

as an autonomous organization or as an identifiable separate operating unit of a parent organization.

- (4) Long-term relationships between the Government and FFRDCs are encouraged in order to provide the continuity that will attract high-quality personnel to the FFRDC. This relationship should be of a type to encourage the FFRDC to maintain currency in its field(s) of expertise, maintain its objectivity and independence, preserve its familiarity with the needs of its sponsor(s), and provide a quick response capability (17).

■ Conclusion

The post-war period started with a large number of federal research laboratories continuing after World War II. These were mostly engineering and scientific centers, many associated with the development of nuclear weapons, except one was a study and analysis center. By 1950, there were 23 federal research centers, three were study and analysis centers: ORO, RAND, and OEG. RAND and OEG (renamed Project Air Force and the Center for Naval Analyses, respectively) survive to this day.

THE GROWTH OF RESEARCH CENTERS FROM THE KOREAN CONFLICT TO THE EARLY 1960s

With the conflict in Korea and the Cold War environment of the 1950s and early 1960s, federal research continued growing steadily. Defense budgets after the Korean conflict were reduced but stable, with spending on strategic weapons, mostly through the Air Force, growing considerably. The think tanks were supported by a positive view of what they could accomplish.

Prior to World War II, total federal spending on research and development was estimated to be \$100 million a year. By 1950, this figure had grown to \$1.1 billion and continued to grow throughout the 1950s and into the 1960s until in 1963 the budget was placed at \$12.4 billion. This growth was attributed at the time to:

...the importance of scientific and technical work to the achievement of major public purposes. Since World War II the national defense effort has rested more and more on the search for new technology. Our military posture has come to depend less on production capacity in being and more on the race for shorter lead times in the development and deployment of new weapons systems and of countermeasures against similar systems in the hands of potential enemies (9, p. 1).

■ Army

At the start of the conflict in Korea in 1950, the Army's ORO had been in existence for two years and was able to conduct operations research in its traditional field environment, much as had the British groups during World War II (77). The war provided ORO with the laboratory for their work, and they quickly organized and sent field teams to Korea.

Ellis Johnson, the head of ORO, thought the conflict in Korea offered an excellent laboratory for operations research. ORO personnel, though many of them had never seen service, visited the theater. Johnson personally led a team of four into the battle area and within a few months the ORO contingent grew to eight teams of 40 analysts. Over 100 ORO staff, subcontractors, and consultants worked in Japan and Korea during and immediately after the war. One hundred and thirteen of ORO's staff members and consultants received the Korean Service Medal of the United Nations Command for work in the combat zone. The ORO analysts were also able to establish close working relationships with the operational researchers from Great Britain and Canada. All this provided ORO with an understanding of military affairs, experience with applying methodologies to operations, and the opportunity to test and develop new methodologies. The field representatives in Korea did extensive evaluations of close air support, utilization of indigenous manpower, effectiveness of leaflets, and a range of other items.

They had a number of notable successes, including convincing the Air Force that it should use

B-29s for tactical bombing at night (87).⁴ The ORO researchers also conducted a systematic data collection on the causes of enemy tank losses by trying to conduct a ground check on every tank destroyed. This resulted in a number of post-war studies on tank losses and the causes. S. L. A. Marshall, well-known author of *Men Against Fire*, worked as a consultant for ORO and created a primer of Chinese tactics during the war. The primer was immediately distributed down to the platoon level in the Eighth Army. A number of ORO researchers, in the desire to collect field data, came under hostile fire. In one case an ORO researcher was shot down behind enemy lines and had to be rescued (66,77,87).

One of the elements encountered in the conflict in Korea was the use of psychological warfare by both sides. The psychological interest motivated the Army to establish the Human Resources Research Office (HumRRO) in 1951 with a contract administered by George Washington University. It was formed specifically to conduct research on human factors, or the study of how people behave as part of a system including tactical matters, training techniques, and man-machine interfaces. Its staff consisted of a large number of social scientists and psychologists. While some human factors research was conducted by ORO, the majority passed to HumRRO and later the Special Operations Research Office (SORO), another federal research center founded by the Army to study social science issues and counterinsurgency warfare (66).

