THE RESEARCH ANALYSIS CORPORATION

A History of a Federal Contract Research Center

by Charles A. H. Thomson

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FOREWORD

This booklet sets forth major elements of the history of the Research Analysis Corporation (RAC)—one of a very small group of highly specialized organizations created to serve the public interest in particular and often not well understood ways. Sometimes called Federal Contract Research Centers (FCRC's), sometimes called "think-tanks," these organizations worked chiefly under contract with the Department of Defense, or with the Army, the Navy, or the Air Force. Their purpose was to provide independent, objective, and scientifically sound studies and advice on problems of national security. At the outset, few limits were set on the fields which they should explore. They and their clients strove to improve definition and understanding of all the factors bearing on problems of national security in a world of expanding basic research and proliferating technology. Both clients and research centers believed that gains in science and technology not only portended great potential changes in the weaponry and logistics of war, but also bore important implications for military strategy and tactics, military force structures, deployments, and operations. They foreshadowed revolution in military communications, surveillance, and intelligence, as well.

It soon became clear that changes in military affairs interacted with the larger fields of national security and national interest. But it was not at all certain what those interactions or their consequences were, or might be. In earlier times such uncertainties would be resolved by existing political, economic, and social institutions. Needed insight would come from universities and from other havens for learning. But in this latter day, it was not at all certain that traditional institutions would suffice. Because of continuing international tensions and demands for secrecy about the weapons of war and their uses, it did not seem that the open world of science and the universities could bring together all the information and understanding needed to bring science and technology fully to bear on emerging issues. New forms of organizations were thought necessary to explore these new issues exhaustively and imaginatively, informed by but free of the weight of tradition, practice, received wisdom, diplomatic discretion, and military secrecy found in government agencies responsible for military and foreign policy. Since burgeoning science and technology were sure to bear heavily on domestic problems as well as to foreign relations, it was likely that the new organizations would have a part in clarifying those relationships too.

Thus the Navy's Center for Naval Analysis (CNA), the Air Force's Project RAND, and the Army's Operations Research Office (ORO) came into being during and immediately after World War II.

The Research Analysis Corporation (RAC) was created in 1961 as the successor to ORO. In 1972, the General Research Corporation (GRC), a for-profit organization designed to provide similar or related services, bought RAC, taking over its staff, physical assets, its

property leases, and its contract relationships with the Army and with other clients. During this decade, important changes took place not only in foreign relations and domestic affairs, in the design and capabilities of weapons systems, in military force structures and deployments, and in management organizations, but also in the perceived needs of the government and of others for studies and advice.

The nature of those studies and the foundations and content of that advice changed as did the methods and skills of those providing the advice. The interaction between advisor and advisee changed, as both became more sophisticated and better aware of the foundations, the implications, and thus the force and potential range of application of the advice and studies commissioned and received.

As the content and practice of operations research and systems analysis developed and matured, capabilities for making studies expanded. The computer made it possible to deal with ranges of detail and complexity not previously feasible. There were some drawbacks and misapplications, as early successes in computer applications tempted users to apply them to problems in which the computer's contribution was more apparent than needed. To use computer-based or computer-assisted analysis conferred both credibility and status on users even in situations where the presence of the computer was not critical to the advancement of theory or the deepening of insight. Meanwhile a more critical spirit developed as mathematical developments dealing with probability, uncertainty, and forecasting, such as linear and non-linear programming, brought new areas within the range of explicit quantitative analysis. The computer and mathematical developments together made it possible to model huge operational systems–like worldwide logistical systems–and thus made them more amenable to understanding and manipulation without the time and costs associated with empirical changes followed by observation, reporting, and evaluation of their consequences.

Developments in game theory, in war gaming, and in strategic analysis of military, political, and economic systems, and their interactions and changes, made it possible to study great unknowns such as the probable nature and potentialities of nuclear war and nuclear weapons, again without having to undergo the horrible experience of world nuclear conflict. Such developments also helped to cast light on areas in which there was concrete experience–in limited war and insurgency, for example.

A comprehensive general history of these organizations together, or of any one of them, has yet to be written. Partly this is so because some of them are continuing organizations. But RAC now has a beginning and end as a not-for-profit provider of studies, systems analysis, and advice. This booklet is intended to contribute to understanding of such agencies by providing an account and assessment of some of the most salient elements of RAC's experience. The booklet, in recounting the background and context of RAC's origin, sets forth some of the conditions and reasons why it was designed as it was. It gives an overview of RAC's main tasks and its contributions. It shows the main lines of its development and gives reasons for them. It outlines RAC's structure and its governing and administrative organization. It deals with the highlights of personnel and financing. It recounts why and how RAC became part of GRC. Finally, it offers a tentative assessment of RAC's achievements and shortcomings and their probable significance for the future of studies and analyses and the need for specialized organizations to conduct them.

The booklet is also a tribute to those who led and managed the organization, to those who did its substantive work, and to those among its clientele who made its existence possible and who helped shape it.

FOREWORD

This booklet is also an accounting of the stewardship of the Board of Directors. For the governing and guidance of the Research Analysis Corporation was a special public trust, going beyond the trusteeship responsibilities commonly borne by boards of directors of private, profit-seeking corporations. More than the wise use of public funds was involved. The development of an institution peculiarly fitted to serve the public interest by exploring the implications of unfolding science and technology for public problems and future progress was also at issue. The concerns of both executive and legislative arms of the government, the particular needs of particular clients at various levels of government, relationships with industry and the academic world—all these and more were involved. How the Board responded to all these concerns and how it acted to preserve the capability built through a decade of experience for future service, are central themes.

James H. Wakelin
President and
Chairman of the Board

McLean, Virginia
May, 1975

AUTHOR'S ACKNOWLEDGEMENTS

This booklet, more than some of its kind, is the product of the thought and work of many people. No one person could hope to know and understand all pertinent details of the many-faceted activities of the Research Analysis Corporation. Similarly, no one person can speak with full information and authority about the organization and management of the corporation as it developed through a decade. Documents provided by corporate officials and staff, or sought out from files and records, call for interpretation; they do not speak unequivocally for themselves.

