BOOK REVIEW

- project and risk management -

Harvey M. Sapolsky
THE POLARIS SYSTEM DEVELOPMENT
Harvard University Press, 1972

How could a book, now three decades out of print and describing an obsolete military program, be of any interest to executives today? Because it offers inspiration to all managers who think they face impossible tasks and risks. This book describes the management techniques that allowed the U.S. Navy to take the Polaris submarine from concept to deployment -- an outstanding technological feat in its day -- within a time-frame that was nothing short of astounding.

HISTORICAL BACKGROUND:

During the 1950s, the U.S. government's top national priority was to build a massive deterrent against potential Soviet aggression. Nuclear weapons would provide the necessary destructive power, but a delivery system was needed. Conventional wisdom then dictated that aircraft and missiles were the most suitable means for the free delivery of this energy to its unwilling recipient. Seeking a key role in the strategic defense of the nation, the three U.S. armed services fought ferociously among themselves to promote their own strategic weapons systems. The U.S. Air Force pushed its family of long-range bombers and later several generations of ICBMs - spawning the System Safety program, typified by MIL-STD 882, in the process. The Army proposed its own ICBM. The Navy proposed a force of nuclear powered submarines carrying Polaris missiles, known as the Fleet Ballistic Missile (FBM). The Army program died from a lack of funds. Both USAF programs survived, but not without costly overruns and several monumental flops, such as the B-36 bomber. The Navy program was a remarkable achievement considering the multiplicity of challenges and risks it had to overcome. The management ingenuity the Navy showed in overcoming these challenges makes this an ideal management case study. The Polaris project was probably the greatest triumph of U.S. government bureaucrats until NASA put man on the moon. NASA owed much of its success to Polaris, having taken advantage of many Navy techniques.

U.S. NAVY MANAGEMENT PHILOSOPHY AND THE POLARIS PROJECT:

As keen and earlier believers in systems thinking, Navy planners believed improvements in any single component of a weapons system would have little effect on the performance of the system as a whole. However, coordinated improvements in several components held the promise of an extremely effective system in five years and an even more effective system in ten. Polaris program managers recognized the emergence of technological trends, versus a traditional reliance on technological events. As a result, they always projected their thinking and planning well into the future -- in almost every area. A typical question they might have asked in 1958 would have been "Why use a 1958 nuclear warhead in a 1965 weapon system?"

ORGANIZATION

With political, financial, career and national defense stakes so high, rivalry between and even within the three services was ferocious. When Congress approved Polaris, the Navy created a new unit, the Special Projects Office (SPO) to manage the project. This was a deliberate move

to avoid awarding it to either its Bureau of Ordinance or the Bureau of Aeronautics. The Navy wisely felt had the task gone to one or the other (since both would be involved), the resultant rivalry might have been fatal to the project.

OPERATIONAL OBJECTIVE

Once given the mandate and start-up funds, the SPO had an enormous task -- to bring into being an entirely new weapons system. This included nuclear powered submarines, then in their infancy, global navigation and communication systems, missile systems, launching systems, fire- control systems and maintenance, support and training programs. Most of these components did not exist at the time -- many were still only on the drawing board. All had to be designed, built, tested and integrated into one workable unit and made operational, from scratch -- within five years! Building a weapons system based on the promise of one or two technologies was not unusual, but doing it on a dozen technologies was.

MANAGEMENT OBJECTIVE

From the outset, the SPO had two contradictory management objectives:

1. Secure full organizational autonomy for the FBM project. Experience had shown that without total SPO control of the program, many bureaucratic and political interest groups could compromise the Polaris project. None of these groups could be expected to have the best interests of the FBM uppermost in mind, but rather only their own. SPO managers also knew from experience that in a crisis, the administration's response was more likely to centralize than to delegate. For these reasons, the SPO needed almost total control of the project in order to meet their objectives.

2. Win technical cooperation of other agencies and financial appropriations from Congress. The success of Polaris would depend largely on technical cooperation from other civilian and military institutions and on large appropriations from Congress. Unfortunately, cooperation and funding were usually only possible if the SPO allowed control, oversight and even outright interference in the project by these institutions. The SPO wanted to avoid, however, the meddling influence of review panels and congressional inquiries. Thus, the SPO had to maximize outside support while minimizing outside interference.

STRATEGY

To achieve both of the seemingly irreconcilable objectives, the SPO adopted four strategies described as:

1. Differentiation
2. Co-optation
3. Moderation
4. Managerial Innovation

1. "Differentiation"

The SPO carefully distinguished its product from other strategic weapons systems. The SPO promoted the invulnerability of submarines and their tactical and strategic advantages. Ultimately, they were successful in convincing Congress of the uniqueness of the FBM.