ORO aided in the establishment in 1953 of the Combat Operations Research Group (CORG) at headquarters, Continental Army Command, Ft. Monroe, Virginia. This organization was extensively supported by a private corporation, Technical Operation Inc., starting in 1955. In the early 1960s this group was reorganized and tied to the Combat Developments Command in Ft. Belvoir, Virginia (66). The Combat Developments Command served as a major seed organization for the

U.S. Army Concepts Analysis Agency (CAA). The Army formed CAA on January 15, 1973 to bring its research analysis in house, absorbing the functions of the existing Strategy and Tactics Analysis Group (STAG), the descendent of Combat Developments Command (79, pp. ii,3; 80, p. i-1; 86). The Stanford Research Institute (SRI) was established in 1956 to provide support for the Combat Development Experimentation Center (CDEC) at Ft. Ord, California (77). This not-for-profit organization was never considered a federal research center.

In 1957, the Special Operations Research Office was formed as a contract agency under The American University in Washington, D.C. It was intended to specialize in what is now referred to as low-intensity conflict or guerrilla warfare (81).

At the turn of the decade, the Army's senior analysis center, ORO, was dissolved and a new organization was established in June 1961. This change was done so as to be able to fire the ORO director, Dr. Johnson. ORO's administrative organization, Johns Hopkins University, was not willing to remove Johnson under pressure from the Army. It was mutually agreed then that Johns Hopkins and the Army would terminate the contract, and the Army established a new organization called the Research Analysis Corporation (RAC) (77,68). On September 1, 1961, there was a new contract between the Army and RAC, with ORO's research program, personnel, physical assets, leases and contracts for supplies and services transferred to RAC. All ORO personnel maintained their salaries and conditions of employment. There were some resignations, but the organization was unimpaired in its ability to continue performing (77,68, pp.271-273,25). A senior ORO staff member quipped that RAC stood for "Relax and Cooperate" (68, p. 272).

In May of 1963, the five agencies—of which only three were classified as federal research centers: CORG (supported by Technical Operations Inc.), CDEC (supported by SRI), RAC, SORO

⁴ This is unusual in that an Army research center is providing recommendations on tactical air support to the Air Force (via the Army).

and HumRRO—had over 400 technical personnel and conducted most of the Army-wide studies in operations research and study and analysis (66, p. 6). The Army also had a developing in-house capability and was contracting to the developing private industry contractors. In FY 1962, 20 different study contractors and 50 research studies of an operations research nature were sponsored by 11 Army agencies to support their in-house operations. Their in-house operations consisted of at least 20 groups scattered among nine commands. They employed approximately 200 civilian and military personnel and ranged in size from 2 to 40 professionals. Like the study contractors, the in-house groups worked mostly in specific study areas with the mission of the command to which they reported (66).

■ Navy

The Navy became heavily involved in providing air support, interdiction, and shore bombardment in the conflict in Korea. The Navy's Operations Evaluation Group (OEG) primarily focused on determining ways to make air and shore bombardment and interdiction missions more effective. The number of scientists grew from just below 40 to just below 60 by the war's end. One died in combat.

After the end of the conflict in Korea and a period of consolidation, OEG resumed slow expansion. As a result of the rapidly changing technologies and the Cold War, OEG's staff rose to a peak of about 70 scientists in 1959 and 140 total staff in 1961, when it was absorbed by the Center for Naval Analyses (78).