For all these reasons, the author is especially grateful to those who gave information, interpretation, and advice on structure and content of this book. To name a few is not intentionally to slight the many others who helped; but those who were of special assistance in shaping this booklet are Frank A. Parker, George S. Pettee, Hugh M. Cole, Edmond C. Hutchinson, General Frank S. Besson (USA Ret), Albert D. Tholen, J. Ross Heverly, Roland G. Ruppenthal, Lawrence J. Dondero, John T. Newman, Charles A. Allen, Carl S. Donaldson, Victor Warcholik, John J. Andre and the staff of the Personnel Department, and Margaret L. Emerson and the staff of the Library. Dorothy Hoover Whitmarsh provided invaluable documentation from corporate files. Eleanor W. Johnson assembled much of the documentation and prepared charts and lists. For the ORO period, Edward Cushen, Margaret Emerson, Brigadier General Lester Flory (USA Ret), Thornton Page, and George Pettee offered their well-founded views and recollections. Robert D. Calkins gave invaluable advice on the scope and organization of the report.

The whole project was brought to completion under the guidance of Dr. James H. Wakelin.

The author takes full responsibility for opinions and assessments, as well as for errors of fact or interpretation.

Charles A. H. Thomson

McLean, Virginia, May 1975

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Chapter I

BACKGROUND

To understand the Research Analysis Corporation, what it was, what it aspired to be, and what shaped its activities and its achievements, it is necessary to consider its origins. It is necessary to go back before the creation of its predecessor, the Operations Research Office, into the experience of World War II in the joining of effort by scientists, technologists, and engineers with government officials and military professionals to devise new weapons and methods of war. It is necessary to recall the mortal threat to the United States and its Allies posed by the Axis powers and to remember how close the margins were by which the war was won on land, sea, and in the air. That was a war calling forth the total effort of the country—all its skills and talents. The existing weapons at its outbreak were not enough to assure even that small margin. To follow the old maxim, that great wars are fought with the weapons available at their outbreak, would not do. Axis superiority in critical weapons and doctrines for their use had been made all too clear by the fall of France and the rout of the British Expeditionary Force and then reinforced by their near-victory in the Battle of Britain. In that latter battle not just British planes and pilots held the day; radar made a critical difference. Even before the entry of the United States into the war, the threat of the U-boat loomed larger and deadlier than in World War I.

The response of the United States was total. It was early recognized that every capability of science, engineering, industry, production, and military science would have to be brought to bear. And it was early decided that weapons development resting on highly sophisticated science and engineering could not be left to the military. A civilian organization was set up, the Office of Scientific Research and Development, under the leadership of a brilliant scientist-engineer, Vannevar Bush. This new organization reported directly to the President and had his confidence. It got its own funds from Congress and was relatively free of procedural complications in the manner in which it spent them. It could bring together the country's finest scientists and engineers, from universities, from industry, and from elsewhere, and put them to work on translating scientific knowledge and sophisticated technology into problems of weapons design. While independent of the military, OSRD learned early that it must work closely with military professionals. Only military professionals could provide the judgment about the conditions under which a new weapon could work best, given military organization and practices and the conditions of the battlefield. A weapon in itself was not enough. There had to be strategy and tactics for its use; and for such problems the knowledge and skills of the scientist were not enough.

As a result, a close collaboration grew up among the scientists and engineers, the soldiers and their civilian superiors. Mutual understanding and respect were established. OSRD spent billions of dollars in the devising of new weapons and untold hours in working with the

military to work out the best means for using them to greatest advantage. All this was done under conditions of tight military security, under great pressure and threat. Radar was perfected and utilized fully in the war against the U-boat. The proximity fuze was developed and introduced into combat during the Battle of the Bulge. (It was estimated that this development alone conferred a tenfold increase in the effectiveness of existing artillery.)[1] Many more advancements were conceived, translated into weapons, and thrown into battle.

By the war's end, the OSRD experience taught many lessons, several of them fateful for the continuation of the terms whereby scientists, technologists, and engineers could work with the military services and the government to ensure a continuation of their wartime collaboration. Bush recommended that OSRD be abolished as soon as possible; it had accomplished its mission, but it had lost flexibility. It was spending as much time and energy on contracts and procedures, by war's end, as it had been devoting to its substantive tasks. The scientists wanted to get back to their laboratories, and the engineers to their places of normal employment. Yet, the need for collaboration continued; not only Bush but the Secretaries of War and Navy insisted that it must continue into the time of peace.

Bush dreamed of a comprehensive civilian organization, a National Research Foundation, to assure that under civilian leadership the benefits of science and sophisticated technology could be made available to the national interest in all important fields. He believed that the collaboration for military purposes could be carried out by one division of the new Foundation. He believed that the military could be entrusted with the improvement of existing weapons but could not be expected to bring the expertise and breadth of view to bear needed to see that the full potentialities of burgeoning science and technology were realized. And with the developments in atomic energy and nuclear physics, it seemed certain that these potentialities would be rich.

Bush, Karl Compton, and others were clear on another point. The needed research would be expensive. It was not possible to frame the problems precisely. Results could neither be programmed nor assured from any given expenditure of funds or search for the answer to any given problem. The government, the Congress, and the country would have to understand—as industry had come to understand in the support of basic science in its own laboratories—that results would come about through time, often after many failures, and in ways not always foreseeable or expected. Uncertainty played a very large role. Bush and his colleagues did believe, however, that some tangible results from this untidy process would have to appear in order to justify it in the long run. To quote Bush:

> Operating agencies have immediate operating goals and are under constant pressure to produce in a tangible way, for that is the test of their value. None of these conditions is favorable to basic research. Research is the exploration of the unknown and is necessarily speculative. It is inhibited by conventional approaches, traditions, and standards. It cannot be satisfactorily conducted in an atmosphere where it is gauged and tested by operating or production standards. Basic scientific research should not, therefore, be placed under an operating agency whose paramount concern is anything other than research. Research will always suffer when put in competition with operations.[2]

[1] Vannevar Bush: *Modern Arms and Free Men,* New York, 1949, p. 30
[2] Bush: *Science, The Endless Frontier,* Washington, 1945, p. 32.

