AUSA SPECIAL REPORT

A PRIMER ON RESEARCH AND DEVELOPMENT IN THE U.S. ARMY

INSTITUTE OF LAND WARFARE
ASSOCIATION OF THE UNITED STATES ARMY

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FOREWORD

Most would agree that the technological edge of the United States throughout the Cold War era has been a major factor in the success of its deterrent national security strategy. At the same time, most would probably agree that there has been an erosion of that advantage that results from a more recent failure of the United States to take full advantage of its technological strength.

Because of this turn of events, this Special Report was written to provide an evolutionary perspective of the Army's organization and methodology aimed at fielding weapon systems that will give the U.S. soldier a technological edge over any potential adversary. The ultimate goal is to provide the reader with an appreciation for the complexity of the research and development process, the efforts under way to efficiently manage the technology base to slow the so-called erosion, and the need for stabilized future funding of R&D programs.

The principal author of this report is General Robert W. Sennewald, USA Retired, a Senior Fellow of the AUSA Institute of Land Warfare. The report could not have been completed without the able assistance of the Institute, the Office of the Assistant Secretary of the Army (Research, Development and Acquisition) and the U.S. Army Materiel Command.

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'I can't believe that!' said Alice. 'Can't you? the White Queen said in a pitying tone. 'Try again: draw a long breath and shut your eyes.' Alice laughed. 'There's no use in trying,' she said, 'one can't believe impossible things.'

'I daresay you haven't had much practice,' said the Queen. 'When I was your age, I always did it for half-an-hour a day. Why sometimes I've believed as many as six impossible things before breakfast.'

The White Queen in Alice in Wonderland

INTRODUCTION

Research and development associated with technological progress has given us the Roman short sword and the English longbow in the age of muscle, to the atomic bomb during the age of technological change. Colonel Trevor N. Dupuy, in *The Evolution of Weapons and Warfare,* contends that "... the introduction of the rifle musket and its conoidal bullet in the decade between 1850 and 1860 was to have the greatest immediate and measurable revolutionary impact on war of any new weapon or technological development of war before or since." Dupuy does concede that if tactical nuclear weapons were used on the battlefield they could presumably have a greater effect. Obviously, other weapon systems using technology improvements or technology breakthroughs have had a profound impact on the battlefield. The Maxim machine gun (1883), the high explosive artillery and mortar shell (1886), the tank (1916) and the fighter-bomber (1917), to name a few, constituted quantum jumps in lethality and changed the way wars were fought.

Ancillary technological developments, such as the steam engine, electronic communication, smokeless powder, photography and radar, have also played a part in increasing the lethality of weapon systems.

In the twentieth century, advances in technology have been revolutionary and have provided an endless stream of systems designed to wage war on the battlefield. The pace of technological innovation shows no signs of slackening. For the most part, the greatest technological impact on military forces in this century is seen in NATO and the Warsaw Pact. The West has an advantage in technology and, consequently, NATO nations have looked for technological solutions to the adverse balance of forces between NATO and the Warsaw Pact. Most experts agree on the importance given to the technological edge when discussing the East-West balance and deterrence. Unfortunately, the Soviet Union is closing the technological gap. Moreover, while NATO may still have major advantages in the laboratory, in the last decade the Warsaw Pact has matched NATO in getting new technologies to the field in operational systems.

History and our recent efforts to exploit technology for military advantage have clearly shown what a difficult task it is to insert the most effective technology into a weapon system at the right time. A declining defense budget today underscores the need to concentrate on the technologies which offer the greatest promise for military application. Decision makers in the research and development business must depend upon assumptions concerning the future threat, technological progress in a given area (with the need to evaluate optimistic predictions by involved scientists), international relations, economic prospects and many vague, unquantifiable social and political elements.

Many have attempted to define the correct research and development strategy. David M. Abshire, former Permanent U.S. Representative to the North Atlantic Council, in a 1985 Adelphi Paper, speaks to technology as a tool and " ... like any tool it can be helpful only if we know what to do with it and then choose to use it." Others have underscored the importance of pure scientific research and the ability to spot potential applications at an early stage. The ability to assimilate a new or greatly modified weapon seems important, as well as the development of supporting tactics and doctrine. In the final analysis, all agree it isn't easy!

Research and development (R&D) in the U.S. Army has traveled a hard and winding road to achieve its present unquestioned position of importance. Few activities have been more controversial than the Army's R&D programs. No activity has been studied with more frequency. Some are quick to criticize the Army R&D efforts. Veterans of the American Expeditionary Force of World War I would have recognized many of the weapons carried by the American soldiers landing on the beaches of Normandy in 1944.

Today, there are complaints that our soldiers can go to the local electronics store and purchase items that have a greater capability, are more reliable, and much cheaper than the gear issued by the Army. The long acquisition cycle (15-20 years from conception to fielding) complicates our technology efforts and tends to tarnish our R&D achievements. Unfortunately, the superb systems in the hands of the soldier seldom get accolades, while failures and mistakes get all the publicity. Study reports from the Department of Defense Science Board as well as the Army Science Board have not always been complimentary of Army R&D programs.

The purpose of this paper is to examine how the U.S. Army has gone about managing and conducting research and development, what it is doing now in this vital activity and where it intends to go in the future. This paper will not argue whether or not the R&D system has succeeded or failed, but will cover the background of R&D management over the years. Hopefully, the reader will be better able to understand, support and objectively judge the research and development system in the Army.

THE BEGINNING

The phrase "research and development" is of recent vintage and probably did not come into common usage until the early 1920s. Until that time there was not a clear delineation between what is research and development and what is procurement and production. From the Revolutionary War until most recent times, research and development has generally been confined to "cannon and musket" and associated weapon systems.

In 1812, the Ordnance Corps was officially formed and in 1815 an Act of Congress established a colonel of the Ordnance Department to " ... direct the inspection and proving of all pieces of ordnance, cannon balls, shot, shells, small arms and side arms and equipments procured for use by the armies of the United States, and to direct the construction of all cannon and carriages and every implement and apparatus for ordnance, and all ammunition wagons, travelling forges, and artificers wagons, the inspection of powder and the preparation of all kinds of ammunition and ordnance stores."

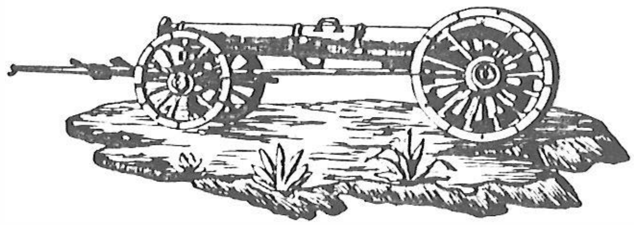

Figure One
Transportation Wagon for Field Guns in Use at the Time of the American Revolution

Pre-dating the Ordnance Department was what could be described as the U.S. Army's first research and development project when Captain John H. Hall received a patent in May of 1811 for his invention — the first breech-loading, small arms weapon in America. In January 1817, the U.S. Army ordered 100 of the Hall breech-loaders.

The Army's arsenal and armory network started with the first arsenal in Springfield, Massachusetts, in 1777. In 1794, a second arsenal at Harper's Ferry, West Virginia, was established. By the end of 1819 the following arsenals were added:

Rome - Rome, New York	1813
Allegheny - Pittsburgh, Pennsylvania	1814
Watervliet - West Troy, New York	1814
Bellona - Richmond, Virginia	1816
Frankford - Philadelphia, Pennsylvania	1816
Pikesville - Pikesville, Maryland	1816
Washington - Washington, D.C.	1816
Watertown - Watertown, Massachusetts	1816
Augusta - Augusta, Georgia	1817
Baton Rouge - Baton Rouge, Louisiana	1819

The number of arsenals increased to 24 by 1860. These facilities provided the Army's in-house research and production capability which was to serve the nation well over the years. Today, many of these locations still house and support a number of Army laboratories and research activities.

By 1940, there were six ordnance manufacturing arsenals which produced the entire family of ordnance weapon systems. However, in early 1940, the first M-3 medium tank to be produced by a private industrial company rolled off the line at the American Locomotive Company, Schenectady, New York. The