Much like RAND, OEG also began to serve as a central point for the creation and spinning off of other federal research centers. The Navy's first attempt at long-range planning was the founding of the Operations Research Group (ORG) in June 1953, which was primarily oriented toward long-term military planning issues related to technological developments. It was staffed with OEG scientists with field experience on a rotational basis and its director was also the director of OEG. The Office of Naval Research (ONR), the federal

government agency that originally objected to OEG calling itself ORG after World War II, wanted an organization for its own operations research group tasked to look at ONR problems only, which it then called ORG. In particular ONR wanted the organization to review long-term problems and solutions. The ORG was sponsored by MIT and located in the same offices as its customer, ONR. Its small staff never exceeded eight scientists, and it became an appendage of OEG, its achievements not considered noteworthy by many. The organization was dissolved on April 20, 1957, with a small group continuing until December 31, when its contract expired.

There had been considerable talk of creating a "Navy RAND" in the early and mid-1950s. On January 1, 1956, again as a spin-off from OEG, the Naval Warfare Analysis Group (NAVWAG) was established under contract with MIT. For its first four years, NAVWAG had the same director as OEG, who was also the director of ORG. Some personnel from OEG were used to seed the organization. It was a very small organization located in the Pentagon, starting with a staff of two. It grew to a staff of 14, with 10 scientists, before being absorbed in 1962 by the Center for Naval Analyses. In 1960 and 1961 it had a budget of approximately \$230,000 (78).

Finally, OEG created a third spin-off group, the Technical Advisory Group (TAG), later named the Applied Science Division (ASD). It was established in November 1959, again under contract with MIT. It was oriented toward basic research and, over three years, grew to a staff of approximately 60 people with 30 scientists and a budget of \$800,000 a year.

It was intended that OEG, NAVWAG, and ASD would exchange personnel as required for their missions. In 1959, the Navy established a long-range studies project headed by the Institute of Naval Studies (INS) in Cambridge, Massachusetts. For its support, it contracted with the Institute for Defense Analyses (IDA) (78). At the close of 1961, the Navy decided that ASD, being located near the Navy's Institute of Naval Studies

(INS), should support INS and severed the ASD connection with OEG.

Finally, in 1961, in response to a formal recommendation from IDA, DoD began looking at combining all these small OEG-influenced research centers into one organization. The Smithsonian Institution was selected as the contracting agency, but that approach ended when the Chief Justice of the United States, who was on the Smithsonian Board, objected strongly. Finally, a contract arrangement was established with the Franklin Institute, a not-for-profit scientific and educational institute that had been involved in sponsoring scientific research for over a century. The Franklin Institute assumed control of the newly established Center for Naval Analyses (CNA) on July 1, 1962. It combined all the functions and personnel of OEG, NAVWAG, INS, and ASD, taking over the contracts from MIT and IDA.

With the new center, the Marine Corps received its own operations research section in December 1961. Up until that time, the Corps had only one analyst at OEG (13, p. 16). The director of the division was located in the Marine headquarters and only reported administratively to CNA. In 1966, the INS along with the ASD was relocated from Cambridge, Massachusetts, to Washington, D.C. to be physically combined with the rest of CNA.

With the advent of a systems analysis division and a cost analysis group, the CNA was a full-service support facility that integrated all of the Navy's civilian operations research staff under one roof. In 1962 the staff of the OEG was 56 scientists (18 in the field) and 42 support personnel with a fiscal year budget of \$1,625,000. NAVWAG had 10 scientists and 3 support personnel with a fiscal year budget of \$221,500. ASD had 12 scientists and 6 support personnel with a budget of \$800,000, and INS had 43 scientists (42 in Cambridge, 1 in Newport) and 14 support personnel with a budget of \$1,500,000. This effectively created a research organization of 186 people with 121 scientists and a FY 1962 budget over \$4 million.

■ Air Force

The conflict in Korea was not a major area of work for the newly established RAND. RAND was more focused on strategic issues of the future and did not become as involved in the conflict in Korea as the Army and Navy operations research organizations did, partly because the Air Force, unlike the Navy, had a well developed doctrine on interdiction and strategic bombing from World War II. Also, RAND itself was less interested in providing immediate operations research support and more interested in studying long-term problems. RAND's own histories make no mention of the conflict in Korea (59,60).