Bush did not foresee a new specialized form of agency to do long-range military scientific research, such as the studies and analysis agencies that grew up in the fifties and sixties. He thought that "long-range research involving application of the newest scientific discoveries to military needs should be the responsibility of those civilian scientists in the universities and in industry who are best trained to discharge it thoroughly and successfully. It is essential that both kinds of research (military and civilian) go forward and that there be the closest liaison between the two groups."[3]

But given the delays in setting up the National Research Foundation, reorganizing the military services, and in other ways reshaping the context for military research and development, the logic of Bush's observations on the need for the correct conditions favoring long-range scientific military research, led to the moves by the Navy, the Air Force, and the Army to set up specialized agencies to supplement the resources of industry, the universities, and their own facilities in-house.

Relatively few people shared Bush's confidence in the need for a continuation of the special wartime combination of science and technology with military professionals to do research on the weapons and practices of war. The atom bomb had raised questions about the probability of future war; who could afford to make war with such destructive power even if it were available to only one of the combatants? There was a belief that if such war did break out, it would last for a matter of hours or days; what sense was there in creating the weapons and forces for longer-term fighting? Moreover, even Bush and his colleagues thought that the potentialities of existing basic scientific knowledge that could be applied to weapons and forces had been fully explored by the end of World War II. There was no immediate need to look further for ways to take advantage of the available knowledge and technology. It was more important to get the scientists back to their laboratories, in universities and industry, to replenish the stock of fundamental knowledge. There was no immediate, clear military threat to the victorious powers. In 1945 and 1946, few saw the threat from Russia as explicit and mortal. The threat from China to external powers was much farther off. To many, the immediate tasks of peacemaking, reconstruction, and demobilization seemed much more important than preparing for some as yet unvisualized threat. The United States was readying itself at home for the peace it thought it had won. Through occupation forces in the homelands of the defeated powers, and through the United Nations in the international arena, a structure of peace was being erected. It is not surprising, therefore, that the United States did not immediately turn to a radical reconstruction of its fighting forces through unification of the services or some similar means. Hence the organizational home for a single research agency within the defense community to serve all defense needs was not being built. And government did not move to set up the comprehensive research foundation Bush had called for.

In these circumstances the services built on existing organizations and operations to deal with the uncertainties and the apparent needs for scientific and technological research to visualize and to cope with the defense problems of the future. The Navy continued its Operations Evaluation Group, building on the analyses of naval operations and their effectiveness that it had been doing, as ASWORG, during the war. The Navy's Office of Naval Research commenced funding a very wide array of small research activities designed to explore research in human behavior and in many other areas that promised to be of increasing importance in the years ahead.

[3] Loc. cit. p. 34.

The Air Force, even then virtually independent of the ground Army, established Project RAND in The Douglas Aircraft Corporation to study problems of preferred methods of fighting future war (not on the surface) that were portended by the science and technology that had gone into aircraft developments and nuclear energy during World War II.

The Army had had no operations analysis group of its own during the war and had relied on OSRD and on its technical services to do what seemed necessary in developing new weapons and other scientific applications.

It was not until 1948 that the Army moved to establish an operations research group of its own. The motivations for this are obscure today. At the time, as subsequently, considerations of interservice rivalry were not unimportant. The struggles of the services for a favorable allocation of roles and missions were proceeding apace. Those falling to the Air Force and the Navy boded well for prominent and prestigious roles. Under the pressures for economy and austerity in the immediate postwar period, the prospect of a key role in the nation's defense, resting on use of the atom bomb and other novel and prestigious weaponry, was important for reasons of survival and service morale. The Army's role was not so clear. The tasks of land warfare, particularly ground warfare, did not promise to be helped so significantly by the creation of new weapons, although the precipitous reduction in the size of the Army after V-J day underlined for the Army the urgency of seeking through sophisticated weaponry some balance to its losses in manpower. Prospects of land war in either Europe or Asia were distasteful in the extreme to a nation accustomed to early demobilization after its previous victories and ready to relapse into its accustomed status of peace.

While programs of exploring the implications of nuclear power and of other scientific and technological potentialities for their roles and missions seemed vital to leaders in the Air Force and Navy, the Army did not seem equally alert to the value of innovations of equivalent sophistication for its role in land warfare. At the outset the Army seemed to be seeking ways to apply operations research to questions of logistics and supply rather than weaponry for combat.

The Army's first official statement of reasons to develop a special organization for scientific studies and advice cited considerations of economy and efficiency. In a memorandum dated April 30, 1946, General Dwight D. Eisenhower, then the Army's Chief of Staff, observed that by setting up a research organization outside the Army, and by

> the cultivation, support and direct use of outside resources . . . the Army would have more time and energy to devote to strictly military problems and to those problems which for security reasons could be handled only inside the military.

This memorandum set the stage for staff actions leading to the creation of the General Research Office in June 1948. This Office commenced operations the following September and was renamed the Operations Research Office (ORO) the following December. It was only later that the Army found and set forth broader reasons for having such an activity, basing its justification more explicitly on the need for using scientists in the definition and exploration of military problems for the future.

In the immediate postwar period the term "operations research" came into wider prominence. It also came to have many meanings for various users and practitioners, both in and outside of the military. In the '50s and '60s it was overshadowed, but not supplanted by the term "systems analysis". At the outset, operations research was in effect defined by specific wartime experience with the utilization of statistical method and mathematical

analysis to cope with problems of military operations under the pressures and driving dynamics of operations in wartime. Although such work was not essentially scientific, it was done by scientists who applied their traditional criteria for judging acceptable methods and the significance of results. Early successes of operations research (OR) for other services were won in determining the most efficient methods of search of large ocean areas to detect enemy submarines and in determining the optimum depths of laying mines and setting their fuzes, so as to defeat those detected. Such solutions as were profferred as a result of formal analyses were put to the test in actual naval operations for combat, convoy, or both.