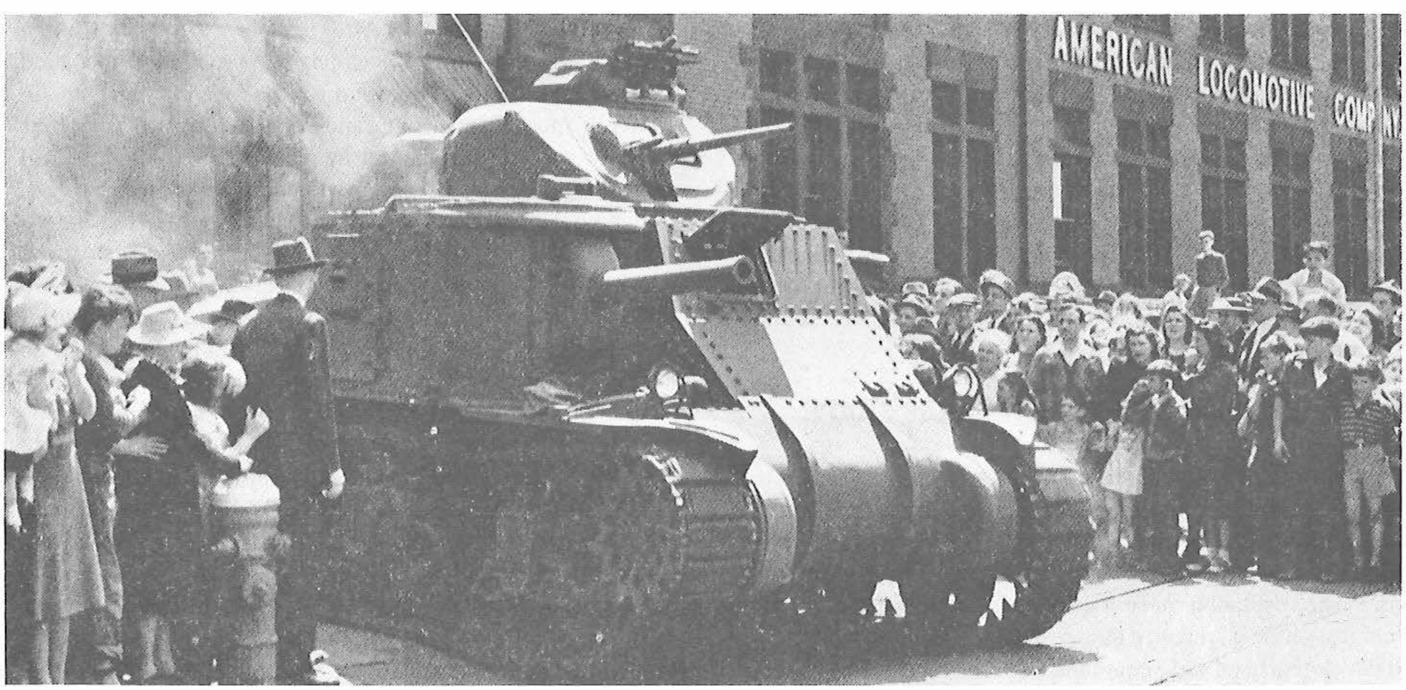

Figure Two
The First M-3 Tank, American Locomotive Company, 1940

M-3 was armed with a 75mm gun and powered by a Wright airplane engine. This move to use the production capability, and later the research capability, of the private sector started just before the United States entered World War II and was to become the norm in later years.

While the Ordnance Department (later designated the Ordnance Corps) had the major research, development and production focus over the years (from 1925-1940 the annual Army R&D budget averaged $2.5 million of which $1.5 million went to the Ordnance Department), other technical service elements were also functioning.

The Quartermaster Corps traces its beginnings to 1775, followed by the Corps of Engineers in 1802, and the Medical Department in 1818. The Signal Corps was started in March 1863. The Chemical and Transportation Corps were established during World War I. These technical services survived name changes, mission modifications and numerous reorganizations. Gradually, each assumed responsibility for research and development within its own area of responsibility. In the acquisition parlance, they were referred to as the "developing agencies." As the technical services grew in power and independence, the problems associated with integrating, coordinating and controlling their activities and R&D programs grew into significant managerial challenges that persisted until the Army underwent a major reorganization in 1962.

As mentioned earlier, the U.S. Army made no real effort until after World War I to establish a clear delineation between what is research and development and what is procurement and production. In World War I the emphasis was on procurement and production. In the years between the two world wars, political complacency on the part of the American public and the severe economic depression affected the Army's research and development effort. As an example, the Quartermaster Corps and the Medical Department were limited to less than $20,000 per year for research endeavors. In 1937, the Quartermaster General requested $123,000 for the development of clothing, equipage and military motor vehicles, but Congress appropriated only $2,000.

Funding, especially at a consistent level, has plagued the Army's technology effort. Therefore, it is understandable when L. Van Naisawald, in his unpublished manuscript entitled "The History of the Army R&D Organization and Program," characterized this era as one devoted " ... largely to product improvement, with research being regarded as almost a benevolent and incidental act of God."

RESEARCH AND DEVELOPMENT TAKES SHAPE

In December 1924, with the publication of Army Regulation 850-25, the Army's formal research and development program was launched. The Army General Staff was required to state requirements for articles of equipment to be furnished to the Army. The regulation made it clear that the chiefs of branches (technical services) retained their responsibility " ... for initiating the development of new equipment or for changes in existing equipment. ..." The regulation further stipulated that each service should submit a report on the status of products under its control.

A development program, as outlined by the regulation, was to consist of:

- Preparation of a statement of requirements
- Construction and test samples
- Selection of best sample
- Test in comparison with any previously adopted item or type
- Preliminary test by an organization
- Further development to correct deficiencies
- Investigation as to production feasibility
- Samples procured for service testing
- Adoption
- Clearance for procurement from Assistant Secretary of War
- Approval by Secretary of War
- Preparation of specifications by the approved supply branch

This list of actions was a good start. However, the regulation did not define the extent of control by the General Staff and lacked long range guidance regarding product improvement as opposed to development. This question of control and responsibility haunts the Army research and development program to this day.

Changes to the 1924 regulation in 1927, 1931 and 1936 began to give form to the Army's fledgling R&D program. Pure research was accepted as an integral part of the program. The G-4 (logistics) Division of the General Staff was charged with the supervision of the Army-wide development program, but no G-4 staff officer or element was assigned responsibility for that task.

WORLD WAR II ACTIVITIES

The oncoming World War II and our involvement generated interest in technological inventions and improvements and a push was given to research. After the German victories in the spring of 1940, research and development appropriations increased from $3.5 million to $20 million for the year ending June 30, 1941. Still, most of the medium and heavy field artillery weapons that were put into production before Pearl Harbor remained standard equipment, with some modifications and improvements, throughout the war. The same is true of practically all the famous truck models: the 1/4-ton "Jeep," the 3/4-ton weapons carrier, and the 1-1/2, 2-1/2 and 4-ton cargo trucks. The M-4 medium tank was standardized in the fall of 1941 and was the mainstay of our armored divisions until the introduction of the heavier M-26 tank in 1944 and early 1945.

Just before and during World War II the Signal Corps became caught up in the electronic technology explosion. The Signal Corps research and development appropriation increased from $700,000 in 1940 to $65,000,000 for fiscal year 1944. Full use was made of civilian scientists and the civilian electronics industry. Development of multi-channel and single-channel radio-teletype systems made it possible to transmit great volumes of military messages rapidly throughout the world. Using specially-designed radar equipment, Signal Corps scientists from the Evan Signal Laboratory at Belmar, New Jersey, successfully transmitted signals to the moon in January 1946.

During this era, the Corps of Engineers developed and produced the atomic bomb (Manhattan District Project) at a cost of approximately $2 billion. In mid-1942, the Engineer Corps took over the direction of the project and pioneered what later became known as project management.

In spite of these successes, research and development of new weapons and equipment by the Army during World War II received mixed reviews. Dr. Vannevar Bush, President of the Carnegie Institute of Washington, Director of the Office of Scientific Research and Development, Chairman of the Joint Committee on New Weapons and Equipment of the Joint Chiefs of Staff, and Chairman of the Military Policy Committee of the Manhattan District, told Congress that "... the armed services did not sufficiently realize the importance of science because military personnel by training and tradition did not appreciate the contribution it could make to national defense."

He went on to note that the services had not learned from industry that "... basically, research and procurement are incompatible; new developments are upsetting to procurement standards and procurement schedules. A procurement group is under constant urging to regularize and standardize, particularly when funds are limited. Its primary function is to produce a sufficient supply of standard weapons for field use. Procurement units are judged, therefore, by production standards.

"Research, however, is the exploration of the unknown. It is speculative, uncertain. It cannot be standardized. It succeeds, moreover, in virtually direct proportion to its freedom from performance controls, production pressures and traditional approaches."

Dr. Bush was one of the first prominent scientists who came to Washington, D.C., during World War II and provided leadership and vision to the technology efforts of the federal government. Over the years many more were to follow. Bush's words characterized the split which continues in different forms today between the civilian scientist and the Army over what is research and development, funding adequacy, and how R&D should be administered and controlled.

Soon after Pearl Harbor, the Army Chief of Staff, General George C. Marshall, realized he had inherited a general staff organization and a structure in the field that was unsuited to fight the war. Consequently, there was a major reorganization at all levels in March 1942. The changes were far-reaching and significant. This account deals only with the impact on research and development.

Under the Marshall reorganization, the War Department was organized into a General Staff, three major commands (air, ground and service), defense commands and overseas forces. The Army Service Forces (ASF), at first called the Services of Supply, was responsible for administration, supply (including procurement) and services for the War Department. This move grouped a vast majority of the logistic activities of the Army under a single command. The ASF assumed authority over the technical services and took responsibility for research and development *operations* from the Army Staff G-4. The technical services retained responsibility for actually doing all military research and development and the G-4 continued to exercise staff supervision over the research and development function.

The ASF Research and Development Branch (buried under the Directorate of Materiel) was largely a coordinating activity between the R&D elements of the technical services and the user, now represented by Army Ground Forces (AGF). Long development delays were caused by disagreements between technical service and user. A classic example was the dispute between General Lesley J. McNair, head of the AGF, and the Ordnance Department over the heavy tank. General McNair repeatedly rejected the need for a heavier tank proposed by the Ordnance Department (hindsight proved the Ordnance Department correct) and delayed the fielding of a more formidable tank until almost the end of the European War.

