LESSONS ON DEFENSE RESEARCH AND DEVELOPMENT MANAGEMENT

Gene H. Porter

The Problem

Getting early decisions on new systems right—ensuring adequate attention is given to the critical "What to Buy" decision—is crucial in Department of Defense acquisition. Some attributes of Office of Secretary of Defense (OSD) organization and practices in the 1970s could be effectively applied within the current structure and procedures for starting and developing new weapon system acquisition programs.

IDA research on the DoD acquisition process in recent years has repeatedly identified the importance of getting the early decisions on new systems "right"—that is, ensuring that adequate attention is given to the critical "What to Buy" decision. But the provenance of such decisions has depended on the degree to which Secretaries of Defense have chosen to exercise their authority over the military services' (hereafter services) traditional "requirements" processes.

Senior military officials generally have strong views on what characteristics are needed in the next generation of the weapons systems that will be acquired to equip the planned active and reserve forces. When a service chief makes a strong public commitment to a specific new weapon system, it generates considerable momentum. On the other hand, the Secretary's writ gives him the responsibility and the authority to make, or delegate, all major decisions within DoD, including the formulation of the budget proposals that define the weapon systems that DoD proposes to buy. This authority has been codified and refined many times since the original National Security Act of 1947 first established the Secretary of Defense position. The actual use of that authority has been, for the most part, quite circumspect, but on occasion it has led to major civil-military confrontations.[1]

IDA researchers have reviewed the history of this decision-making process; this article summarizes their findings, with a focus on the role of "outsiders" in instigating real innovation in military technology and operational concepts.[2]

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[1] Probably the most notable of these was Secretary Louis A. Johnson's peremptory cancellation of a new "super carrier," the USS *United States*, in 1949 incident to the early decisions on the roles and missions of each of the Services in the emerging field of nuclear warfare. This action resulted in what is generally known as "the revolt of the Admirals."

[2] The term "outsiders" is used to differentiate important contributors to military innovation whose primary fields of activity are outside the normal service-specific military chains of command. Such outsiders have, historically, included members of the Secretary of Defense's staff.

World War II Roots

The important role of outsiders in bringing new technology and new operational concepts to bear on the World War II effort has been widely documented in recent years (Kennedy 2013, Budiansky 2013, Conant 2002). Allied leaders, particularly Winston Churchill and Franklin Roosevelt, recognized that defeating Germany, and then Japan, would take more capability than could be achieved by mobilizing military channels alone. In the United States, President Roosevelt chartered the Office of Scientific Research and Development (OSRD) under Vannevar Bush to mobilize the science and technology community for wartime research and development.

At a cost of only about $500 million, OSRD developed a remarkable array of innovative weapons, as well as novel and effective operational concepts using the new science of operations research.[3] Many of the 5,000 OSRD scientists and engineers met with knowledgeable service personnel to discuss operations and problems, propose technical solutions, and, when they agreed that the problem had been solved, begin development. OSRD engineers and scientists worked closely with users, involving them more deeply in engineering and operational testing—often in the field of combat—until the system was ready to be handed over for production and operational service. At the end of the war, OSRD was closed down, but its image lingered.

Establishment of the Director of Defense Research and Engineering

With the end of World War II, there was an extended period of debate and adjustment as new structures for defense were worked out. The dramatic news of the Soviet Union's Sputnik satellite launch in October 1957 created a sense of threat and urgency that President Eisenhower used to demand long-desired changes. Among them was a highly centralized overall authority for defense R&D operating under a civilian official, the Director of Defense Research and Engineering (DDR&E), who reported directly to the Secretary. In response, Congress passed a sweeping reorganization act in August 1958 that gave the President much of what he asked for, including a powerful DDR&E.

In collaboration with the new office of Assistant Secretary of Defense (Systems Analysis) or ASD(SA), the DDR&Es during the 1960s and 1970s[4]

[3] This amount, equivalent to roughly $5 billion in today's terms, covered all the work on the atomic bomb through the end of 1942, and the development of all U.S. microwave radars, the proximity fuse, a wide variety of rocket weapons, specialized vehicles for waterborne invasions, pioneering guided weapons, advanced torpedoes, electronic countermeasures, new explosives, anti-malarials, DDT, penicillin production methods, and a host of other equipment and systems, as well as operations research and other support for military operations and many important advances in basic knowledge for weapons development.