Under the conditions of trial in war, it was possible to have early and persuasive evidence about the success or failure of new weapons and the strategies and tactics for using them. Operations research at this stage did not seek to devise new weapons but did seek to find optimum ways of using weapons and forces in being or already projected. Some operations researchers devised quick-fixes for adaptation of existing weapons and conducted imaginative tests to determine causes for success or failure in weapons functioning; but characteristically they used statistical and mathematical methods to search out the best ways of using what was available against a known enemy, limited in his ranges of adaptation and response, in which both sides had clearly defined tasks and goals.

As a result, the problems perceived and attacked by operations research were clearly bounded. And operations research during and for long after the war performed best when it was applied to such definable and inherently tractable tasks. The role of operations research and its practitioners as such did not include the delimitation and attack on problems which did *not* have clear limits or forms, and for which neither the military nor the scientist had appropriate experience for defining and clarifying them.

In wartime, success or failure in the achievement of missions seemed validation enough for innovations applied. In battle, the experience needed to judge the military worth of an innovation could be quickly generated. That experience often led to strong opinions among participants and observers about that worth. But scientifically valid assessment of that experience proved to be much more difficult. After the war, when time was available to make searching judgments about the validity of important innovations, scientists and military professionals needed to pool their observations and critical judgment in making fully valid assessments. Together they had to decide whether the innovation had been used under appropriate conditions and according to correct tactics. If conditions and tactics were not appropriate, they had to study how conditions of terrain, weather, and tactical employment interacted with weapons performance, and had to determine the individual and collective contributions of each and all of these factors to measurable success in battle.

In the last days of the war, it was already clear to those who had been concerned most intimately with the applications of science and technology to national security, that the implications for warfare of known and foreseeable science and technology were great and revolutionary. They called for previously unexampled exploration and evaluation. So did the application of science and technology in the assessment of the consequences and costs of new weapons and their effects. Wartime experience in the search for new weapons demonstrated that these consequences and their implications could not be fully worked out by military professionals or career civil servants. First-rate scientific talent was necessary. Yet it seemed likely that few scientists who had been willing to serve in government positions during the war would continue to do so in peace. They wanted to return to their posts in universities or in industry. They wanted to escape from the real or apparent constraints on their freedom and

conditions of work posed by conditions of government service. They wanted to be as free as possible to determine the subjects of their research. They wanted to pursue it in their own way. They wanted full freedom of communication and publication. They wanted the informed criticism of their professional peers as a necessary condition for the validation of their findings and for the furthering of their discipline. True, work in academia might offer the maximum of those freedoms a scientist considered essential, but there would be teaching loads and quite possibly a dearth of funds and other resources. Work for industry would always be constrained by the necessity to contribute in tangible fashion to the products and profitability of the companies the scientist served. But to many, the conditions posed by government, including relatively low pay, frictions and rigidities in government personnel policies, constraints on the choice of research topics and evaluation of the quality and results of research by administrators, not scientists, made continued service to government look less attractive.

Some new kind of organization was called for to deal with the questions of secrecy, rates of pay, conditions of employment, and freedom to determine the areas of research and to define the problems most worth study. The new organization need not be large. Those best qualified to judge believed that only a small number of first-rate scientists, technologists, and engineers would suffice. Since they would deal with concepts for the application of the findings of basic science and technology, the new organization need be neither costly nor elaborate. The problem looked soluble. The motivations for a first-rate person to join would arise from the challenge of exploration of a vital but uncharted area rather than from pay. The new challenge looked strong enough to overcome objections to working in an environment of secrecy, in peacetime, when the existence of the nation and the perpetuation of freedom for science to be science did not seem to be at immediate issue. Enough good scientists were around who had been engaged in the wartime efforts, had become accustomed to working under restraints on freedom to communicate, and had found out how much could be accomplished in any case, to launch whatever small new organizations seemed to be appropriate. Their prestige could attract others. The possibility of setting up relations with military clients that would assure access to all needed information and assure necessary collaboration between military professionals and the scientists, but would not burden the researchers with restricted task conceptions, schedules and priorities, also looked good.

The stage was set. The Air Force and the Navy built on their existing wartime research experience and organizations. Later the Army came to emulate, with less direct experience and, as it turned out, with problems less amenable to attack and solution by methods of scientific analysis. All three services, and later the Department of Defense itself, set out on a voyage of exploration.

An essential point to remember is that the ethos of those who manned the new, special organizations was that of science. They were scientifically trained and disciplined. Even though they early recognized the need to bring several or many established disciplines to bear on the solution of their problems, and in the course of events created a new discipline (if not a science) called operations research, they insisted on establishing and enjoying so far as might be the freedoms and practices that lay at the core of science. Questions were to arise later whether the discipline of operations research, or the broader art of systems analysis, really needed the full freedoms of classical scientific inquiry and communications. But the practitioners demanded them. Sometimes their clients understood and granted as much of them as they could within limits of constraints put on them by their position as government

personnel, responsible to Congress, accountable for results, accustomed to schedules and priorities and tangible products, and, above all, for conformity to law and to regulations.

In the military world, the relations between the sponsoring services and their specialized research arms were to be affected throughout by considerations of interservice rivalry. This was not abolished by the growth and strengthening of the role of the Secretary of Defense and the system of Program Planning and Budgeting that grew out of operations research itself. The tensions between the ethos of science and the interests and obligations of governmental clients persisted.

As important for the course of development, the structure and functioning, and the nature and quality of results of the work of the specialized organizations, were the varying positions of the clients. The Air Force's position as most favored in terms of budget and tasks during the 1950's did much for the scope, prestige, and significance of the work of the RAND Corporation. The Navy's needs did much to shape the work of the Operations Evaluation Group and its successors. The Army's position of responsibility for land warfare, and its relatively disfavored position in terms of budget allocations, did much to shape the work of the Operations Research Office. The differing styles of leadership of the three services had as much to do with the formulation of research programs and the posing of critical and challenging problems. What the clients wanted and supported, in short, made all the difference to the spirit and work of the specialized agencies.