Secretary of War Henry L. Stimson was dissatisfied with the

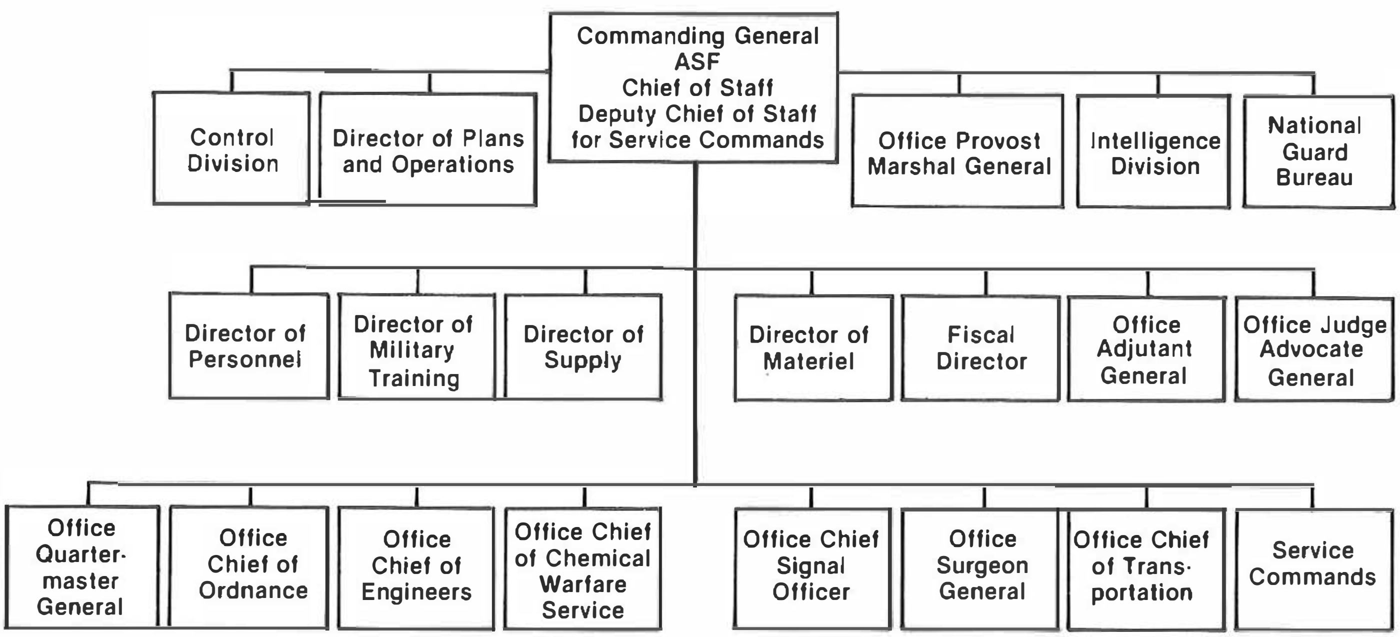

Figure Three
Organization of the Army Service Forces, 30 June 1944

slowness of research in the Army, especially in the field of electronics. Partly because of their slowness to act in the R&D area, the Chief of Ordnance was replaced in 1942, as was the Chief Signal Officer in 1943. Stimson turned to a civilian and appointed Dr. Edward L. Bowles of Massachusetts Institute of Technology as his expert consultant to rush the development of radar and other capabilities in the electronics field. Bowles encouraged the use of operations research techniques, but made little headway. Stimson also created a special staff division, the New Developments Division, to expedite production and procurement of new and improved equipment. This was primarily a troubleshooting agency headed by a major general that tried to bridge the gap between producer and consumer.

Significant delays were encountered in the test and evaluation of new equipment. Disagreements between the technical services and the combat arms over testing equipment and the rigid testing requirements of the AGF were the main issues.

Just prior to the end of the war in Europe, the War Department published its first official policy on research and development. In brief, the paper:

- acknowledged the importance of research and development work;
- stated the importance of not only maintaining a superior position in materiel now, but also to assure that all possible impetus will be given to research and development of military equipment in the future;
- emphasized that R&D activity must be given a high priority;
- underscored the fact that close liaison and cooperation was essential between the developing agency and the using agency. To this end guidance should be sought from the operations division of the War Department General Staff;
- instructed responsible agencies to put their R&D programs on a permanent post-war basis with attention given to providing a well-qualified staff of civilians and military personnel;
- called for continued emphasis on projects in the areas of guided missiles, rockets, heavy armored equipment, large caliber bombs, new applications of electronic equipment, jet aircraft, and equipment for amphibious, airborne and joint air-ground operation.

World War II showed U.S. military leaders the importance of research and development. The war highlighted both the strategic and tactical advantages gained on the battlefield through technology. The emergence of the Soviet Union gave further impetus to research and development. The scientist's role in military affairs was assured.

Throughout this period, as research and development grew in stature in the Army, a series of lessons learned or basic principles on how to do R&D business emerged. The pursuit of technology was costly and a steady, adequate flow of funds appeared to be critical. It became clear that responsibility for R&D should be centralized and independent of the procurement function. Split responsibility often caused delays and bureaucratic wrangling. Requirements definition and long-term strategic guidance became essential to a productive R&D program. Closely allied to this tenet was the important relationship between the military user and the producer. New technology must be assimilated into weapon systems and the weapon in tum capitalized upon through evolving tactics and doctrine.

More and more it became apparent that the Army leadership must appreciate, stimulate and support the quest for new things employing new technology. Innovation and imagination are key. Finally, the need to integrate the role of the civilian scientist and research conducted in the civilian scientific community into a cohesive program were seen as critical components of any successful military R&D program.

THE POST-WORLD WAR II PERIOD

As the nation moved into the post-war period, some would have predicted smooth sailing for the Army's R&D program. Nothing could have been further from the truth. On May 14, 1946, War Department Circular No. 138 eliminated the Army Service Forces (ASF) and the R&D functions were transferred to the new Research and Development Division, War Department General Staff. This move gave greater emphasis to research and development. It was a change strongly endorsed by the R&D community, especially the civilian technologists associated with the U.S. Army.

Despite these positive changes designed to improve R&D activities, the Army was having difficulty moving forward. There was a growing lack of confidence in the Army's ability to carry out top quality research programs.

Someone once remarked how we love change, and the organizational adjustments to the R&D structure surely underscore this observation. In the fall of 1947, there were indications of change in one of many studies accomplished on the R&D activities of the Army. In December 1947, the separate division status (which had been sought by so many and supported by General Eisenhower) was abandoned. The independent division at the General Staff level was redesignated as the Research and Development Group in the Supply and Procurement Division (Logistics) of the War Department General Staff. The issue of where the R&D function should reside in the Army staff and how centralized it should be, developed into a struggle that would not be resolved until almost 10 years later.

As we moved into the 1950s, Secretary of the Army Frank Pace, Jr., was disillusioned with the R&D effort in the Army and pushed for another change in the organization. Secretary Pace and Major General Maxwell D. Taylor worked out a new R&D organization in the Pentagon which was adopted in December 1951.

The Deputy Chief of Staff for Plans was assigned responsibility for integrating Army R&D programs with missions assigned by Joint Chiefs of Staff war plans and the latest tactical doctrine. A new position, Chief of R&D, was established in the office of the Chief of Staff responsible for Army Program No. 7, Research and Development. Other General Staff agencies established R&D elements and participated in the overall R&D program.

The R&D Division in the logistics agency (G-4) retained its authority and jurisdiction, but was reduced in scope. The G-4 R&D element was only responsible for the supervision of the development, execution, review and analysis of the materiel segment of the R&D program to include R&D activities of the technical services. The G-4 continued to argue persuasively that R&D could not be separated from production since both were concerned with equipping the Army.

Also considered sacrosanct was the idea that only the G-4 could supervise the technical services, an idea which supported G-4's involvement in R&D since the technical services did most of the actual R&D work in the Army. To many on the General Staff, the changes in the R&D organization of the Army had merit. However, LTG Anthony C. McAuliffe, then the G-1 (personnel), urged removing the R&D function from the G-4 and thought the fragmenting of the R&D effort a "screwy idea."

In November 1951, Secretary Pace appointed twelve "outstanding scientists and industrialists" as members of an Army Scientific Advisory Panel to assist him and the Chief of Staff in creating a fighting force " ... as effective, economical and progressive as our scientific, technological and industrial resources permit." Dr. James Killian was the first chairman of this group and, like other civilian scientists, was dedicated to the idea of a research and development agency separate from logistics at the Army staff level.

It is important to remember that the struggle over the control of research and development in the Army was also part of a struggle for control over the technical services. Secretary of Defense Robert A. Lovett, in his end-of-tour letter to President Truman in December 1952, noted:

> There are seven technical services in the Army. ... Of these seven technical services, all are in one degree or another in the business of design, procurement, production, supply, distribution, warehousing and issue. These functions overlap in a number of items, adding substantial complication to the difficult problem of administration and control.
>
> It has always amazed me that the system worked at all, and the fact that it works rather well is a tribute to the inborn capability of teamwork in the average American. ...
>
> A reorganization of the technical services would be more painful than backing into a buzz saw, but I believe that it is long overdue.

As the Pentagon R&D struggle continued in the 1950s, the Army was fighting a war in Korea by and large with the same weapons and doctrine as World War II. Consequently, the need for a combat developments program was recognized that would, among other things, employ modern scientific operations research techniques developed since World War II. Today's ideas of how to develop doctrine and tactics, train, structure and equip the force began to take shape.

It soon became apparent that the 1952 changes did little to improve the R&D organization or its productivity. Congress began to play in the R&D field and a congressional investigation of the Defense Department's research and development programs found that the military departments needed to "pull up their socks." Dr. Killian, as Chairman of the Army's Scientific Advisory Panel, personally urged Secretary of the Army Roger T. B. Stevens to separate research and development from logistics and raise the status of Chief of Research and Development to the Deputy Chief of Staff level. Finally, in December 1954, Stevens agreed and moved all research and development functions assigned to the Deputy Chief of Staff for Logistics to the Deputy Chief of Staff for Plans and Research.

This new organizational structure remained flawed so that on October 10, 1955, the position of Chief of Research and Development (CRD) was established. Lieutenant General (LTG) James M. Gavin was appointed the first chief. A new civilian post, the Director of Research and Development at the assistant secretary level, was established about the same time. The Army R&D organization at the Army Staff level came just about full circle from the staff structure adopted by General Eisenhower in the spring of 1946.