To motivate their project team the SPO also differentiated Polaris personnel from other navy staff. They wore special uniforms, worked a 5 and 1/2 day week, had all their mail shipped "High Priority," were told to "think big or get out," and, unusually, enjoyed first-class travel arrangements and hassle-free expense accounts.

The SPO made a major effort to communicate the uniqueness and importance of the FBM by sending top brass on frequent tours and speeches to motivate SPO and contractor personnel. The SPO actually hid its public relations budget from public by getting contractors to advertise the project. The SPO even briefed families of SPO personnel, explaining why their spouses worked such long hours and were under so much stress.

Press releases were invariably optimistic, if not deliberately exaggerated. This created a supernatural aura about the program and put added pressure on the project team to ensure that technology and progress kept place with advertising.

2. "Co-optation"

The SPO deliberately dealt with potential outside threats to the program by bringing them into the program in a leadership or policy function, even if only titular in nature. Thus SPO systematically drew critics of the FBM into the program and maneuvered them into a position where they were a part of the schedule. Scientists and academics, especially doubters, were targeted for special briefings. The SPO set up a slush fund to pursue outside suggestions. The SPO sought private shipbuilding companies (versus contracting to public shipyards) to ensure wider political support. Because time-frames were critical, the SPO demanded and got personal pledges from contractors, and even from the contractor's employees, that their work would be completed on time.

The SPO frequently used "goodwill" to achieve their ends. An example was the number of ballistic missiles each submarine was to carry. By merely stretching the boat, it was possible to carry between 2 and 48 missiles. The SPO originally suggested 32 as a compromise. The old WW II submarine skippers refused, saying this would make the boat too long to maneuver easily. To please the senior captains, the SPO asked them to record, on a piece of paper, their preference. When these were all drawn from a hat, added up and then averaged, the SPO reduced the number of missiles to 16!

Incidentally, the SPO never achieved its goal of total control over the FBM project. The Navy's Nuclear Propulsion Directorate, headed by Admiral Hyman Rickover and the Bureau of Ships demanded -- and got -- a share in the project. At the time, Rickover set the qualifications for and selected nuclear submariners - but this is the subject of a separate review.

3. "Moderation"

The SPO built long-term support by sacrificing short-term gains. The success of the FBM concept was more important than getting perfect control over all aspects of the program. The SPO deliberately ignored several opportunities to achieve tactical successes in order to concentrate on its primary objective. This allowed the SPO to avoid making extra enemies. By being selective and disciplined, the SPO also increased its credibility with Congress in

requesting funding and support. "Whatever Lola wants, Lola gets," was how one SPO official put it.

An example of the moderation was in the selection of the FBM headquarters. While other branches had their Project Headquarters on site, SPO installed theirs in very modest buildings in Washington. Not only was the SPO's moderation seen to be genuine but, more importantly, it was seen by Congress.

The SPO also showed considerable restraint by not taking the lead in every project in which it had an interest (e.g., communications systems). Unlike other branches of the service, the SPO had a policy of not attacking its opponents. In official briefings and before Congress, the SPO always made respectful reference to the USAF's ICBM system, emphasizing the only real enemy was the Soviet Union. Interestingly, the USAF did not reciprocate, but instead took every opportunity to attack the FBM program.

4. "Managerial Innovation"

A big challenge facing the SPO was integrating all the components of the project. The SPO knew that other weapons systems had failed due to piecemeal integration. This review will skip the many fascinating technical challenges facing the SPO and focus instead on management tasks such as planning, organizing and performance reporting. The SPO felt that existing Navy systems were more concerned with inputs than outputs. In their integrated project, they wanted to look at costs only in relation to output, and every function, be it operational or administrative, should be geared towards output.

The SPO was also concerned about the commitment of its personnel. They would have to work on a near wartime footing for several years. The SPO started in 1955 with a staff of 45 officers and an equal number of civilians. None had ballistic missile experience. Five years later, they had 325 personnel and by 1972, by the time of the next generation (i.e. Poseidon) missile, they had 1,800.

Top-notch management techniques made the SPO so successful that Navy, Army and Air Force units paled in comparison and consequently lost considerable influence. For example, to ensure the closest cooperation from their operational colleagues (the fleet), the SPO received all combat patrol reports. They assigned SPO officers to sea duty in rotation. The Deputy SPO position went to a top submarine skipper, then, Admiral I.J. Galantin. Not surprisingly, the SPO got good cooperation from the fleet.