How all these factors affected the structure and work of the Army's specialized research agencies, ORO and RAC, is a long and complicated story. Its essentials are given in the chapters to follow.

Chapter II

THE OPERATIONS RESEARCH OFFICE

As postwar developments in the cold war underlined the urgency of taking definite steps to ensure that science, technology, and engineering would be fully exploited in the Army's efforts to prepare for war in the future, and to cope with emerging and growing uncertainties, the Army moved to set up a new research capability.

The problem in essence was very simple—to find an organizational device to which certain types of scientists and analysts might be attracted and to which the Army General Staff could turn for assistance in dealing with problems in which science and technology would play an important but not wholly foreseeable part.

The solution—shaped largely by Dr. Vannevar Bush, wartime Director of the Office of Scientific Research and Development—was to set up a university-affiliated organization. Such an organization seemed to offer more promise of attracting highly trained and motivated professionals than a newly devised government agency without prestigious institutional sponsorship. The Johns Hopkins University (JHU) was conveniently located and enjoyed an excellent reputation in the world of science, technology, the professions, and scholarship. Moreover, JHU had already had several years of experience in structuring and operating a closely related activity, the Applied Physics Laboratory. This laboratory under government contract with the Navy, had, since 1942, been doing fundamental research and development and providing technical oversight of the design, production, and use of the proximity fuze and anti-air guided missiles. JHU's leadership and administration were hospitable to the new venture and well understood the special needs and situation of the new organization. As a result, the Operations Research Office was set up by contract between the Army and JHU in 1948.[1]

1. Theoretically, the Army could have chosen from four forms of organization: an in-house agency, an independent non-profit corporation, a university-affiliated organization, or a for-profit corporation, either independent or affiliated with an existing industrial corporation. There is no evidence that the Army explicitly considered the advantages and disadvantages of all of these alternatives at the time, although it had the advantage of the experience of the Air Force in setting up RAND. RAND at its inception in 1945 was administered by the Douglas Aircraft Corporation but in 1948 became an independent corporation. This change was made in large part because RAND's administration and the Air Force sensed difficulties because of RAND's location within one aircraft manufacturing company and because RAND drew advice and guidance from a group of other aircraft firms. These circumstances not only created problems of access to privileged information from competing firms but, more important, because getting support and guidance from the major airframe manufacturers was considered to weaken the effectiveness of RAND advice by robbing it of the appearance of independence and objectivity. Preservation of independence and objectivity was felt to be vital in attracting and retaining first-rate staff. The logic of General Eisenhower's memo, cited in the previous chapter, suggests that the Army did consider the merits of setting up a new organization in-house, or of charging existing staffs or laboratories with the newly conceived function.

The university affiliation, as well as the independent not-for-profit framework, offered important advantages. Salary structures were more generous, and hiring and firing procedures were more flexible than those of civil service at the time. It would be possible to bring in consultants to round out the roster of disciplines needed for special or short-term tasks for which permanent staff would not be needed—and some of these professional specialists might well come from the university's departments. A university-affiliated agency could offer a congenial professional atmosphere. Once created, such an agency would set up appropriate connections with military agencies while providing an independent base of operations and communications. From that base, research specialists could become acquainted not only with the nature of military strategy and operations, but also with other aspects of military life, problems, and personnel pertinent to the choice, definition, and solution of problems and policy and operations. The not-for-profit aspect—virtually automatic in the university structure of the time—preserved a pattern of goals and incentives compatible with the academic views on the requirements for disinterested and objective professional work.

To head the new organization, The Johns Hopkins University and the Army chose Dr. Ellis A. Johnson as Director. This choice was fateful for shaping ORO and the major lineaments of the relationship between the new organization and its major client. It was fateful as well for the growth of the discipline of operations research. Dr. Johnson was a respected scientist with fundamental discoveries in the field of magnetism to his credit. He had pioneered in the operations research that brought undersea mine warfare against Japan to an unprecedented level of effectiveness.

In the course of assuming the directorship of ORO, Dr. Johnson perceived that problems of operations research for ground warfare were not likely to be as simple and manageable as were some of those dealt with by operations research for the Navy and Air Force. Land warfare did not possess the relatively simple elements of geometry, time, and space that characterized much of naval warfare. Problems of ground warfare did not seem as amenable to solution by new technology and weapons as did problems of air warfare to the application of such technology as radar. Ground operations took place on much more complicated terrain. Many more critical factors could affect ground combat.

Nevertheless it was clear that the Army did face great problems that might be attacked with the methods of operations research, although much less was known about how this could be done than was the case with the sister services. Innovation would be called for. At the outset it was necessary to set up the right relations between scientists and military professionals for dealing with problems of land warfare. This had not been done for the U.S. Army in World War II.

It was also clear that interested and qualified scientists were scarce. Many of those available had already been snapped up to do operations research for the new organizations serving the Navy or the Air Force. Moreover, pioneering operations research for military services called for help from many disciplines. Applications of economics, political science, sociology, anthropology, psychology, and history to military and politico-military tasks during World War II had brought home the relevance of these disciplines for the full understanding of military problems. In the immediate aftermath, the efforts of the services to understand the experiences of the war, and to ready them for the unknowns of war in the future—where uncertainty had been vastly deepened by the undefined but terrifying perspectives of nuclear war—called afresh for help from these and other disciplines. The new organization would have to provide an institutional framework for interdisciplinary research and discover the best ways in which men of varying training and background could pool their several skills in attacking multifaceted problems.