About this time, the Army Scientific Advisory Panel conducted a series of studies that underscored the growing lead time necessary to develop, procure and field new weapons and equipment. The panel reported that it required ten years (1950-1960) for the Army to produce a replacement for the World War II amphibious vehicle called the DUKW. It was a relatively simple program with a modest amount of research involved. The Ordnance Department was given the development task initially, but soon the Transportation Corps had their own candidate. It was clear that the major cause of long delays in developing new equipment could be traced to disagreements among the technical services. Delays in fielding equipment would soon be a recurring theme in the Army's acquisition program.

THE 1950s AND 1960s: A TIME OF PROGRESS

Under the leadership of LTG Gavin, and later LTG Arthur G. Trudeau who succeeded him in the spring of 1958, R&D in the Army moved ahead. Struggles continued over whether the Chief of Research and Development should assume control over R&D funds, personnel and facilities. In March 1958, under pressure from the civilian scientists, the Army established the Army Research Office (ARO) under the Office of the Chief of Research and Development (OCRD). Its major task was to " ... plan and direct the research program of the Army, to make maximum use of the nation's scientific talent, to provide the nation's scientific community with a single contact in the Army, and ensure the Army's research and development program emphasized the Army's future needs." ARO would also coordinate the Army's program with similar programs in the Navy, Air Force and other government agencies; within the Army the ARO coordinated the research and development programs of the technical services. Although OCRD enlarged its control over the Army's R&D programs, the issue of control over the research and development programs of the technical services remained unresolved.

As the Army grappled with its internal R&D structure and roles, the 1958 reorganization of the Department of Defense (DoD) created a DoD level Director of Defense Research and Engineering. President Eisenhower also established a special White House Assistant for Science and Technology. Dr. Killian, former Chairman of the Army Scientific Advisory Panel, was appointed to the position. These moves prompted the Army to conduct a complete reevaluation of its research and development organization.

Once again there was a struggle over control of R&D people, funds and facilities. A separate research and development command was proposed. In July 1960, Army Secretary Wilbur M. Brucker restated that the Deputy Chief of Staff for Logistics would remain the principal channel of command between the Army staff and the technical services. However, the Chief of Research and Development would have a "parallel" line of authority to the technical services on matters in his area. He would control research and development personnel within the technical services through the bulk allocation of civilian spaces to the technical services and contribute to the efficiency reports of R&D personnel in the technical services. Further, he would be consulted on the assignment of key personnel and, most importantly, control allocation of R&D funds among the technical services. These changes bolstered the authority of the Chief of Research and Development and positioned the R&D activities for the major Army-wide reorganization in 1962.

The 1962 reorganization had its origin in one of Secretary of Defense Robert S. McNamara's study projects, known as Project 80. The Project 80 study examined the question of assigning functions to the technical services beyond that of earlier studies. Because of the sweeping changes associated with the study, its development — along with the emotional review process — makes interesting reading. In sum, Secretary McNamara's reforms eliminated five of the chiefs of the technical services. Their command functions were taken over by the Defense Supply Agency (a McNamara creation) and by the new field commands of the Army: the Army Materiel Command (AMC) and Combat Developments Command (CDC). The training functions of the former technical services were assumed by Continental Army

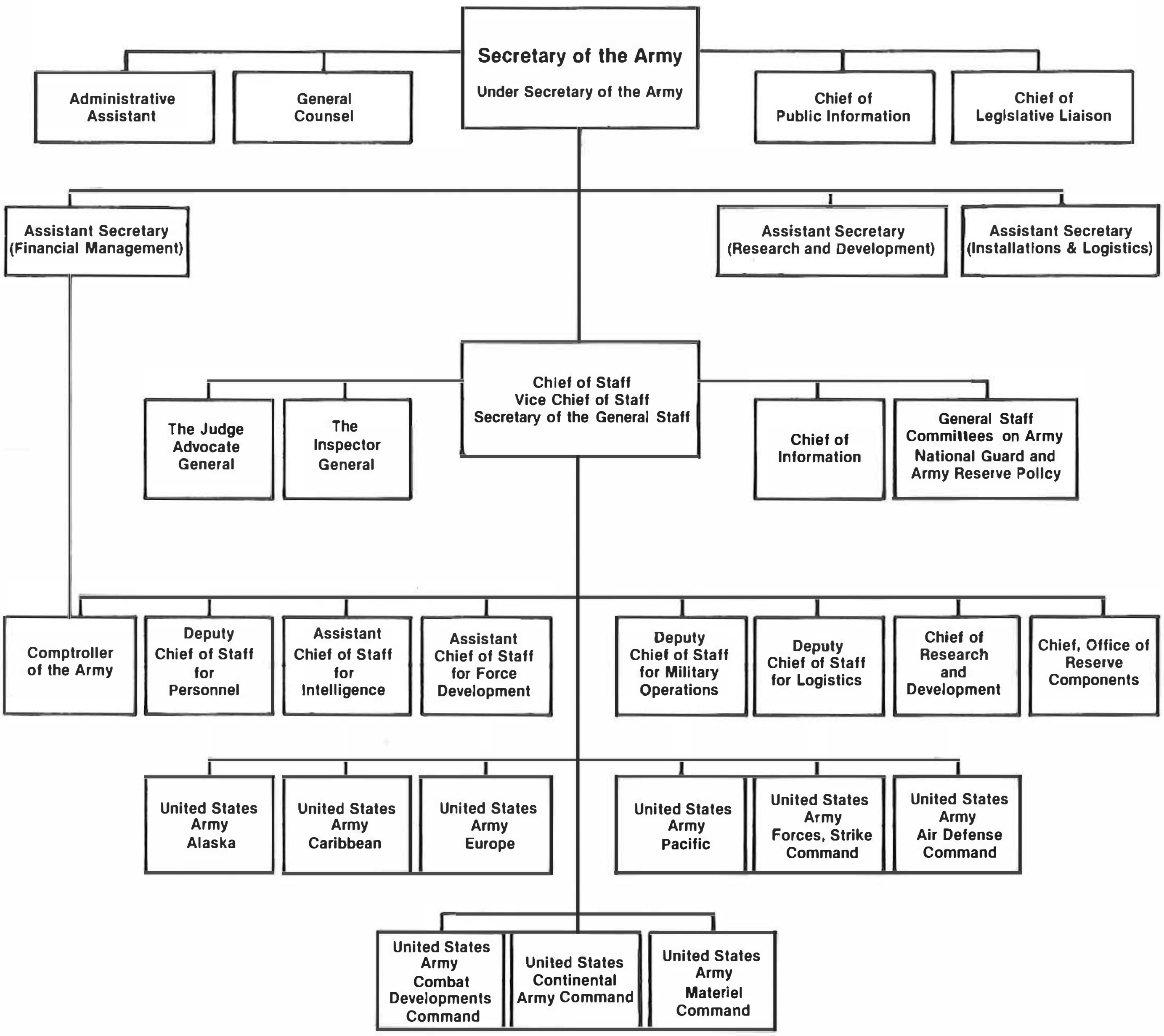

Figure Four
Organization of the Department of the Army, April 1963

Command (CONARC), the personnel functions by the Deputy Chief of Staff for Personnel (DCSPER) (in the form of the Office of Personnel Operations), and the staff functions were absorbed by the Army Staff agencies.

The research and development functions of the technical services, except for the Surgeon General and some aspects of the Chief of Engineers, were passed to the new Army Materiel Command. Some will contend that the implementation of the Project 80 study recommendations culminated twenty years of struggle to organize the Army staff along functional lines. There can be no doubt that the reorganization left the Chief of Research and Development in control of the R&D activities at the Army Staff level. Moreover, the R&D organization created in 1962 would, except for modest changes, remain in place for more than 20 years.

THE ARMY'S EVOLVING R&D PROCESS

It appears appropriate at this juncture to go back and examine the R&D process used by the Army. It is apparent that the Army came out of World War II with a rather clear idea of how to develop a weapon system. The Army's broad general policies for conducting research and development in the late 1940s would have credibility and validity today. They were:

- Research and development programs in the peacetime period will be placed in the highest priority.
- Research and development agencies will vigorously conduct research and development of new weapons, equipment, techniques and supplies. R&D agencies in coordination with other Army elements will keep under continuous study and analysis the political, economic, industrial and military implications of technology.
- Research and development will proceed vigorously and with forward-looking vision to maintain the high standard and superiority of our weapons and equipment, to guarantee the availability of proven types, superior in all respects to those of other nations, and to constantly maintain a lead position in the creation and fabrication of all items essential to ground and air supremacy. This will require among other things a continuing evaluation of foreign research and development activities.
- Development programs will, in general, be based upon the reported needs of the eventual using organization. Particular attention and cognizance will be given the recommendations of the user during actual construction and tests of pilot models. Research and development agencies will maintain close liaison with the using agencies so that new principles discovered during research and development may be applied to the using agency's needs.
- Vigorous attention will be paid to the development of new techniques for the use of new weapons and equipment.
- Using units will be given an opportunity to train with the latest types of new weapons. For this reason quantities of newly-developed equipment will be issued and rotated among using units in cases where Army funds do not allow complete replacement of old equipment.
- Research and development agencies will guide their development in such a manner as to minimize the use of materiels which may be expected to become critical during any emergency.

The developmental process in those days was similar to that used today. Army leaders in the weapons development business knew that the need for a new weapon or the modification of an existing weapon may originate in a number of ways. Once an idea was born, the next step normally taken by an appropriate command echelon within the using agency was the preparation of the desired military characteristics and essential qualities of performance. The characteristics of the new system were then forwarded to one of the seven technical services to determine possible duplication with other projects under way and to assign a priority which indicated the relative availability of funds, personnel and facilities for development.