While RAND continued to expand during this period, it also fostered several spin-off organizations. In 1950 RAND began a study by a team of psychologists on how groups operating complex machines work under stress, which led to an air defense training system in 1953 that was put into operation throughout the Air Defense Command. A whole division, which grew to twice the size of the rest of RAND, supported this new, large semi-automatic air defense control system. The Systems Development Division provided routine technical services, computer programs, and training for this system (59, p. 17).

Because it differed in its basic purpose from RAND, the Systems Development Division became, on December 1, 1957, the Systems Development Corporation (SDC), an independent not-for-profit entity. The original proposal created a for-profit organization, but was rejected by the Air Force due to concerns about conflicts of interest (68, pp. 114-119). Lincoln Laboratory had been established in 1951 to develop an air defense system that became the Semi-Automatic Ground Environment (SAGE) system. RAND's support of the training aspect of this effort (arguably an early instance of distributed interactive combat simulation if not of virtual reality see OTA background papers *Virtual Reality* and *Distributed Interactive Combat Simulation*) was continued by SDC. SAGE pioneered the use of a digital computer as

a real-time control system as well as to simulate combat: in training, radar operators and weapon controllers reacted to simulated targets presented to them as real targets (84, p. 10). After becoming independent of RAND, SDC continued to grow to many times the size and budget of its parent organization. At one point, SDC employed about 90 percent of the nation's computer programmers (18, p. 131). SDC survives to the present day.

RAND also helped create Analytic Services, Inc. (ANSER) in 1958 for reasons similar to those for which RAND separated from the Douglas Aircraft Corporation. Back in 1951, the Air Force had established the Assistant for Evaluation (later changed to the Director of Development Planning). The office was primarily responsible for estimating the technical feasibility of new weapons and planning the Air Force's research and development objectives. The office suffered from understaffing from its inception and was unable to obtain the right type of personnel through the civil service system or the military. RAND initially provided a number of technical people on loan. The office contracted work out to companies such as the Cornell Aeronautical Laboratory and Corvey Engineering and not-for-profit firms including the Stanford Research Institute.

Eventually the Air Force decided it needed a central study group, and Corvey Engineering was issued the contract. Meanwhile, Corvey Engineering was purchased by Melpar Inc., a manufacturing firm that developed and sold test equipment to the Department of Defense. Melpar was a subsidiary of the Westinghouse Air Brake Company. In September 1957, Melpar Inc., received a contract to create a Scientific Analysis Office using the Corvey Engineering personnel. Even though Melpar tried to physically and organizationally separate the people, this arrangement was ill-received by others in private industry and by the Air Force's own Air Research and Development Command because of the potential conflicts of interest. It was a situation analogous to the relationship between RAND and Douglas. The Air Force then requested RAND take over the office. RAND felt that this was a staff research function that did not fit RAND's mission and informally recom-

mended that the Air Force use its own in-house technical capability, the Operations Analysis Office, an operations research group of approximately 200 people. Apparently concerns over performance, responsiveness, and objectivity predisposed the Air Force against another department in its own organization. So, RAND instead agreed to help establish ANSER, using the core of the personnel from the short-lived Melpar Scientific Analysis Office. ANSER was founded in July 1958 as a not-for-profit research corporation also incorporated in California.

On July 12, 1961, ANSER became independent of RAND except for two RAND members on the ANSER board of trustees. ANSER was considerably smaller than RAND, with 40 professionals. It was located in Virginia, within convenient distance of the office it was supporting. It conducted cost-effectiveness studies and technical evaluations of weapon systems and subsystems and provided technical advice to the Directorate of Development Planning.

