system "in an efficient, economic, and timely manner." (U.S. Bureau of Naval Weapons Special Projects Office, 1963, p. 2). SPO was formally established in December under the leadership of Rear Admiral William F. "Red" Raborn (1905-1990), a career Navy officer who led the development of Polaris and later headed the Central Intelligence Agency under President Lyndon B. Johnson.

Despite its strategic importance to the U.S. defense, Polaris met controversy and unprecedented challenges from the outset. First, the program lacked broad public support. The 1972 interview of Admiral Burke revealed the limited enthusiasm for Polaris, commenting that although intercontinental missiles were already being discussed, their development still seemed distant and uncertain to many people at that time (Burke, 1972, p. 6). From a technical standpoint, the program required compact solid-propellant rocket motors at a scale and level of reliability that remained immature at the time. During a 1972 interview with Dr. Mason, Admiral Raborn stressed that the Navy was introducing machines and equipment it had neither previously encountered nor had experience operating (Raborn, 1972, p. 60). Operationally, Polaris involved coordination across a wide network of contractors. By 1961, it was estimated that "250 prime contractors and 9000 subcontractors were working on the program." (Morris, 1994, p. 27). The scale and organizational complexity required to bring the system into existence posed a significant challenge to Polaris's timely delivery. Beyond its technical and operational challenges, Polaris was also driven by a rapid schedule. As Atomic Energy Commission historians Richard G. Hewlett and Francis Duncan noted, Admiral Burke ordered Admiral Raborn to "squeeze every drop of time out of the Polaris schedule." (Hewlett & Duncan, 1974, p. 314). Carleton Shugg (1899-1922), head of the Electric Boat Company who worked on the detailed design of Polaris, confirmed the intense time pressure in his September 1973 interview with Dr. Mason. Shugg recalled that speed was the major challenge for Polaris (Shugg, 1973, p. 9). These factors combined made Polaris a complex national innovation in both engineering and organization.

Innovation of PERT in Polaris

Facing these extreme challenges, SPO developed the Program Evaluation Review Technique (PERT) as a statistical, network-based technique for planning and evaluating the research and development of Polaris. Before PERT, SPO primarily relied on milestone reporting to track and communicate actual versus planned progress across all assigned work areas (U.S. Bureau of Naval Weapons Special Projects Office, 1963, foreword). This method had several disadvantages: it could not manage networks of concurrent activities or account for uncertain task durations. Polaris participants Richard Young and Everett Lennen highlighted in their 1959 article that milestone reporting could not reliably forecast project progress (Malcolm et al., 1959, p. 647). In response to these shortcomings, SPO collaborated with its civilian contractors and developed a more integrated management practice, which became PERT in 1957. By mid-1958, Admiral Raborn and SPO began publicizing PERT as "the first management tool of the nuclear and computer age." (Morris, 1994, p. 27).

The mission of PERT was "to estimate progress to date of the complete system." (Malcolm et al., 1959, p. 647). At the SPO level, PERT supported periodic assessments and forward-looking evaluations of the overall missile program. At both the SPO and contractor management levels, PERT tracked complex subsystem development and component programs, typically through bi-weekly reviews (U.S. Bureau of Naval Weapons Special Projects Office, 1963, p. 12). Specifically, PERT had two requirements: a flow plan and elapsed-time estimates. PERT breaks a project into interrelated activities and represents them in a diagram called a flow plan – a network of planned events in dependency sequence (U.S. Bureau of Naval Weapons Special Projects Office, 1963, p. 12). With events and activities defined in the flow plan, PERT then obtained elapsed time estimates from individuals who performed specific tasks. In an October 1972 interview with Dr. Mason, Dr. Jack W. Dunlap (1902-1977), a member of the civilian steering committee for Polaris, commented that the most important requirement for project evaluation at SPO was the provision of detailed, well-thought-out time estimates on future activities (Dunlap, 1972, p. 14). PERT used three probabilistic time estimates - optimistic, most likely, and pessimistic – to infer the uncertainties associated with the effort. PERT used the three-point estimating formula to produce a more balanced and realistic time prediction: Three-point estimate = [(O+4R+P)/6]. With this formula, PERT calculated each activity's earliest and latest start and finish times to highlight schedule risk. After activities were arranged in a flow plan in the proper order, PERT could determine the longest sequence of activities from start to finish, which determined the project's minimum duration. PERT called that sequence the critical path - the sequence of activities that determined the shortest possible project duration. The critical path provided a probability-based estimate of the entire project completion time.