Appropriate research was conducted by the technical service (developing agency), other government research agencies, or by contract with a commercial or educational facility. Several staff reviews of the project were required to ensure that production difficulties were minimized and coordinated use was made of scarce materials. A pilot model or "mock-up" was constructed in order to uncover obvious deficiencies in design. A working model followed with changes as necessary to improve design and facilitate quantity production.

Engineering tests were a part of the development process as were service (user) tests. Normally, the service tests were conducted by one of four Army Field Forces test boards that made final recommendations. A weapon would then be type-classified standard if the Army Staff, as well as the developing agency, would give their approval for the weapon. In brief, the basic tenets of the early 1950s development process included: determine a need, establish requirements, do research using a number of facilities, hold a series of reviews, plan for transition to production, build prototypes, test, and issue to the field. Most of these tenets are captured today, albeit in different forms, in the Army acquisition process.

Actual Army research was initially accomplished in the arsenal system and by in-house personnel under the direction and control of the technical services. Control of the R&D facilities shifted to the Army Materiel Command (AMC) as described earlier and more and more in-house efforts shifted to outside agencies. Today, almost 70 percent of the annual Army technology base budget is directed toward high-technology companies and academic institutions.

With the establishment of AMC and the demise of the technical services, the Weapon System Materiel R&D Laboratories were placed under the control of the major subordinate commodity commands of AMC. By 1972, several more changes to the Army laboratory structure were accomplished. The commodity command laboratories which had been spun off into separate R&D commands were reunited with the logistics function to form again major subordinate commands (MSC). The laboratories were concerned about the technology applicable to the MSC's functional responsibility. Through internal realignments these MSC laboratories turned into Research, Development and Engineering Centers (RDEC). Corporate laboratories were also established. They were designed to pursue generic technologies which cut across a number of commodity commands. Also, lead laboratories for certain technologies were designated. As an example, the Harry Diamond Laboratory was the lead activity for radars.

The Army's laboratory and RDEC system moved into the 1980s with 34 laboratories and RDECs and over 19,000 scientists, engineers and support personnel. On the first of October 1985, the U.S. Army Laboratory Command was established under AMC to command and control the corporate laboratories. The corporate laboratories would concentrate on advanced, high-risk technology with potential application to several types of systems. The commodity RDECs did not change their role or affiliation. However, the commanding general of the Laboratory Command also serves as the AMC Deputy Chief of Staff for Technology, Planning and Management. In this capacity he oversees the management of the technology base throughout AMC, including the RDECs.

Returning to the Army Staff level, the Office of the Chief of Research and Development assumed the staff responsibility for acquisition from the logistics agency and was named the Office of the Deputy Chief of Staff for Research, Development and Acquisition (DCSRDA). This change was accomplished in 1973 and again combined R&D with procurement — an association which many fought against in the 1950s. The study group which suggested DCSRDA opined " ... that life cycle management of materiel involves many technical functions like research through development, procurement, distribution, maintenance and disposal. The question was how to divide these activities. The DCSRDA model was chosen because, in the opinion of the board, the most intensive management challenge existed between development and procurement rather than between procurement and distribution."

One more major organizational change was yet to come. In October 1986, Congress passed the Department of Defense Reorganization Act. This Act, along with recommendations of the Packard Commission on Defense Management, directed the appointment of an Army Acquisition Executive (AAE) and a Program Executive Officer (PEO) system for the management of the materiel acquisition programs. Each major program manager

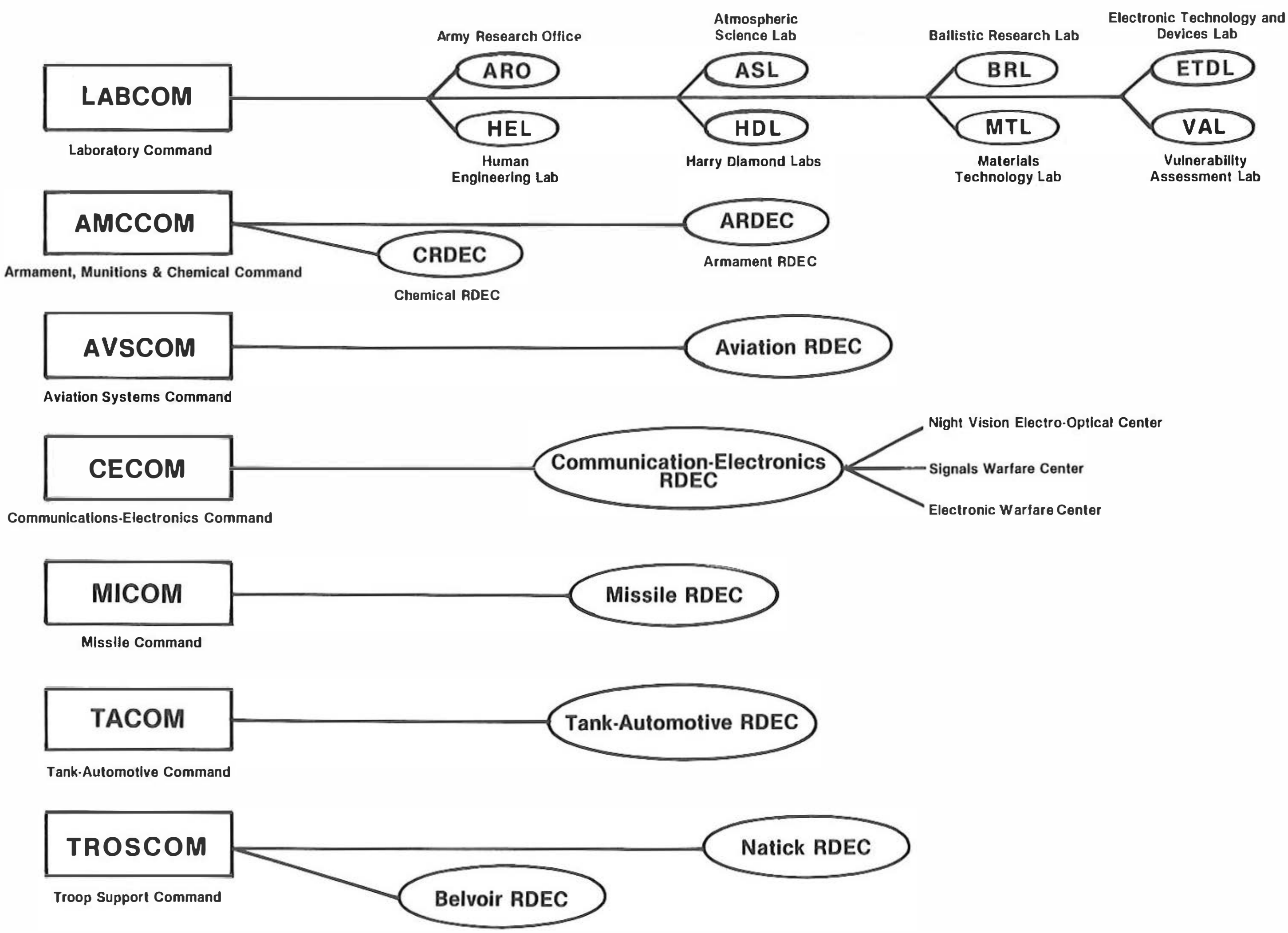

Figure Five
Army Materiel Command Research, Development and Engineering Centers (RDECs)

(PM) now reports to a PEO (rather than the MSC) and the PEO in turn reports to the AAE. AMC continues to provide support to the AAE/PEO/PM chain.

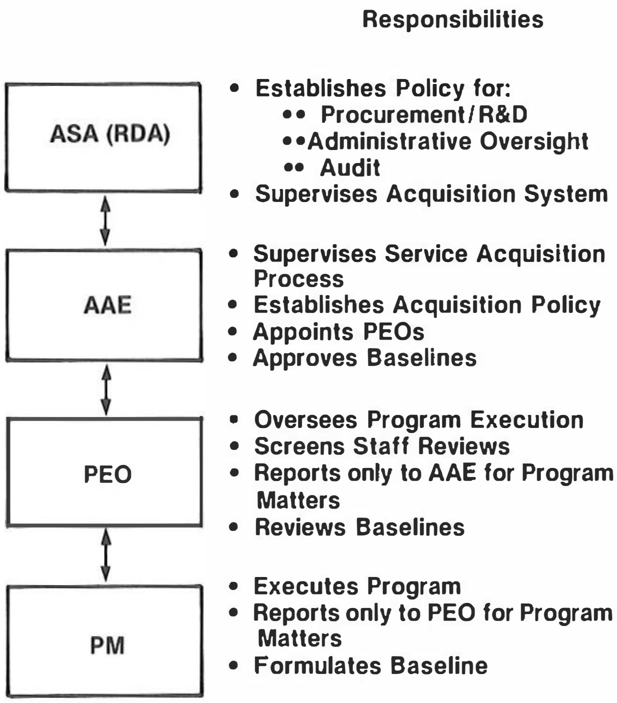

Figure Six
Acquisition Executive/Program Executive Officer Concept

The Offices of the Assistant Secretary of the Army for Research, Development and Acquisition OASA(RDA) and the DCSRDA on the Army Staff were combined to create a newly-focused Office of the Assistant Secretary of the Army for Research, Development and Acquisition ASA(RDA). A lieutenant general is military deputy to the ASA(RDA) in the office, but there is no staff agency for R&D or acquisition at the Army Staff level. This office, at the Army Secretariat level, is the focal point for all research, development and acquisition activities. In theory, the Chief of Staff will only participate in the acquisition process through the generation of requirements.

R&D ACHIEVEMENTS

Despite the many twists and turns, various reorganizations and the ups and downs endured by the Army's R&D program, there has been refreshing consistency in the overall thrust and performance of the effort. Military leadership supported by civilian scientists has worked well. From the beginning, the need for vision was recognized and technology development was not the sole domain of the Army R&D in-house community. By 1958, 123 colleges and universities were participating in basic research for the Army.