[4] Of particular importance during the period 1958–73 was the fact that the DDR&Es were three experienced leaders from the nuclear weapons community—Herbert York, Harold Brown, and John Foster, who were committed to expanding U.S. non-nuclear military capabilities. They were followed by Malcolm Currie, an experienced electronics industry executive with strong credentials in sensing systems, who also strongly supported major non-nuclear transformational technology developments including stealth aircraft. It is also important to recognize that the ASD(SA) (changed to Program Analysis and Evaluation or PA&E in 1973) and the DDR&E had a close working relationship, with the DDR&E providing technical assessment and evaluation, while the ASD(SA) focused on assessing mission needs and resource aspects.

implemented mission analysis and systems engineering at the mission area level to explore the potential of technology to transform the structure of warfare, rather than simply improve the performance of individual systems. Mission area systems engineering was at the root of the DDR&E organization's greatest successes in the 1970s. In a significant number of cases, it led to innovations with broad impacts. It was also a focus of criticism from those who wished to limit OSD to policy, management, and coordination functions and reassert the authority of the services.

During the 1980s, a series of actions by the Administration and the Congress shifted the focus of innovation toward the military departments, reducing the ability of the new Under Secretary of Defense for Research and Engineering (USD(R&E)) to affect major acquisition choices and bringing the pattern set by prior DDR&Es to an end.

Accomplishments and Lessons

The 1970s are remembered as an era when DoD produced especially innovative and successful programs. There is no conclusive way to measure this, let alone distinguish among its causes. But many successful programs and systems from the period are still in front-line service, and notably, several had a transformational impact. In addition, one factor that is almost always associated with serious problems is cost growth. Yet statistical analysis shows that programs that had their inception in the late 1970s, after the DDR&E approach had fully matured, had, in general, better cost growth records than those of any other period between 1970 and 2000.

Principal factors contributing to the DDR&E organization's success included:

- Operating at the intersection between technology and military need; working in close cooperation with other relevant OSD offices; and focusing particularly on the critical period at the inception of a concept, where the success or failure of programs is principally determined.
- Use of the DDR&E's history and heritage to establish and uphold the validity of its model of civilian scientists and engineers exercising a dominant voice in deciding what programs to pursue and how to structure them.
- A compact and elite staff that had the qualifications and qualities to powerfully and creatively support the top executives of the DDR&E in meeting their objectives.
- A strong culture of objectivity and an absence of either pessimistic or optimistic bias, backed by the systematic use of comparative analysis.
- Excellent communications within the DDR&E organization and with the other organizations that played key roles in the "What to Buy" decision.
- A sharp focus on the things that made a real difference.
- Close meshing with the top management of DoD and its priorities.

Case Studies

The foregoing lessons are drawn from several detailed case studies of

"What to Buy" decisions during this period.

TFX/F-111—One of the first major non-strategic programs with extensive DDR&E involvement, it was a major learning experience for the DDR&E organization. It represents a baseline in more than one sense—no other program showed DDR&E in such a bad light. This was due, in large part, to the lack of serious mission area analysis that would have revealed the incompatibility of the Air Force desire for a high-altitude nuclear bomber and the Navy desire for a carrier-based multi-purpose fighter/attack aircraft.

Missile Defense Alarm System (MIDAS) and Defense Support Program (DSP)—These were conceived as space-borne infrared (IR) sensors high above the atmosphere that would watch for the signatures of rocket engine exhausts to warn of ballistic missiles en route to the United States or other locations of defense concern. The DDR&E urged a deliberate development program that would ensure the needed technical performance and reliability. The Air Force criticized the DDR&E approach, recommending instead urgency in deploying an operational system based, in part, on inaccurate assessments of the likely expansion of Soviet intercontinental ballistic missile (ICBM) capabilities. Without DDR&E intervention, the program very likely would have become mired in premature efforts to deploy inadequate technology.

Global Position System (GPS)—The DDR&E had become a driving force in deciding what to be acquired and how. In 1973, the Air Force sought permission from the Defense Acquisition Review Council (DSARC) to proceed with full-scale development of a global position system. Then DDR&E Malcolm Currie was sharply critical of what he correctly perceived as defects in the service's proposals, and directed the Air Force to seek input from others—the Navy in particular—which had important contributions to make. The program manager promptly reordered the program to meet the DDR&E's demands, secured approval from a second DSARC, and went on to develop the GPS.