SPO maintained that PERT had proven effective for supporting decision-making and ensuring internal balance and coordinated action across the program (U.S. Bureau of Naval Weapons Special Projects Office, 1963, foreword). Polaris reported a 20–25% reduction in development time compared with prior expectations (Sapolsky, 1972, p. 253). Beyond speeding development, PERT's impact on Polaris extended much further.

First, PERT reshaped the culture of time and power in Polaris. By making the schedule visible, PERT shifted time from a private concern to a shared goal and a focal point for interaction. That visibility also gave SPO master control over Polaris scheduling and performance. As management expert Peter Morris noted, "measuring performance against plan was a central objective of SPO control." (Morris, 1994, p. 30). In a 1990 interview with the journal *PM Networks*, two retired engineers from Mitre Corporation, a civilian contractor on Polaris, discussed how consolidating scheduling authority helped SPO gain program funding from Congress (Enright et al., 1990, p.

26). By making scheduling transparent and central to decision-making, PERT was not merely a technical tool but became a strategic lever that helped legitimize funding requests. The concentration of authority within PERT reflected a tradition in American management. Sociologist Max Weber proposed Bureaucratic Management Theory in his 1921 book *Economy and Society*. This theory treated bureaucracies – marked by specialized functions and authority hierarchy - as the most efficient way to organize large, complex organizations. Business historian Alfred Chandler later followed the intellectual tradition that viewed hierarchy as a mechanism of control. His study of large American corporations in the late 19th and early 20th centuries concluded that professional, multi-level managerial hierarchies were the principal mechanism that enabled large-scale, complex business growth (Chandler, 1977). The centralization of power within SPO for managing Polaris followed the managerial pattern described by Weber and Chandler, demonstrating historical continuity with a longstanding management culture.

Second, PERT reshaped management culture within Polaris by institutionalizing public review. Dr. Jack W. Dunlap, a member of the civilian steering committee for Polaris, recalled in an October 1972 interview with Dr. Mason that the meetings became calendared events that anchored decision-making (Dunlap, 1972, p. 13). The managerial tool of regular reporting thus evolved into a set of rituals that structured attention and coordination. To generate a more objective measure, a small team of SPO staff and civilian contractors, Lockheed Corporation, and Booz Allen Hamilton, developed "a number of criteria for the required project control system." (Morris, 1994, p. 30). The terms and criteria used by SPO and its civilian contractors produced standardized communication tools for meetings and correspondence. Project management expert Peter Morris noted that PERT meetings used terms such as "good shape" or "minor weakness" to describe work status (Morris, 1994, p. 30). Contemporary research also showed that institutionalized communication rituals helped strengthen organizational accountability. For instance, political science scholars James G. March and Johan P. Olsen proposed the theory of new institutionalism, advocating that institutions shaped political behavior through routines, norms, and organizational logic rather than solely through rational choice (March & Olsen, 1989). Project management expert Bob Prieto maintained that large projects developed standardized tools, such as specific quantitative metrics to manage uncertainty (Prieto, 2025). A 2025 article on defense supply chains also showed how standardized meeting procedures and reporting formats made operations more predictable and easier to manage (Pedersen et al., 2025, pp. 152-177).