Throughout, there has been a continuing focus on the requirements of the individual soldier as well as on weapon systems. The size of the R&D budget has always been a strongly debated issue. Reducing the time between concept and operational capability has been a constant goal. In 1957, Dr. William H. Martin, Director of Research and Development for the Army (the director was equivalent to an assistant secretary and would later assume that title), noted in *Army* magazine that a falling defense budget " ... poses the problem of being more selective in the projects which we carry to production and on into operation." He went on to write that " ... there is the necessity for reducing the time between concept and availability in order to avoid having our end items obsolete before we can place them in the inventory. Today, in some areas with present procedures, this development cycle may be longer than the service life." Finally, and most importantly, Army R&D efforts have provided a steady stream of weapon systems and military capabilities flowing into the hands of soldiers.

LTG James M. Gavin, the chief of Research and Development in 1956, postulated that " ... the traditional artillery gun may well be on the way to obsolescence, for the new missiles have almost unbelievable possibilities both for antiaircraft and antitank purposes and for all kinds of other enemy targets." In the late 1950s, LTG Arthur G. Trudeau, another former R&D chief, noted that the Army was pursuing basic research in seven areas: human factors, medical, nuclear effects, polar and arctic research, rocket exploration of the upper atmosphere, chemical and biological warfare, and nuclear reactors. In the applied research and development area of the R&D program, he underscored the Army's activities in:

- Precooked, dehydrated and irradiated foods to reduce the need for refrigeration.
- New protective clothing, lightweight durable tentage, vapor-insulated boots, protective body armor and the combat-reliable crewman's helmet.
- Tactical weapon systems designed to integrate the atomic weapon and missiles with two new ground vehicles for the Pentomic Division, the Rolling Fluid Transporter and the Armored Personnel Carrier.
- Aircraft vertical take-off and landing characteristics like a helicopter, but with fixed-wing characteristics of an aircraft in forward flight.
- Battlefield surveillance air vehicles such as the Mohawk, a fixed-wing aircraft designed for shallow reconnaissance penetrations. Surveillance devices are another capability which can use cameras and infrared detectors.
- The development of new electronic components, tubes and materials.

Trudeau also highlighted the Army's role under the then new National Aeronautics and Space Administration (NASA). Based on this association, the Army was assigned to work on two lunar probes and three satellite projects. Many of the items discussed by Trudeau are now household names in the Army's lexicon. Today, the Army has a memorandum of agreement with NASA for rotorcraft technology supported by three Army technology base activities.

The Army moved into the 1960s with a clear understanding of the need for an effective, efficient, well-managed research and development program. The Army leadership subscribed to a sign in Dr. Wernhner von Braun's office that read: "Research is like savings, if postponed until needed, it's too late to start." Not settled was the how-to-do part.

The development process became increasingly more important in the early 1960s. Major General Dwight E. Beach, then Deputy Chief of Research and Development, wrote that few understood how Army R&D works and "... that unfortunately the process is neither simple nor short." Concern was growing that the Soviets were getting their equipment to the field faster than the U.S. Army. Studies during that period concluded that the U.S. Army needed somewhere between eight to ten years to field a weapon system — it was believed the Soviets required only five years. Many studies on how to fix the problem have been generated and their recommendations have had little impact. It still takes a long time to get a system into the hands of the soldier.

By late 1962, Army laboratories were performing the largest share of basic research and testing, compared to that performed by private industry. However, in the development area— that is, in pursuit of specific objectives, such as a missile — industry performed the overwhelming bulk of the research. The interdependence between the Army and private industry was clearly established. R&D programs started to use competition as a technique. In the TOW anti-tank missile program, three primary companies were selected to develop an infantry anti-tank missile in a short period.

In spite of the Army's growing involvement in Vietnam, its R&D program in the early sixties was rigorous and productive. Second-generation surface-to-surface missiles such as Pershing, Sergeant and Lance were taking shape. The United States and West Germany were looking to codevelop a new main battle tank for the 1970s. The Redeye, a bazooka-like antiaircraft guided missile, entered limited production. The Army was still determined to field a V/STOL (vertical and short takeoff and landing) aircraft. New turbine engine helicopters, such as the UH-1 "Huey" and the CH-47 Chinook, were just going into the force. On the minus side, the Army had great expectations for a combat vehicle main armament weapon called the Shillelagh and a two-unit vehicle linked by a unique articulating coupling named the Gamma Goat. Both items proved that there is indeed risk in the R&D world.

In the R&D area, each decade had its share of successes and failures. But most agree that the Vietnam War cost the Army a good portion of a normal R&D cycle and half a generation of new equipment. Out of necessity, resources were committed to fighting the war.

Immediately following the end of the Vietnam war, the Army's attention returned to developing weapon systems and trying to catch up. Thanks to these R&D efforts, the Army entered the 1980s fully committed to a massive modernization program. More than 48 completely new systems were fielded in the first few years of the decade, led by the M-1 tank, the M2 and M3 infantry and scout fighting vehicles, the Patriot air defense missile system, the UH-60 utility helicopter and the AH-64 attack helicopter. In 1979-80, the Army established the Army Force Modernization Coordination Office (AFMCO) charged with the mission of smoothly fielding almost 30 major systems. The R&D programs of the 1970s were bearing fruit.

TODAY'S CHALLENGES

Today, as in the past, the Army is struggling with the task of ensuring that the right technology gets into the operational Army at the right time. Attempting to insert immature technology into weapon systems can cause delays and increased costs. On the other hand, waiting too long in most cases means losing the capability edge gained from the technology as other nations field similar or better systems. To achieve effective and efficient technology insertion, the Army has developed a process chronicled in a series of regulations, pamphlets and other documents. The process is complex with a number of players and agencies involved, but retains essentially the same development functions that were outlined earlier.

As the current R&D activities are described, it should be understood that the time has long since passed when the Army was an independent player. Today, the Office of the Secretary of Defense (OSD) and Congress exercise significant oversight and carefully control the resources available to the military services. The Army Training and Doctrine Command (TRADOC) represents the user or operational Army in the research, development and acquisition process. Using a system called Concept Based Requirements System (CBRS), TRADOC identifies doctrine, training, organization and materiel deficiencies. A series of Mission Area Analyses (MAA) are conducted to identify mission deficiencies which are evaluated for possible technology solutions. In support of this effort, TRADOC activities, including major TRADOC centers and schools, stay abreast of new and emerging technologies by maintaining close working relationships with the Army laboratories, research development and engineering centers, industry and academia.

While the purpose of this paper is not to detail the Army's present research, development and acquisition (RDA) system, it is necessary to cover the major points of this process in order to understand the role of research and development.

The RDA activity is initiated as a result of output from the CBRS/MAA efforts of the combat developer mentioned above. This front-end analysis fixes an Army battlefield need or deficiency. Once a requirement is established, three alternative solutions must be considered and eliminated in the order listed below. Only if these alternatives will not satisfy the need or deficiency is a new weapon system development pursued.

The alternatives are:

- Change tactical or strategic doctrine, improve training, or institute a unique or expanded organization.
- Improve existing Army materiel through a product improvement program (PIP).
- Acquire nondevelopmental items (NDI).

NDI are systems, subsystems or major components of a system that are acquired from many sources and have little or no developmental effort by the Army. Category A items are off-the-shelf (commercial, foreign, other services) and need no development or modification of hardware. Category B items require ruggedization or militarization to meet Army specifications. Therefore, the modification usually includes R&D engineering, design or integration efforts before operational fielding.

Another type of NDI work involves the integration of existing components and essential engineering efforts to accomplish the systems integration. As with Category B items, a dedicated R&D program is necessary for the integration. This procedure is very similar to the "from scratch" developmental technique and must meet all procedural tests and gates associated with a full-blown acquisition program. NDI has been a favored acquisition strategy for some time, but the results in terms of equipment fielded have been spotty.

Should the above alternatives not satisfy the requirement, a new weapon system development program is initiated using the traditional Life Cycle System Management Model (LCSMM). The LCSMM acquisition process consists of a series of steps as the development of an equipment system progresses from concept to fielding. The LCSMM is divided into distinct phases:

- **Requirements/Technical Base Activities Phase.** This phase firms up the requirements and their documentation. The technology effort is focused among laboratories, industry-independent R&D, foreign research, depots, arsenals, and AMC's Research, Development and Engineering Centers (RDEC). It includes the maturation of technology and its suitability for further exploration in Phase 1.
- **Phase 1: Concept Exploration/Definition.** The purpose of this phase is to explore potential ideas, concepts and solutions in a competitive environment. Information is assembled in order to select the proper alternatives for hardware development.
- **Phase 2: Demonstration/Validation.** This phase is designed to reduce program risk before selecting a contractor's system which best meets program objectives and to determine whether to enter full-scale development with the intent to field a system.
- **Phase 3: Full-Scale Development.** During this phase it is necessary to design, fabricate, test and evaluate a complete system.
- **Phase 4: Production and Deployment.** Successful completion of technical testing and operational testing, along with the appropriate program approvals, permit the item to move into production.
- **Phase 5: Operational and Support.** During this phase, the material system is operational and is supported, as well as maintained.

As this process unfolds, a complicated, detailed and growing set of documents are produced which track the development program and provide the basis for reviews and decisions. Associated with the review and decision process is a series of milestones which relate to specific accomplishments and decisions in the Life Cycle System Management Model (LCSMM). Integrated into the LCSMM by regulation and federal law is a rigorous technical testing program accomplished by test agencies independent of the system's program manager plus operational tests under the auspices of the operational user.