Public shipyards had a reputation for demanding equality with the client organization, and were often unwilling to compromise or subordinate their own interests. The private shipyards had no such problem. In fact, they often sub-contracted work to other firms and maintained control over them, a vital first step in project integration.

The SPO assumed overall control of the project, but also relied heavily on the contractors. Privately, the contractors did not think highly of SPO staff, realizing that the SPO could not have done it alone. To their credit, however, the SPO staff always stayed one step ahead of the contractors, and one step ahead of technology. They always put themselves in a position where they could choose between several alternatives, which they did, and competently. By having so many contractors make so many proposals, the SPO's authority was never challenged.

The SPO was very receptive to innovative ideas. Interestingly, an earlier "idea safari" of private industry turned up nothing of significance. The SPO was concerned about dedication and honesty in reporting goal progress from the top down. Early warning and correction of problems was a prime need. The SPO wanted a method for knowing what was going on (or wrong) down the entire organization.

The SPO ultimately became so famous in its time as a management model that it had to hire a full time staff to brief government and industry officials on SPO management techniques! Some of these techniques included:

a) **Program Evaluation and Review Technique (PERT)**

The SPO developed PERT to be a computerized planning, scheduling and control device. SPO managers knew that high level Navy or political interventions and reviews always disrupted programs.

With the help of PERT, the SPO gained a reputation for management excellence with DoD and Congress, and got hands-off treatment during the entire Polaris project. This allowed the SPO to concentrate on managing the technical aspects of the program instead of justifying its existence and management of it.

PERT officially began when a civilian employee, Gordon Pehrson, wrote a staff memo in January 1957, calling for a common integrated planning and evaluation system for the entire project. At every level in the project, there must be a plan and a performance report that logically and clearly relates to the project at large. This system required frequent performance reviews and plans for corrective action.

The SPO was familiar with the Critical Path Method (CPM) developed jointly by the du Pont Corporation and Remington Rand Univac and the Line of Balance (LOB) method used for repetitive tasks. It contracted further research and development into a monitoring system, and the outcome was PERT. One advantage of PERT is the identification of a critical path, which allows the redeployment of resources from non-critical tasks to the critical ones. Its primary purpose is to save time, not money. PERT was thus ideal for SPO since time, and not money, was the critical resource.

PERT identifies the progress made to date and the forecast progress. It can evaluate changes to existing plans and can determine the effects of any such change. It draws a relationship between time, cost and performance, but is hard to make accurate. It requires engineering estimates of time, which are usually imprecise. It takes the best, worst, and most likely time, and factors these to develop both the expected time and the critical path. A complex project requires a computer to make all the calculations.

$$Tc = \frac{b + 4m + w}{6}$$

Where Tc = Time to complete
b = best time
w = worst time
m = most likely time

At the time, some people thought PERT was more important than Polaris itself! It probably shaved two years off the program. The other services at first disparaged PERT, then copied it

shamelessly. This caused a substantial PERT cottage industry of consultants and trainers during the 1960's.

PERT was nevertheless distrusted by the contractors, who resented SPO project managers looking over their shoulders. The SPO project managers in turn resented the PERT computer specialists looking over their shoulders! The only way the SPO could coerce contractors into using PERT was to publicize its widespread use and success! The SPO wanted access to raw PERT data, right from the scientist's workbench. The contractors fought back, ironically, by setting up their own PERT units, to "process" PERT data before feeding it to the SPO. Although this played right into the SPO's hands, it also made PERT susceptible to GIGO (Garbage In - Garbage Out).

SPO Director Vice Admiral William F. Raborn pushed PERT mercilessly. The colorful PERT charts impressed everyone, and coupled with the nature of the project, they exuded management "sex appeal." This kept other DoD poachers at bay and politicians off SPO's back. Other government services became so enamored with PERT, they quickly made it a requirement in subsequent contracts.

A more objective assessment of PERT is that the network analysis is the major benefit. PERT can reduce cost and time overruns, and make its practitioners look like better managers. On the negative side, it was expensive, drawing 4-5% of the project's resources, and up to 15% if not managed well.

The Royal Navy knew of the over-inflated success of PERT when it embarked on its own Polaris program in the 1960's. The Royal Navy deliberately adopted PERT, essentially to keep Whitehall, Parliament and other critics away from their project. It worked just as well for the RN as it did for the USN.

b) **Reliability Management Indicator (RMI)**

RMI looked at the validity (i.e., accuracy and longevity) of the PERT data. In theory, it should have signaled how often the calculations should be revised to stay on top of the Project. In practice, it was never fully successful.

c) **Project Management**

The SPO is credited for refining the Project Management concept as we know it today. They defined management as monitoring and controlling the work behavior of subordinates. The SPO demanded and got its contractors to set up project style organizations. This concentrated resources full time on Polaris work, rather than doing it merely as a sideline. It also turned the contractor into a blind believer in the FBM and wedded the contractor to the FBM project.