Third, PERT reshaped government-contractor relations by promoting collaboration through full transparency, a principle that closely resembled later Agile project management methodology. Agile management, which emerged in 2001 with the publication of Agile Manifesto, features an iterative, collaborative approach that delivers value quickly by prioritizing customer feedback, adaptive planning, and continuous improvement. By standardizing communication and making expectations, interdependencies, and progress explicit, PERT reduced information barriers between SPO and its contractors. Contractors were required to submit regular PERT updates to SPO and participate in frequent coordination sessions. This practice created continuous feedback loops like Agile reviews and planning meetings. This close coordination and high level of visibility promoted a culture of joint problem-solving and a stronger sense of collective ownership. Contemporary accounts illustrate how this transparency supported collaboration. Booz Allen Hamilton's archives documented an early anecdote about the creation of PERT. SPO members discussed the Polaris Program over dinner with Booz Allen Hamilton analyst JW "Bill" Pocock. As SPO described the program step by step, Bill sketched what he later called a cross between a network diagram and an illustrated flowchart on the tablecloth, revealing a roadmap of the program. Over the next few weeks, Bill and his colleagues turned that sketch into PERT (Booz Allen Hamilton, n.d., paras. 3-7). SPO and civilian contractors collaborated to publish articles that introduced and legitimized PERT. On April 27, 1959, SPO officer W. Fazar and three specialists from SPO's civilian contractors Booz Allen Hamilton - D. G. Malcolm, J. H. Roseboom, and C. E. Clark – co-authored an article in the journal *Operations Research*. This article was among the first publications to introduce PERT to the public as a technique for evaluating research and development programs (Malcolm et al., 1959, pp. 646-669). These examples revealed that PERT relied on transparency to enable close cross-functional collaboration, shared learning, and collective responsibility for managing complex work.

Fourth, PERT transformed the risk management culture. A 1958 SPO work report on Polaris highlighted PERT's risk-management focus, noting that PERT encouraged technical personnel to do their forward planning (U.S. Bureau of Naval Weapons Special Projects Office, 1958, p. 1). The three-point estimation explicitly acknowledged the existence of risks, reducing overly optimistic or inflated schedules and helping mitigate the risk of project failure. The PERT flow plan introduced probabilistic task durations and emphasized the critical path, turning uncertainty into tractable inputs for decision-making. By focusing on tasks that threatened the critical path, PERT shifted organizations from reactive firefighting to proactive prioritizing. Participants of the Polaris Program - Malcolm, Roseboom, Clark, and Fazar - emphasized PERT's risk management function in their 1959 article on PERT. They explained that PERT provided "an analytic tool for making the expected time estimates along with their variances," (Malcolm et al., 1959, p. 648) allowing planners to "predict slippage and also estimate the effect of any actual or potential slippage." (Malcolm et al., 1959, p. 648).

Fifth, PERT created new professional identities, such as schedule analysts, integration managers, and PERT coordinators or analysts. For example, Admiral Raborn established the Progress Analysis Branch to audit actual rather than officially reported progress (Morris, 1994, p. 30). In his 1972 interview with Dr. Mason, Dr. Dunlap discussed the background of his selection to Polaris's civilian steering committee. He recalled that Admiral Raborn asked him to put together some training ideas for the committee on human engineering - a then-new industry technique that Dunlap defined as "the art of establishing interfaces between men and equipment." (Dunlap, 1972, p. 8). The new roles and practices shifted day-to-day ownership of the project from individual engineers to specialized managers whose job was to monitor the schedule, spot problems, and ensure the pieces fit together. Over time, PERT did not just improve scheduling and systems integration; it helped professionalize project management by creating a new kind of professional who thought in timelines, dependencies, and risk. Scholars of management have documented a similar pattern that technical and managerial innovations created new occupations or career ladders. A recent work on digital management showed that technological advances had significantly reshaped how we worked and transformed the professional skills and personal attributes necessary to thrive in the modern workplace (Kvirchishvili, 2024, p. 81). A 2023 article that examines the impact of technological change on employment in high-income countries since the 1980s further demonstrated the dual impact of technological change - although technology could displace some jobs, "the replacement effect is likely to be more than offset by the labor-creating effect of technology." (Hötte et al., 2023, p. 19). Together, these findings underlined that tools and organizational methods like PERT did not merely improve efficiency; they also reshaped professions and the way people worked.

Diffusion of PERT

Admiral Raborn, Director of SPO, was originally given eight years to develop the world's first submarine-launched nuclear ballistic missile, but he delivered the Polaris A1 missile in July 1960 — three years ahead of schedule. Navy executives praised Polaris' rapid progress: A 1958 *New York Times* article quoted Rear Admiral A. G. Mumma, Chief of the Bureau of Ships, calling the Polaris advances "amazing," and Admiral Burke, Chief of Naval Operations, describing the progress as "tremendous." (Morris, 1958, p. 1). In 1959, Polaris achieved a series of increasingly reliable test successes, setting the stage for the first operational conversion of a fleet submarine. On November 15, 1960, USS George Washington (SSBN-598) departed Charleston, South Carolina, on the Navy's first nuclear deterrent patrol carrying Polaris missiles. By providing a credible assured second-strike capability, Polaris strengthened the U.S.'s strategic deterrence (Burr, 2009).