Sensitive to the imperative to reduce development time, the Army's Streamlined Acquisition Process (ASAP) is emerging as the preferred acquisition strategy. ASAP includes the use of innovative, practical measures derived from past experience in order to expedite low-risk developments. It combines various elements of the concept exploration/definition and demonstration/validation phases. It is designed to assure that development and production are low-risk and that future capability needs can be achieved through pre-planned product improvement (P3I).

P3I provides for deferred insertion of selected emerging technology and support capabilities in a new weapon system. The product improvement is deferred until the technology development is completed and matured. P3I is a planned, future evolutionary improvement to weapon system capabilities. P3I makes provisions for planned improvements during initial development as opposed to the product improvement program, a post-development material change to meet an unforeseen need. P3I is involved from the early requirements phase through full-scale development phase.

It is apparent that research and development and the insertion of technology are key aspects of the Army's acquisition program. Army R&D gets its initial orientation and provides its first contribution in the requirements process and plays an important role throughout the LCSMM. Laboratories and Research, Development and Engineering Centers (RDEC) are the Army's technology centers of excellence. They respond to taskings from most of the players in the acquisition family, but play a particularly important function for the project manager. Their role and achievements in basic research, especially in areas which have a heavy military application, are critical if the Army is to achieve success on the battlefield.

To accomplish these vital R&D tasks requires dollars. Funding support is obtained via the competitive prioritizing process of the Planning, Programming, Budgeting and Execution System (PPBES). In the Defense budget, there is a Research, Development, Test and Evaluation (RDTE) appropriation. This appropriation provides funds for research, technology design, engineering and prototype design fabrication, along with test and evaluation activities. To assist in managing the RDTE account, the appropriation is divided into six R&D categories:

- **Research.** Basic research which develops new knowledge and understanding with long-range potential military applications.
- **Exploratory.** Efforts directed toward the solution of broadly-defined problems with a view of developing and evaluating technical feasibility.
- **Advanced Development.** Includes all efforts that have moved into development of hardware for test. Further broken down into:

  — **Non-System Specific Advanced Development.** Technologies are demonstrated at the component or subsystem level, where demonstrators have potential application to a variety of similar end products, e.g., fiber optics.

Up to this point the categories are sometimes referred to as technology base (more about this later) programs and they can proceed without a mission need statement or formal requirement document.

— **System-Specific Advanced Development.** Includes the design and fabrication of prototype systems directed toward full-scale engineering development of a specific system. These funds support the system demonstration/validation phase.

- **Full-Scale Engineering Development.** Includes programs in which the item is being engineered for production to meet a specific requirement, e.g., AH-64 helicopters.
- **Management and Support.** Supports the installation and operations required for use in general research and development, e.g., operation and support of test ranges; operation and support of management headquarters.
- **Operational System Development.** Includes R&D effort directed toward fielded systems, e.g., product improvement for CH-47 helicopters.

MANAGING THE R&D EFFORT

The importance of a well managed Army technology base (a reservoir of science and technology that can meet long-term operational needs) cannot be understated. A technology base that is strong, innovative, efficient and focused on the Army's critical future war fighting needs is essential.

The pace and scope of the science and technology explosion, the cost of research and development and a falling defense budget demand a disciplined R&D effort. Moreover, our national military strength is predicated on maintaining a technology advantage over potential enemies in order to overcome a numerical shortfall. Furthermore, with current world events, ongoing conventional force reduction talks and national priorities in transition, it is more important now to protect the technology base "seed corn." The technology base is a corporate investment vital to preserving future options in an era of increasing uncertainty, global economic and technological competition and rising third world military capability.

The significance of the Basic Research Program in the universities, including the Congressional/OSD University Research Initiative (URI), has already been mentioned. Allied with the URI program are academic "Centers of Excellence" for key defense technologies. Both the URI efforts and Army Centers of Excellence directly supplement the Army laboratories and the Independent Laboratory In-house Research (ILIR) programs. Another program called Independent Research and Development (IRAD) consists of projects initiated and directed by industry, but reviewed by DoD laboratories and RDECs for relevancy and excellence.

Other sources of technology include foreign R&D, sister service technology programs, the Federal Laboratory Consortium, the Defense Advanced Research Projects Agency (DARPA) and other federal agencies, e.g., NASA. DARPA pursues highly imaginative and innovative research, high-risk/high pay-off ideas and concepts offering military application to the services.

In 1979, the Army made its first formal attempt to fuse a vision of the prospective battlefield with the anticipated technologies that will impact how and with what the Army will fight. This initial attempt to develop a technology blueprint for the future was just recently given usable definition in what is now called the Army Technology Base Master Plan (ATBMP), published in April 1989.

The ATBMP, which acknowledges budget realities, basically contains the Technology Base Investment Strategy (TBIS) to meet the war fighter's vision of the future. It hopes to amalgamate

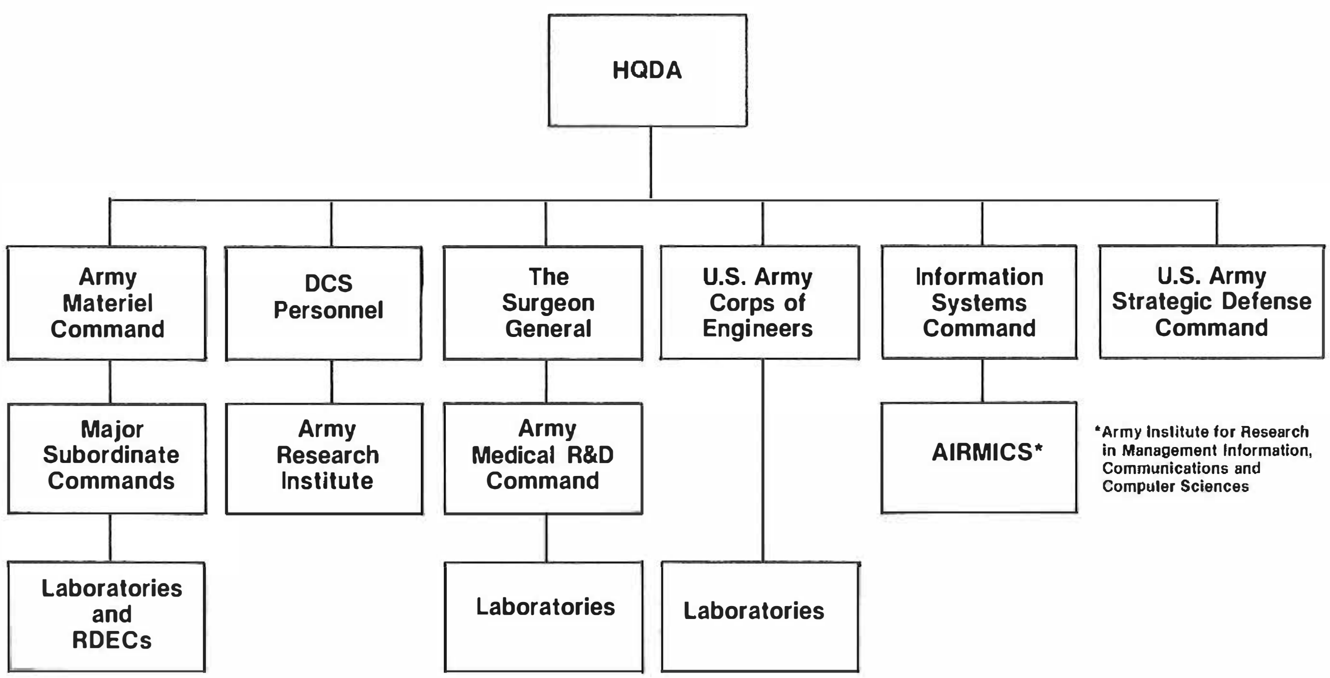

Figure Seven
Army Technology Base Organization

the future threat, Army doctrine and emerging fighting concepts, essential battlefield capabilities and the procedures for implementing the TBIS. The strategy incorporates the following guidelines:

- Support Army's war fighting capability needs
- Balance technology base:
  (1) near, mid, and far-term needs
  (2) technology push/requirements pull
  (3) balance between weapon systems and other requirements to sustain Army on battlefield
- Distribute technology base resources in four areas:
  (1) future systems
  (2) supporting capabilities
  (3) systemic issues
  (4) key emerging technologies
- Seize and retain technology initiative
- Enhance return on investment by leveraging R&D outside the Army
- Speed fielding through focused advanced technology transition demonstration
- Restore stability to the technology base
- Provide top-down guidance

Technology base funding measured as a percentage of Army Total Obligation Authority (TOA) has declined roughly 40 percent over the last 15 years. In FY89, research and exploratory development funding was approximately one percent of the Army Total Obligation Authority (TOA).

The investment strategy advocates a funding floor for Army basic research plus exploratory development that maintains this level, adjusted for inflation, based on the FY90 funding levels. If this initiative is successful, it will assist in restoring program and planning stability that is vital to maximizing technology base efficiency and responsiveness.

The ATBMP acknowledges the evolutionary change in war fighting concepts found in Airland Battle Future (ALB-F), the concept for 15 years out, and Army 21 which projects the change to 30 years. The ALB-F contains five basic ideas. They are:

- **Gain and retain the initiative.** During military operations short of war this may mean employing intelligence sources and resources to understand the environment, identify the causes of conflict, the antagonists and their intentions. In war, this implies using combat forces to exploit enemy vulnerabilities and create operational and tactical opportunities.
- **Develop the Army's spectrum of capabilities integrated with other services.** This ensures the ability to project and to position operational forces any place in the world to meet the requirements for war and operations short of war.
- **Apply current and emerging technologies to select and destroy specific elements of the enemy.** This makes other enemy elements vulnerable while enhancing friendly survivability.
- **Destroy the enemy's tempo.** Once the enemy is off balance, sequence U.S. operations so that he cannot regroup.
- **Properly sequence the destruction of enemy capabilities.** This has a synergistic effect.