In addition, a number of RAND personnel left to establish other organizations. Notable among these are the for-profit firm Planning Research Corporation (PRC), General Electric's TEMPO Division, and the not-for-profit Hudson Institute (68), founded by Herman Kahn in 1961 as a break-away organization from RAND. In interviews Herman Kahn expressed concern that RAND was losing its vitality and becoming a captive of its client (27, pp. 89,189). He claimed RAND had become the "loyal opposition" while he was the "disloyal opposition" (68, p. 306). The Hudson Institute was a federal research center for a time during the 1960s, but was no longer listed as one by June 1, 1968 (52). (In 1983, after a competition among several institutions, the Department of the Navy would select the Hudson Institute as the contracting company for the Center for Naval Analyses, taking over from the University of Rochester (12).)

Two not-for-profit federal research centers, The Aerospace Corporation and MITRE Corporation, were established by the Air Force to provide systems integration and managerial assistance to particular Air Force commands to serve as a bridge

between the Air Force and industry. The Air Force lacked the in-house technical resources to design or specify systems in enough detail to conduct meaningful competitions for procurement and monitor the efforts of the chosen contractors.

On February 10, 1954, the Air Force Strategic Missiles Evaluation Committee (SMEC) reported that an intercontinental missile could be developed by 1960. (A study released by RAND two days earlier had stated a similar conclusion.) The Air Force decided that the systems engineering and technical oversight of the development of such a complex, high-risk system should be provided by an independent organization rather than an industrial manufacturer participating in the project. As such, the Ramo Wooldridge Corporation was contracted in 1954 as the systems engineering contractor. The division doing this work grew to become, in December 1957, the Space Technologies Laboratory (STL) of Ramo Wooldridge (1, pp. 12,13). The Air Force gave STL access to both federal government plans and contractor-proprietary data. The first Atlas launch was in June 1957, with successful launches of the Atlas and Thor missiles occurring before the end of the year (1, p. 15), well ahead of the SMEC forecast.

Ramo Wooldridge was financially backed by Thompson Products, a supplier for the automotive and aircraft industry. In 1958 Thompson Products and Ramo Wooldridge merged to become TRW Inc., with the STL as an independent but wholly owned subsidiary, creating a potential seeming conflict of interest analogous to that created by Douglas Aircraft's original ownership of RAND. There was a hardware exclusion clause in the Ramo Wooldridge contract, but no such clause existed for Thompson Products (1, p. 15). The Senate Armed Services Committee and a subcommittee of the House Committee on Government Operations investigated potential conflicts of interest between 1957 and 1959, with the House subcommittee recommending in a September 1959 report (1, p. 16) that STL be converted into a not-for-profit institution like RAND. When the Air Force, at Congress's request, set out to create a federal research center, it discovered that TRW

did not want to relinquish STL. The Air Force requested that an organizing committee of private citizens establish a new not-for-profit corporation with a board of trustees. That not-for-profit became The Aerospace Corporation.

The Aerospace Corporation was established on June 3, 1960, as a not-for-profit organization under the laws of California. It was to be responsible for advanced planning, initial system design, technical evaluation of proposals, and technical oversight of hardware development and operation. On June 9, The Aerospace Corporation received a \$1 million contract, effective July 1. On June 10, the Air Force gave Aerospace an advance of \$5 million. This relieved the organization of having to obtain capital funds from other sources such as the Rockefeller Foundation or the Ford Foundation. Aerospace consisted of a board of directors, a contract, and a major responsibility to integrate space and missile programs. It did not have a staff or facilities. At the end of the first month, it had 15 staff; a week later, 126 staff; and, at the end of six months, more than 1,700 (1, pp. 19,21). Most of this staff was recruited from private industry. The president from 1960 to 1977, Dr. Ivan A. Getting, had previously been director of the Fire Control and Army Ground Forces Division at MIT's Radiation Laboratory. Several other prominent Aerospace figures came from this World War II-era organization (1, p. 7). Other vice presidents and department heads came from the Naval Research Laboratory, RAND, Raytheon, and STL. Seventy-five percent of its staff came from STL.