Polaris's success during the Cold War constructed a narrative that mastery of PERT signaled both managerial competence and commitment to national priorities. When the first Polaris missile was launched in 1960, "press coverage of PERT was almost as great as the coverage of the launch itself." (Morris, 1994, p. 31). This publicity helped drive adoption. Following Polaris's success, other government and military agencies, as well as private firms, adopted PERT to manage complex projects and to demonstrate professional rigor. PERT quickly became a popular subject in scholarships. As Peter Morris summarized in a historical survey of project management, "By 1962, the US Government had issued 139 different documents and reports on the technique. By 1964, the bibliography on PERT comprised nearly 1000 books and articles. The technique has become almost a household word, synonymous in some people's minds with project management itself." (Morris, 1994, p. 31). Scholarly studies considered Polaris and PERT as catalysts for modern project management. As Morris put it, "PERT became iconic as a symbol of the new discipline of project management." (Morris, 2011, p. 18).

Multiple federal and military agencies adopted PERT for their projects. In June 1962, the Department of Defense and the National Aeronautics and Space Administration (NASA) issued a manual titled *DOD and NASA Guide - PERT Cost System Design*, adopting PERT as a standard for major federal and military acquisition programs (Hill, 1965, p. 1). According to a 1964 technical report the Mitre Corporation - a nonprofit managing federally funded research and development for the U.S. government - prepared for the U.S. Air Force, "the U.S. Air Force accomplished initial implementation and testing of PET on the F-111 weapon system at the Aeronautical Systems Division by a special Air Force Systems Command implementation team under the supervision of the AFSC PERT Control Board." (Hamilton, 1964, p. iii). In addition to the U.S. Air Force, NASA explicitly adopted PERT for space projects. A NASA technical memorandum from 1982 evaluated the application of PERT and linked it to formal, rational management of high-risk programs. The report stated that NASA extensively used PERT during the 1960s "because of an increased awareness of the cost implications of schedule performance." (Sibbers, 1982, p. 1). These adoptions across space and defense agencies celebrated PERT's status as an essential tool for planning and controlling complex government and defense programs.

In addition to federal and military agencies, private corporations and public events in the U.S. and other countries also adopted PERT. General Electric provided PERT programs for its GE-625/635 computers and published manuals in April 1967 to guide their use (General Electric Information Systems Division, 1967). Civilian programs likewise viewed PERT adoption as a sign of modern, professional management. Public health analysts advocated using PERT for community health service programs. In a 1966 article, public health analyst Walter Mert assessed the application of

PERT in public health, concluding that "PERT can assist the public health administrator in precisely estimating program progress, coordination, rational phasing of activities, delineation of responsibility for various program components, and preliminary and final evaluation." (Mert, 1966, p. 454). Internationally, PERT spread to France in the 1960s. The Organizing Committee for the 1968 Winter Olympic Games used the PERT technique to organize the different tasks to build the Olympic village in Grenoble, France, a site selected for the Games in 1964. As Jessica Katel Valencia-Martin comments in her 2024 study of the PERT method in the 1968 Winter Olympic Games, PERT provided "an image of the organization of works and their interrelations within a fixed time" (Valencia-Martin, 2024) and became "a management tool - not of space but of human time in a context of accelerating tempo." (Valencia-Martin, 2024).

Despite the publicity of PERT, its contribution to the Polaris Program should not be overestimated. While PERT produced gains, it could potentially cause tensions. Oral interviews with SPO members could reveal tensions in the adoption of PERT. In his 1974 interview with Dr. Mason from the U.S. Naval Institute, Gordon O. Pehrson (1906-1985), head of Polaris's planning staff, described the project's bureaucratic aspects from a civilian standpoint. Pehrson used the word "cumbersome" to describe how PERT worked and commented: "PERT shows computer-based statistical massage of the data, which was becoming too voluminous for us to identify." (Pehrson, 1974, p. 25). Project management expert Peter Morris also identifies the tensions and biases involved in implementing PERT. He commented: "Contractors resented being asked to estimate pessimistic schedule dates, and, like the SPO staff, they were reluctant for 'their' data to be processed outside their control, to produce a result with which they might not be happy." (Morris, 1994, p. 31). Pehrson's interview and Morris's research revealed that the ritualization of reporting could become bureaucratic overload; engineers sometimes resented paperwork that seemed to constrain technical initiative.