ORO quickly assembled a competent staff of professionals from various disciplines and furnished them with administrative and technical help. Depending on the problem at hand, these staff members would apply a single major discipline to its solution, or work in a team to bring the resources of several disciplines to bear. A key element of success in these joint endeavors was recognition of what disciplines were really needed, and then the leadership to see that all were used to good effect, in harmony. These interdisciplinary efforts were vital for development of operations research beyond its World War II dimensions. Dr. Johnson's ability to recognize important new military problems, and to identify the scientific and technical skills needed to address them, was evident from the outset. His pioneering was critical in creating a new kind of structure, developing its style of work, and coping with unforeseen requirements that arose as the nature of warfare took on new dimensions. In meeting them, he established a worldwide reputation for himself and ORO in this new field.

Operations research as a discipline was new. As yet there were no recognized curricula in major institutions for training people to practice it. There was only a tiny pool of those qualified by World War II experience for the burgeoning tasks. Hence ORO could not staff itself entirely by recruiting those already prepared. It had to choose those with sound basic qualifications in a pertinent discipline and then train them on the job. This training had several dimensions. First, the scientist adept in his own discipline had to learn how to apply its data and insights in novel ways to novel problems. Then, staff had to explore and learn how to utilize new techniques. New areas of analytic methods and procedures were just being laid out, and these were to be of prime importance to the methods and capabilities of operations research. In particular, computer design, programming, and modes of use were in their infancy in 1948. New fields within established disciplines such as nuclear physics were developing rapidly, and with them new implications for many tasks of military operations and intelligence.

Operations research as a field of work was developing as new tasks were taken on, new problems solved, new methods found for tackling existing or emerging applications. New modes of training, based on fresh understanding of the methods and uses of operations research, developed as the discipline developed. Often the best preceptors were the project directors who taught their trade as they were discovering new skills and preferred practices. Those working with and under them not only learned, but often contributed. This ferment was actively fomented within ORO. As ORO grew, however, its key managers had to devote more of their time to administration and could spend less in performing research, expanding the skills and art of their disciplines, and training their co-workers.

Operations research called for training not only of its professional practitioners, but of its sponsors and supporters as well. Both civil servants and military professionals needed training and experience in understanding and applying the knowledge and skills called for in the new relationship. The operations analysts needed training in the ways of the Army, so they could identify problems, see them within a military context, and approach their solution in ways that would be feasible within that context. For research results to be fully effective, not only would they have to be theoretically sound, but also they would have to be understood by the organization applying them—and that meant training and experience for the Army as a client.

Much of ORO's accommodation to its military client was achieved in two ways—by the sharing of experience and guidance within ORO by staff members who had had previous Army or other military experience and by the fresh experience of ORO staff members deployed at Army installations abroad. Over 100 ORO staff, subcontractors and consultants,

worked in Japan and Korea during and after the Korean war, providing specialized on-the-spot studies and advice to military commanders. ORO analysts also established close working relationships with specialists in operations research from Great Britain and Canada also working there. ORO set up a field office at Army headquarters in Germany as well as one in the Far East.

Assignments to these offices and to smaller field parties enabled the staff to participate in Army operations and exercises that generated important data and vital opportunities to observe military systems and weapons in action. ORO specialists learned where to go for existing military data and how to generate facts and information needed for problem-solving that were not automatically provided by Army reporting systems. Army personnel learned what sorts of data were needed by the operations analysts and how best to make them available. Throughout the course of these field and staff relations of the specialists with Army personnel, opportunities arose for the latter to learn about the procedures and realistic capabilities and needs of the former.

Vital fresh experience in learning and serving the Army took place in the United States as well. ORO personnel were detailed on occasion to field headquarters to participate in tests and other studies. Meanwhile, the many interactions between ORO and the Army continued in Washington.

What problems should ORO address? Specific areas of work, issues in need of resolution, and other analytic tasks had not been defined in any clear fashion at the time ORO commenced its work. Questions of what to study, and how, posed new dimensions both for the operations researchers and for the client. The researchers were at the outset clear on the point that they should address first-rate problems that could not be clearly defined–and certainly not framed authoritatively by the Army. They believed that if a problem could be clearly defined, and a rational schedule set up for analysis and reporting of definite results, then it should be handled by existing staffs or other analytic services. Moreover, they believed that the search for problems, and their definition, should be a joint search in which the researchers should play a leading part. These uncertainties posed problems for financing and administration, as well as for continuing understanding and justification of the need for such research. At the outset the researchers strove to outline problem areas–fields within which ORO would establish expertise and a fund of useful data, both as a means of outlining important future problems and preparing to deal with them, and as a means for contributing effectively, quickly, and responsibly to the immediate solution of more specific problems when they arose. Research activities would have both long-range and short-range aspects. One feature of the new approach was to permit long-range work on enduring problems, with the clear expectation that results could neither be guaranteed nor predicted, nor need they come in the tour of service of the military men responsible for launching them.

ORO early launched work on studies proposed by the Army, including a large study of military assistance, a less extensive investigation of armored operations, and a small but significant study of the causes of error in artillery fire. In addition, ORO proposed to the Army that they should work on a wide range of standing studies of nuclear weapons, ground weapons and tactics, logistics, military costing, psychological and guerrilla warfare, and air defense. The Army agreed to fund continuing work in these areas at levels deemed appropriate by ORO.

The problem of identification and selection of subjects for study continued throughout ORO's life, involving relationships both between ORO and the Army, and within ORO itself.

Dr. Johnson and many of his key assistants, project leaders, and staff, continued to emphasize the needs for study of emerging problems, not yet clearly delimited, calling for fresh combinations of disciplines and research techniques, leading to fresh insights and specific findings and recommendations expressed in a form that the Army could reasonably be expected to understand and to apply. The Army, meanwhile, tended to emphasize short-run, concrete, clearly feasible studies that would produce visible short-run improvements and help to meet immediate needs.