To provide continuity until the work could be taken over, Aerospace gave STL a subcontract. Aerospace awarded subcontracts to other industrial firms for specific research tasks. To facilitate operations, the Air Force inserted clauses in Aerospace's contracts with the manufacturers that gave Aerospace right of access to the contractor's facilities, personnel, and information. Its original facilities were purchased from STL, eventually expanding to offices in Florida and California. By the end of 1962, The Aerospace Corporation employed 4,275 people, 1,463 of whom were engineers and scientists. Most of the technical staff

came from industry, only a few from universities and the federal government (2, p. 1).

The other systems integration research center was MITRE Corporation, formed in 1958 out of the Computer Systems Division of the MIT's Lincoln Laboratory. It was established to assume the responsibility for the operational implementation phase of the SAGE (Semi-Automatic Ground Environment) system. The SAGE system was part of the continental air defense system in the late 1950s and 1960s. The purpose of the system was integration of ground elements—radar, communications, computers and control centers—with a new generation of interception weapons. The Air Force did not have the needed systems-integration expertise in-house and did not wish, for reasons of potential conflicts of interest, to give the work to a for-profit contractor. MIT viewed the implementation work as extraneous to the desired scientific mission of Lincoln, and therefore the Air Force was obliged to create a new FCRC, MITRE. MITRE's first contract was with the Air Defense System Integration Division. MITRE eventually became involved with most of the major strategic air programs of the 1960s, 1970s, and 1980s, including North American Air Defense Command (NORAD) headquarters, Ballistic Missile Early Warning System (BMEWS), Airborne Warning and Control System (AWACS), and the Strategic Defense Initiative (SDI).

In 1959, MITRE got a second contract, to perform work on air traffic control systems for the Federal Aviation Administration (FAA). Air traffic control and continental air defense share many technologies in common, and in a Cold War environment the two functions overlapped. In 1966 MITRE began work with National Aeronautics and Space Administration (NASA) on its mission control centers (44).

■ Office of the Secretary of Defense

The Office of the Secretary of Defense (OSD) began creating federal research centers starting in 1956 in an effort to support its Weapons Systems Evaluation Group (WSEG), a defense agency es-

tablished Fall 1947 as an adjunct of the Joint Chiefs of Staff to assess objectively the claims for competing weapons systems by the different services. There was considerable concern in the early and mid-1950s that this organization was not performing effectively, so the Institute for Defense Analyses (IDA) was created to act as a technical backstop to WSEG and to facilitate the recruitment of high-caliber scientific manpower. WSEG was to provide tasks for the Weapon Systems Evaluation Division (WSED) of IDA, arrange for access to information, provide military personnel to assist, and provide a board to review completed work and arrange for distribution and publication. There was considerable cross-over in assignments. For example, the same person served as the Director of WSED and the Director of Research for WSEG. This arrangement led to some confusion over who was ultimately responsible for the finished work, IDA or the federal government, and reflected wider uncertainty over whether contractors could have detachment and objectivity. It also resulted in an investigation by Congressman Chester Earl Holifield (D-CA) (68). As a result, late in 1962 members of DoD and IDA restructured the WSEG/WSED working relationship so that there were no more dual federal government and company positions and the WSEG review board was not actively involved in daily IDA work. These changes were strongly opposed by many professional military. They felt that the changes effectively eliminated military control over WSEG's studies, operations, and reports. They were concerned that the group's work would be less responsive to actual needs and security requirements. Another serious concern was that the changes would degrade the influence of the professional officer in the defense decision-making process. This controversy was part of the developing struggle over whether the civilian expert or professional military would be making the decisions on systems and weapons that were to be used by the military. The objections resulted in a revised decision that partially reasserted WSEG's control of WSED, but as part of the changes, the