In addition to potential issues of tension and bias, PERT has limitations in its application. A 1958 work report on the Polaris Program explicitly acknowledged that applying PERT required the accuracy of human judgment. It stated: "The system will still be based on human judgment at its very source. The system can integrate these judgments in an orderly, consistent, and rapid manner- but the quality of these judgments is a constraint upon the method." (U.S. Bureau of Naval Weapons Special Projects Office, 1958, p. 1). This statement acknowledged that the PERT analysis could be highly subjective. As Mert points out in the study of applying PERT in public health programs, PERT is suited only for objective-oriented efforts - programs designed to meet specific and measurable organizational goals. Because of this restriction, PERT cannot support the total health planning process. Its greatest use "occurs after the selection of specific objectives and during the implementation and evaluation steps." (Mert, 1966, p. 450). Taken together, these reports suggest that PERT should be used cautiously and in combination with broader planning methods.

The innovation of PERT in Polaris and its subsequent diffusion offer enduring management lessons that remain relevant today. First, narratives reinforce adoption. Telling the story of PERT's contribution to Polaris's success helped depict the technique as a symbol of managerial modernity. Second, tools must create shared meaning. PERT succeeded in part because network diagrams and status reports became a common language across agencies, enabling coordinated action. Third, cultural fit accelerates the diffusion of technology. PERT resonated with Cold War managerial values such as the desire for stability, control, and predictability, which helped it spread into other government and civilian programs. Together, these points show three factors that promote the diffusion of management techniques: demonstrable results that build credibility, a shared language that helps organizations coordinate, and alignment with prevailing managerial values that make adoption culturally acceptable.

Conclusion

Born of Cold War urgency and political pressure, PERT emerged not just as a scheduling tool; it created a new way of managing large, complex projects such as Polaris. PERT made the program possible by making time visible and uncertainty calculable, institutionalizing public review, integrating risks in estimation, centralizing authority while fostering a joint problem-solving culture across military and civilian boundaries. In Polaris, these practices fostered accountability and created new professional identities centered on integration and risk management. Yet PERT introduced tensions—between engineers and managers, and between flexibility and bureaucracy—that reveal the potential biases and limits of this system.

Polaris's success turned PERT from a technical solution into a symbol of managerial modernity. The diffusion of PERT across defense agencies, civilian industries, and even international events illustrates how new managerial or technical innovations spread when they align with existing values and create shared meaning that helps coordinate teams. From a technical solution to a managerial revolution, PERT exemplifies how tools designed to solve immediate problems can reshape culture, power, and professional practice in enduring ways. The historical case of PERT will inspire us to seek new ways to innovate with greater and lasting impact.

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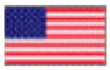
About the Author

Evelyn R. Chao

Washington, DC, USA



Evelyn R. Chao is a high school senior at Sidwell Friends School and passionate about learning, practicing, and advocating project management. At age 14, She earned the Project Management Ready Certification from the Project Management Institute (PMI). Since then, she has channeled her enthusiasm for civic engagement into championing project management education and empowering young changemakers to serve.

Believing in the transformative power of education, Evelyn took the initiative to establish the nonprofit organization PM Ready Inc., accessible at www.pmready.org. PM Ready serves as a unique platform for fostering intergenerational conversations about project leadership and inspiring youth of diverse backgrounds to apply project management learning to achieve their full potential, take actions to promote community and global development goals. She published two books - *Project ABCs for Aspiring Changemakers (2024)* & *Youth Voices of Change: Case Studies of Impactful Student-Led Projects (2026).*

Beyond her academic pursuits, she is an active member of the U.S. Naval Sea Cadets and a coxswain with TBC Rowing Club. Outside of school, she enjoys playing the violin, drawing, reading, watching movies with her family, and hanging out with her friends. A loving older sister to Elaine and Elise, Evelyn takes pleasure in nurturing their curiosity through fun, hand-on projects. Evelyn can be contacted at evelynchao.r@gmail.com