The Army was not unmindful of the benefits it could draw from the long-range exploration of major new areas, such as potential roles for nuclear weapons in ground warfare. Throughout the 1950's many in the Army felt their service had been denied a major role in what seemed to be the definitive and critical aspect of modern warfare. The situation for Army morale was not eased much by the Eisenhower Administration's patent preference for seeking security through massive retaliation, in which the Air Force would play the major role. Many military and political analysts believed that if nuclear war ever broke out, it would be very short, and there would be no role at all for long-sustained ground warfare. ORO's studies of nuclear weapons, however, pointed to a valuable and feasible role for the Army in ground nuclear warfare. In view of the greater size of the Russian army, and its widely accepted capabilities for operations in Europe, nuclear weapons and the know-how to use them in land warfare seemed a logical way of achieving a balance in combat capabilities between West and East. ORO's studies of air defense and of other problems of coping with the effects of strategic nuclear attack had implications running well beyond defining an appropriate role for the Army.

Many in ORO, however, believed that it was ORO's first duty to respond to the Army's stated requirements for studies, be they long-range and conceptual, or short-range and concrete. For this group, and it came to include several of the most influential division chiefs, tight study definition, close Army monitoring, adherence to deadlines for performance and reports, were acceptable. Such studies could be pioneering–as for example studies of the "day of supply" concept in logistics planning–while they were precise in their needs for data and rigorous in their use of it. But over-emphasis on such studies ran the danger of turning ORO into an agency that was no more than an extension of Army staffs, doing work that the staffs could be easily trained to do, while diluting ORO's resources or diverting them from its exploration of new problems. There was widespread agreement within ORO that the organization should explore tasks such as determination in the "day of supply" in concrete terms (i.e., what supplies a unit needs to carry on for a day) under specified conditions of combat or other operations. ORO should carry out the design of a system to make the calculations and to try it out–but only as a demonstration. Once the concept had been adequately explored, the manner and modes of calculation demonstrated and purged of error, and Army personnel given the training materials and documentation so they could carry it on, then ORO should turn over the system to the Army and devote its resources to other tasks. However, ORO was subject to inertia and aware of the temptations of playing a sure thing–just as was its client. The near-certainty of success in detailed and concrete endeavors not running any real risk of failure to complete a task on time, within budgets, was hard to give up. Such sources of tension continued within ORO.

Visualization of problems not fully foreseeable, yet likely to affect ground warfare in major fashion in years or decades to come, was never easy, and ORO sought to improve it in several ways. First came the work of the Tripartite and Quadripartite conferences. These

emerged from the collaboration between ORO and British, Canadian, and later Australian specialists in operations research. Held annually, hosted in turn by the participants, these conferences brought together highly qualified specialists in operations research from each country. Each conference, lasting a few days or a week, concentrated on a specific major topic, such as problems of scientific advice and evaluation, or of war gaming. The interplay among the participating specialists was rarely limited to the specific topic. It goes without saying that the topics themselves were so broadly cast as to invite discussion of widely ranging issues. Thus there was ample opportunity for persons professionally concerned with new applications of science and technology to prefigure the situations in which these applications might be used.

Second came the series of "search conferences" sponsored by ORO, under the name of PISGAH. These conferences were specifically structured to bring together the best and most imaginative of ORO's specialists, with equally experienced and qualified military officers, and with operations researchers from other specialized research organizations and from universities. Their intention was not to deal better with clearly delineated problems but to improve the delineation of future problems. The participants sought to assess probable future problems as realistically as possible. From this standpoint the experience of military officers was especially valuable, both to temper the imaginations of the other specialists and to indicate lines of development calling for special examination. Both military and civilian experts sought to generate new and promising ideas about how best to attack those problems.

The inclusion of specialists from other operations research agencies, and of special consultants from the academic world, had several purposes. One was to ensure against the parochialism of outlook and ideas all too easily arising within the closed communication circuits of ORO and its military clients. Another was to provide an opportunity for the widest possible informed discussion among specialists who were eligible for access to classified information, who understood the methods and objectives of operations research, and who had gained experience in considering developmental aspects of science and technology from the standpoint of the missions, the weapons, the other resources, and the current and possible roles of the other services. One of ORO's constant concerns, especially in defining the potentialities and limits of new developments, was to keep communications vigorous on as wide a basis as possible. Since requirements for military security and respect for privileged information restricted participation, it was necessary to make special efforts to have as full as frank communications within the closed community as possible. The PISGAH conferences were structured and run insofar as might be to favor this purpose. In all these conferences the researchers sought to come as close as they could to the full and free communication of methods and findings characteristic of science.

Even with hindsight, it is difficult to point to any special and concrete result from these conferences. But it is certain that they permeated the process of problem definition in many subtle and effective ways. ORO people gained a better view of what the more imaginative minds in the Army—including some disciplined by long experience—had to offer in visualizing problems. And the military specialists gained a better view of what was possible within the ORO framework. Some who attended thought they were even more valuable than attendance at one of the War Colleges, partly because there was better balance between civilian and military participation. Some also said they had been helped to get a sharper and deeper insight into the nature of national needs transcending their particular operational concerns.

During its existence, ORO produced studies of nuclear strategy, war gaming, politico-military interactions, operations, logistics, weapons design, and weapons systems. In all, ORO completed 632 publications arising from 1,666 studies or phases of studies ranging over some 98 subjects and problems of concern to the Army.[2]

Within this gamut of studies were to be found examples of the highly concrete and particular along with those concerned with large problems full of implications for the future of ground warfare. ORO had produced the first studies on the role of nuclear weapons in ground warfare, paving the way for understanding the needs for tactical nuclear weapons and their probable role in battle. ORO specialists had explored problems of racial integration in the armed services, concluding that on grounds of cost effectiveness alone (without shirking attention to other aspects of the problem) it was better to have full racial integration in units, not by units. Stressing the element of cost, they gave new definition to the concept of cost-effectiveness in evaluating the worth of a weapons system. They pioneered in the application of computers to operations research problems. They pioneered in developing war gaming, not as an instrument to predict overall outcomes (a risky and not always reliable use), but more importantly as a means to gauge the worth of weapons systems, singly or in mixture, in specific conditions of ground warfare, involving small to large military units.