Currently, the ATBMP lists 13 "Key Emerging Technologies" that seem to hold significant promise for solving anticipated battlefield requirements. This list was reviewed by the Army's scientific community and approved by the Army's leadership. DoD developed a similar list of critical technologies that is compatible with the Army's list. The Army's Key Emerging Technologies are updated periodically and are currently being examined by the National Academy of Science's Board on Army Science and Technology. Approximately 25 percent of the Army

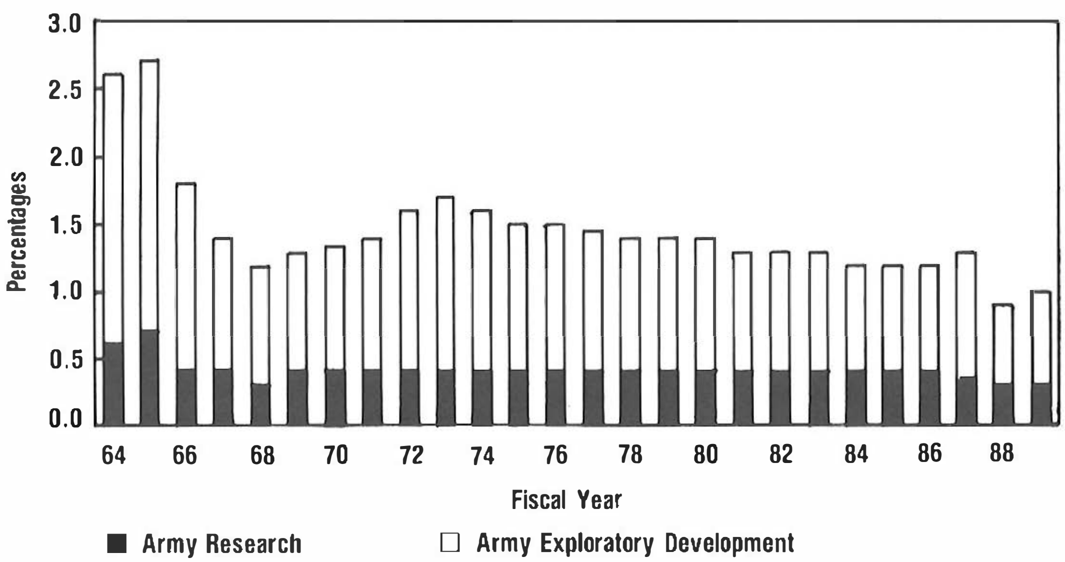

Figure Eight
Army Science and Technology as Percent of Army TOA

Technology Base funding is directed to these 13 key emerging technologies:

- Protection/lethality
- Micro-electronics/photonics/acoustic devices
- Advanced signal processing and computing
- Advanced materials/material processing
- Advanced propulsion
- Power generation/storage/conditioning
- Artificial intelligence
- Robotics
- Directed energy
- Space technology
- Low observables
- Neuroscience
- Biotechnology

R&D DOWN THE ROAD

Controversy continues to be a part of Army research and development. This paper began by mentioning some of the concerns and shall conclude on the same note.

The Soviets demonstrate they can get their systems to the field quicker and the U.S. technology advantage over them, which is critical, appears to be disappearing. Given these facts, how effective is the Army's R&D program? Do we really need an in-house capability which today extends over 41 centers, laboratories and activities containing 25,000 people? Can we increase our dependence on industry and academia, cut our in-house activity, and be more cost-effective?

Many challenge the duplication and the high overhead costs of the in-house effort, as well as the "not invented here" syndrome. It is true that few if any other Western nations maintain an extensive in-house military laboratory capability. Supporters of the current system will point out the need for an in-house capability so that the Army can be a smart buyer and keep abreast of emerging technologies. Often cited reasons for why an Army laboratory and RDEC system is needed are:

- Sponsor long range high risk/high payoff research and advanced technology (R&AT)
- Sponsor military unique R&AT
- Critical in-house role in requirements analysis, advanced concepts and architecture to support Army strategy
- Development and career path for science and technology (S&T) component of acquisition corps
- S&T information management, assessment and dissemination
- Technologically "smart buyer"
- Focused leveraging of industry, academia and other government agencies
- Quick reaction solution to field problems
- Speed technology transition/transfer

Supporters note with pride the many recent scientific and technological contributions of the in-house technology base — such as night-vision device technology and the U.S. superiority in rotorcraft. The Army's interest and funding support contributed to several Nobel Prizes:

1964 - Physics; Charles Townes: Maser and laser
1972 - Physics; John Bardeen: Superconductivity
1973 - Physics; Leo Esaki: Electron tunneling
1976 - Chemistry; William N. Lipscomb: Borane compounds
1979 - Chemistry; Herbert C. Brown: Boron and phosphorous compounds
1981 - Physics; Arthur Schawlow: Solid state laser (laser spectroscopy)
1981 - Physics; Nicholas Bloembergen: Non-linear optics

Similar to the discussion of military tactics — where principles as opposed to specifics pertain — there are no hard and fast right answers to the questions posed earlier. The system or process has produced weapons and battlefield capabilities that have given the Army a technology edge using a blend of in-house and external research and development efforts.

On the other hand, few are completely satisfied with the way the Army conducts R&D. Secretary of Defense Richard B. Cheney's July 1989 Defense Management Report to the President addresses technology and the technology base. The report highlights the need for a strong defense technology base and the broad mandate of the Under Secretary of Defense for Acquisition to " ... strengthen technology development programs of the military departments and the Defense Advanced Research Projects Agency; encourage technical competition and technology-driven prototyping that promise increased military capabilities; exploit the cost-reduction potential of innovative or commercially developed technologies; and develop procurement policies conducive to this purpose."

As a result of the Secretary's management review actions and the current and future budget environment, the Army formed a LAB 21 Task Force to study the quality, effectiveness, efficiency and external image of the Army laboratories and RDECs. The purpose of this task force is to define what the missions and functions should be for the Army laboratories and RDECs as the Army enters the 21st century. It is also looking at the possible elimination and consolidation of laboratory organizations to improve management accountability and to garner whatever savings these structure changes might produce. The task force recommendations are expected to be made public in late 1990. This Army review effort highlights the Army's commitment to a productive technology base capable of supporting the Army's war fighting capabilities.

Many R&D experts are encouraged by the Defense Management Review and the Army's Lab 21 Task Force effort. Both of these actions are viewed as superb opportunities to make needed changes. Some thoughts and ideas that may be validated in these reviews are listed below:

- Form a laboratory center of excellence to replace the large number of geographically separated laboratories that exist today as a result of the 1962 reorganization.
- Improve working relationships with industry to improve transfer of technology between the Army and industry.

Change rules on profit to get the best value, not fixed maximums which give industry no incentive to reduce development and production costs. Guarantee a fair return on investment to industry for increasing their R&D investment. Allow more open dialogue to ensure industry knows what the Army needs.

- Support and execute the OSD initiative to reduce rules and regulations. An equal effort must be applied to accepting industry standards where possible.
- Strengthen procedures that bring the design engineer and production engineer together on the front-end of a developmental program. The Army and U.S. industry in general have had too much trouble transitioning to production because of poor conditions in the R&D phase. Production R&D funds are still insufficient to develop modern, efficient production techniques.
- Enhance the R&D organization with understanding and help from Congress. Pork barreling over the years has repeatedly prevented improvement in the R&D system.

Although the Army's approach to and achievements in research and development may be tough to evaluate, there are some constants associated with the Army's technology development and insertion efforts. They have been described earlier and bear repeating.

First and foremost, there must be a well-defined vision of what the future Army will look like and how it will fight. Closely allied with this anticipated picture is a description of the future threat. Requirements must be established that can be supported by a carefully crafted list of vital emerging technologies that are carefully reviewed by the scientific community both in and outside the Army. Only technologies that have a high potential payoff for the Army should make the list. Undoubtedly, there will be changes to war fighting concepts and scientific breakthroughs which must be accommodated. However, an R&D system must be disciplined and be judged on how well it meets Army war fighting requirements.

Control and responsibility for the R&D program at each organizational level should reside in one office. Continuous and meaningful coordination at each level between R&D people and the user is important.

The Army's in-house scientific program must have qualified, visionary technologists who are growing intellectually and can interface on equal terms with the outside scientific world. Personnel policies must allow proper compensation for top engineers and scientists. The Army and OSD cannot compete with private industry for the superstars. There should be a few Ph.Ds in the hard disciplines who wear the Army green. Leadership and good people make for good military organizations — the same is true in the R&D arena.

Members of the Army's laboratories and RDECs must get out and get to know their customer, the U.S. Army. At the same time, the Army leadership should go out of its way to make the Army scientists members of the team.

Adequate and consistent funding for basic research is vital. It must be recognized that frequently there is not a direct return on investment from basic research. Basic research funds are not fair game when the budget is being cut.

Finally, it must be recognized that the acquisition process, including its research and development element, is complex and difficult to operate. It is a tough job to conceive, develop, test and field a new weapon system that dominates the battlefield because it was properly designed to meet accurately-stated requirements, is easy to operate and maintain, and incorporates the latest technology. Additionally, it is tough to develop a weapon system that meets the development schedules and cost estimates despite all the "help" and pressure generated by Congress, OSD, defense contractors, the other services and the parochial centers of influence inside the Army.

The acquisition business involves complex tasks and no amount of studies, commissions and sage papers by experts will alter this fact. There is no doubt that the Army can do a better job of inserting and capitalizing on technology in its weapon systems. The solution in large part is an informed, understanding and supportive leadership at all levels — which demands the best, delegates responsibility and holds people accountable.

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