Stealth—The DDR&E and Systems Analysis offices collaborated early in the mission area analysis that demonstrated the importance of radar cross section (RCS) reduction, if it could be achieved. The DDR&E and the Advanced Research Projects Agency (ARPA) provided the follow-on leadership to bring it to fruition. Radar stealth has been perhaps the single most dramatic development in technology for combat aircraft since the advent of jet propulsion, more than 30 years earlier. While stealth has been claimed by many fathers, reflecting its great success, the DDR&E played a significant role in crystallizing the program and securing support.

Surface Effect Ship (SES) Prototype Program—The fullest, most detailed case study concerns the 2,000-ton SES program (which grew to a 3,000-ton program). Admiral Elmo R. Zumwalt, Jr., a visionary and a reformer who became the Chief of Naval Operations in 1970, was personally devoted to the development of a "100-knot," oceangoing, SES surface combatant. Although the SES was a program of a heroic nature, it was also brought low by its own internal flaws, which the DDR&E staff (together with the Program Analysis and Evaluation PA&E staff) worked diligently to keep in view. First, no one could offer a convincing explanation of the special value of the SES's speed in surface ship missions since the inherent limitations of sensors and weapons generally restricted their combat operating speeds to no more than 20 knots. Second, key features of small test vehicles—particularly the critical hull-to-water seals—could not be scaled up with any real confidence. There were also fundamental problems with performance in high sea state.

Ultimately, the prototype program was canceled in late 1979, after the expenditure of more than $300 million dollars (a figure in excess of $1 billion in today's dollars). The SES program illustrates many of the ways that DDR&E/USDRE operated during the period to provide an objective, detached perspective on major acquisitions.

Relocatable Over-the-Horizon Radar (ROTHR)—The ROTHR case involved a new concept for long-range aircraft detection and tracking that the DDR&E staff understood could provide a cost-effective alternative to the burgeoning interest in costly airborne and space-based radars. When the service staffs could not be persuaded to seriously consider such an approach in the late 1970s and early 1980s, the DDR&E staff started briefing the regional military commanders on the concept. Their efforts garnered the support of the new Commander in Chief of the U.S. Pacific Command, Admiral William J. Crowe, who took advantage of Defense Secretary Caspar W. Weinberger's enthusiasm for responding to regional commander "requirements" to spur the development and fielding of the TPS-71 ROTHR program, just as the threat of Soviet long-range bombers collapsed at the end of the cold war. The "relocatable" nature of the system, combined with its relative affordability, led to its continued use, and today the system detects and tracks potential drug aircraft in the southern approaches to the United States.

Looking to the Future

Could attributes of the successful organization and practices of the DDR&E of the 1970s be applied effectively within DoD's current structure and procedures for starting and developing new acquisition programs? Under the current structure, the Under Secretary of Defense for Acquisition Technology and Logistics (USD(AT&L)) has both statutory and delegated responsibility and authority over all aspects of defense acquisition. He has delegated specific responsibilities for strengthening the early development planning phases of the acquisition process to the Systems Engineering Directorate in the office of the Assistant Secretary of Defense for Research and Engineering (formerly DDR&E). In consonance with that organizational framework, three recommendations from this IDA work are:

1. Ensure that personnel experienced in system design and operations analysis, and free of bias and conflicts of interest, are directly

and substantively involved in and approve the early concept formulation and requirements determinations for all new major weapon systems, prior to formal Defense Acquisition Executive approval of a new program start at the Materiel Development Decision point.

2. Increase the authority of the AT&L staff to initiate and guide promising innovative technological approaches, including Advanced Technology Demonstrations that can lead to important new military capabilities, as well as attract highly qualified scientists and engineers to government service.
3. Empower the ASD(R&E) to review and approve the adequacy of every development plan and associated funding profile as a condition for starting all new major acquisition programs.

Other supporting recommendations include positioning the ASD(R&E) organization at the technology-operations interface; making use of its heritage to reinforce its authority; continuously improving staff quality through training and emphasis on personal skills development; promoting objectivity and close communication among the staff; and institutionalizing learning from experience.

Mr. Porter is an Adjunct Staff Member in IDA's Strategy, Forces and Resources Division. He holds a Master of Science in Physical Oceanography from the University of Washington.

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