The classical problem faced by project managers is the disbandment of the project team and its organizational structure once the project is complete. Although the SPO was in effect disbanded, it gave birth to two successive generations of FBMs: first Poseidon, then Trident. Ironically, despite the success of Polaris, these offspring became increasing delinquent. The Trident program was the single worst managed project in U.S. military history in its day.

d) **Project Management Plans (PMPs)**

Each task had a commonly formatted plan, identifying sub-tasks and milestones, and using standard symbols to depict approval, coordination, etc. All performance was measured against these plans.

PMPs were not totally successful, since the SPO kept changing its mind. As a result, the plans were often as much a source of confusion as direction! The plans often couldn't keep up with the program. Imprecise milestones caused considerable interpretation and confusion. For example "deliver Air Conditioning system" could mean the system was to be delivered dockside in a crate, delivered dockside ready for installation, installed in the submarine or installed and operational in the submarine.

e) **Technical Development Plans (TDPs)**

These identified the tasks, methods, performance objectives and test procedures for developing technical objects. This added a qualitative dimension since PERT did not address quality.

f) **Program Management Center (PMC)**

This secure room in the SPO's Washington Headquarters was the focal point for all management and the site for all management briefings. It had extensive Audio Visual aids and seated about 110 persons. The success of the PMC was due primarily to the weekly meetings held in it, chaired by the SPO Director.

g) **Weekly Program Review Meetings**

The SPO Director held a Program Review meeting in the Program Management Center every Saturday morning. The format was rigid, the first agenda item always being "Progress on Goals," from the PMPs described above. The project manager would report progress in one of four ways:

"Good Shape"

Everything on target, progressing as planned. No further action required.

"Minor Weakness"

Minor problem that had to be corrected immediately by the SPO branch concerned or the contractor concerned.

"Major Weakness"

Serious problems that could become critical if not dealt with effectively. Required immediate intervention of SPO.

"Critical Weakness"

A problem so large that it threatened the integrity of the program and required immediate outside help.

Top SPO managers expected to hear about problems before, not at the meetings. This allowed them to determine a proper course of corrective action, and avoid making rash or reactive rulings. The meetings helped control the project by motivating (read pressuring) the staff. Admiral Raborn selected people seemingly at random and pummeled them with questions. As the project matured and the first Polaris submarines went to sea, returning skippers briefed the meeting on problems encountered.

These weekly meetings worked well. The staff prepared rigorously for the Saturday morning meeting. In front of the SPO Program Director, sat contractors, branch heads and subordinates. Contractors and visitors were barred from every fifth meeting. Given the presence of so many other knowledgeable people and all the dependencies created by the interfaces, there was tremendous pressure to be totally honest in progress reporting. Lying was a cardinal crime that carried severe consequences.

h) **Management Graphics**

The Polaris project enjoyed top quality graphics -- crisp, clear, full color, visually very attractive and impressive. They were successful in persuading congress.

GENERAL MANAGEMENT TECHNIQUES

Despite all the ballyhoo about PERT, the success of the program was more due to:

- management techniques (as described),
- leadership (as evident from above),
- esprit de corps (evident) and
- an effective organizational structure (see below)

The SPO was organized to be both decentralized and competitive, providing a self-regulating power over the project. The six branches were a loose federation. Tight, centralized control from Washington was avoided to minimize the dissipation of contractor talent in the bureaucratic paperwork that would inevitably follow. Decentralization would also minimize attempts to deceive Washington, thereby protecting the integrity of the program. Thus, there was a deliberate decision to decentralize and encourage competitiveness. Organizational units not only had to cooperate, they often had to compete with one another. This had a salutary effect on the program, but at a cost to the staff.

Branch heads could be dismissed within 24 hours of a failure, and civilian staff were prohibited from returning to their previous positions if they failed! Long hours, travel, separation from family, and the need to perform placed a heavy strain on the staff. To compensate, Raborn encouraged Military/Contractor fraternization, paid first class travel for everyone in the program, did not nit-pick on expense claims. He also awarded higher ranks, and gave personal commendations and awards for technical excellence and meeting or beating deadlines. (It is noteworthy that no one ever got a medal for saving money.) What he got in return were totally committed zealots.

The project presented an enormous synergistic risk, since it was far more difficult to deliver an operational FBM submarine than merely develop all the subsystems.

There were four major management complications to Polaris:

1. Managing the Synergism: because of the complexity of the project, it was broken into subsystems. However, the narrowness of these subsystems could be detrimental to the macro-system. Managing the interfaces between the subsystems became a supremely important management task.

2. Difficulty in Realizing Goals: trying to keep pace with all of the plans for things that were yet invented was an almost impossible task!

3. Organizational Change: the SPO was asked to integrate personnel from the Navy's failed Jupiter project into the FBM program.

4. Accelerated and Expanding Schedules: Within a year of starting, SPO and the U.S. government got the shock of their professional lives: Sputnik. Delivery of the first boats had to be accelerated from 1963 to 1960; and the number to be delivered went from three to six to nine to 27 and finally to 41!

Admiral William Levering Smith, who succeeded Admiral Raborn as SPO Director, developed the following SPO Management Maxims:

1. Performance requirements: must be set by technically competent staff and be deliberately vague!

2. Back-up teams: two or three teams should be assigned to complete every critical component of the task. If they all succeeded, the SPO could pick the best one. If one failed, they still had two others. Even if two failed, the SPO still had a back-up.

3. Fallback strategy: even if all the back-up teams failed, the wily SPO always had an alternative that did not rely on the problematic component!

4. Deployment vs. improved technology: it was more important to meet the original schedule than to delay, hoping to take advantage of a technology that offered improvement further in the future.

5. Goal discipline: every activity that did not specifically advance the project was ignored (e.g., surface Navy and land Polaris).

6. Avoid Naval Labs: they are too sensitive to cutbacks and other priorities.

7. Interfaces: Knowing what to control is as important as having the power to control. Managers must be more concerned with interfaces than subsystem details. Interface specifications were fixed early and monitored closely. This helped the SPO from becoming bogged down in technical detail, and encouraged initiative and energy amongst the contractors and the six SPO branches.

8. Resources: were controlled by the Technical Director and a Board of Directors.

CONCLUSION: SECRETS OF THE POLARIS SUCCESS

At $11 Billion (US 1967 dollars) the Polaris project was the largest project undertaken in its time by the U.S. Government. It held the highest priority and received congressional appropriations without question. Its success was due to several factors:

1. It was rational project with well-defined goals.

2. As a national priority with the power of huge appropriations, it demanded and got the best access to technology available.

3. It enjoyed a unique confluence of emerging technology and the highest national security need (i.e. Sputnik).

4. SPO managers had management, military science and political skills who could out maneuver their opponents.

5. SPO staff were bureaucratically skilled, self confident, aggressive and entrepreneurial and knowledgeable of their technical field and totally committed to the program.

6. It was effectively organized to promote subtle but intense competition through decentralization and the competition amongst choices. Every unit had an actual or potential rival and no one had a monopoly. Everyone had an incentive to watch his own pot, and keep his eyes on the other guys'. It made the division of labor manageable and kept everyone honest.

7. It enjoyed outstanding coordination through performance objectives, excellent interfaces between units and components, back-up and fall-back positions and by not delaying the project by waiting for later technology. The SPO deferred enhancements to a later upgrade.

8. Finally, Polaris had a gimmick, PERT. As Sapolsky wryly observed, PERT was less effective than advertised but more so than rain dancing. As such, it served its purpose.

Ironically, the FBM program has become a victim of its own success: witness the lack of public support in the 1970s for Poseidon and the scandal of the 1980s with Trident! Sapolsky all but predicted this, and even described the important changes in DoD that would cause this fall from managerial grace. Sapolsky cited the following, prophetic reasons:

- a change in DoD role from operations to procurement
- a change in contracting from competitive to single source
- a change from project status to program status, and
- a change in mission from second strike to first strike

STYLE:

Sapolsky writes fluidly and his prose read easily, which is not always the case for an academic. At the time, Sapolsky was Associate Professor of Political Science at the Massachusetts Institute of Technology, one of many institutions that the SPO relied on. The author is objective, and accurate, in spite of his sponsorship by the Navy. All his major claims and predictions have withstood the test of time.

CRITICISM:

To Sapolsky's credit, he candidly confronts, in his very first pages, a potentially debilitating charge of conflict of interest and professional compromise. He refused to accept an offer from the SPO to be the project historian but did accept a Navy offer to document the process on the condition that the only vetting the book would receive would be for security reasons.

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We can learn much from this fascinating account of bureaucratic excellence.

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Original text: The Polaris System Development, Management Book Review #1, Book Summaries and Reviews, CADMUS Home Page

Source: http://www.cadmus.ca/bookreviewpolaris.htm