They produced numerous studies, in the field, under actual operating conditions, of the performance and reliability of weapons and supporting equipment. (One study simply counted the number of tanks that set out on a mission one morning, counted those that arrived at their destination, determined how many had failed enroute, and found out where and why. Such observations were vital to the determination of tank reliability, and hence to planning factors used by military commanders.) They explored in detail the fields of psychological warfare and guerrilla warfare, examining experience in World War II and in Korea. They did innovative work on technological forecasting, illuminating the probable pace and direction of weapons development and acquisition. An early study of the concept of an airmobile force contributed to the later Army work (abetted by RAC) in fashioning an air cavalry division. They explored in detail the problems of air defense of the United States against a strategic nuclear attack.

One result of ORO's studies was the creation of new agencies to deal with operations research. ORO's experience in studying psychological warfare led to a decision to continue specialized studies in this field through another research agency—the Special Operations Research Office (SORO)—sponsored by the Army under contract with the American University. Similarly, ORO's early explorations of military training contributed to the Army's decision to establish the Human Resources Research Office (HumRRO) under contract with the George Washington University. ORO's initiatives led to additions to Army staffs, too. Recognizing that operations research needs a strong link between producer and user, ORO recommended that the Army set up operations research units in arsenals and laboratories. Finally, ORO did much to stimulate the efforts of the Army to set up operations research units at high staff levels. These new units could conduct those forms of operations research that could be well done by an in-house agency (usually dealing with specific and concrete issues not highly controversial within the Army). They could also improve the usefulness and

2. Testimony of Frank A. Parker in *Hearings,* Subcommittee of the Committee on Government Operations, House of Representatives, 87th Congress, 2d Session, August 15, 1962, Part 4, p. 1435.

relevance of operations research done by ORO or by other specialized agencies outside the Army. For ORO's kind of work to be fully effective, the client had to be well-informed about its nature and worth and willing to accept and adapt it to Army uses.

Despite this record of solid accomplishment, ORO was not without critics, nor was the record without serious failures. Criticism appeared early. ORO's activities often touched off expressions of dissatisfaction by some Army agencies and officials, especially when ORO dealt with important and sensitive issues. Sometimes there were objections to the nature and substance of ORO's recommendations. Sometimes there were complaints about the manner in which ORO reported its findings. In particular, there was discontent over the tendency of some ORO leaders to report major findings first to top officials and later to the lower-level staffs. Such discontent was not dispelled by the beliefs and acts of others in ORO who thought it preferable to work out conclusions and major findings as closely as possible with lower-level personnel specifically concerned with the consequences of the recommendations, or who had participated in the work and felt as contributors they had a right to be informed of results as soon as any others. If ORO reports dealt with issues already controversial within the Army, one side or another was almost certain to question the findings, and counterattacks were launched not only against ORO's work but its concept as an organization as well.

Difficulties were sometimes compounded by the uncompromising and forthright tone of some of ORO's reporting. Dr. Johnson insisted that ORO recommendations should be in clear language, easily understandable in Army terms, adjusted to Army ways, and suitable for application by the Army without change. If the Army did not accept them, and the issue appeared to be of public importance, Dr. Johnson believed the canons of scientific procedures justified efforts to report his findings and recommendations elsewhere. Such occasions were rare but trying when ORO insisted on reporting its findings not only to the Army but also to the Congress, to the scientific community, or to the general public. Claims that such public reporting was needed to build ORO's prestige, guard against charges of bias, and to demonstrate adherence to academic standards of scientific research and disclosure of method and results, often fell on deaf ears in the Army if the implications of findings or advice were thought embarrassing to the Army or unjustifiably threatening to established doctrine and operations. Rarely if ever was the Army insensitive to the implications of ORO's announced findings for interservice rivalry.

In 1953, the Army set up an *ad hoc* group to examine the merits of the complaints and to recommend changes if necessary. This group concluded that an organization like ORO, designed to improve Army management, procedures, systems and weapons, would have to arrive from time to time at evaluations or recommendations stating or implying dissatisfaction with current ways. The group regarded this as a necessary price for good work on important subjects—a price worth paying even it if meant some discomfiture or embarrassment.

Despite this vindication, complaints continued. Some in the Army felt that ORO was not performing as well as it might either in providing short-term help on immediately pressing issues or on longer-range problems. Such complaints were not stilled, nor was the tone of the relationship between ORO and the Army improved by Dr. Johnson's continued insistence on reporting findings in his own uncompromising way. At stake, in his judgment, were ORO's proper independence, and its reputation for candor and objectivity in its work. Dr. Johnson was always ready to act on his belief that a serious military issue—of policy, doctrine, organization, weapons development, or operations—was not one between the Army and ORO

alone. If the Army did not accept and act properly on ORO's findings, more was necessary. Higher authority in the Executive Branch, Congress, and its chief committees needed to be informed as well, so a genuinely national resolution could be attained. Dr. Johnson found it difficult to reconcile his role as an informed scientist with his role as director of an organization funded by the Army and bearing special responsibilities to it. So did many in the Army, some at high levels.

This reconciliation of independence, candor and full expression of opposition with responsibility to the client was not helped because many in the Army, while insisting on high-quality work and good studies and advice, did not see how ORO's demonstrated independence and objectivity served the Army—as well it could in debates where ORO and the Army stood together against other critics, or sought support in the competition for roles, missions, and appropriations. These Army officers preferred a confidential or privileged relationship. They acquiesced in publication, but in forms approved by the Army as chief client and source of funds, coming as an additional element after the advice had been received and acted on. They wanted to preserve the Army's freedom of choice among options—whether to act on all, few, or none of ORO's findings and recommendations without external pressures. They expected ORO to act as a technical resource and an adviser and not to go beyond those roles.

Chapter III

TRANSITION

Late in the 1950's, continued stresses in the relationship of ORO within the Army, complicated by ORO's status as a division of a university, led to efforts by the Army, The Johns Hopkins University (JHU), and ORO to reexamine the basis of the relationship. Not only had ORO grown, along with the discipline and capabilities of operations research, but the Army had developed a much broader awareness of the dimensions and potentialities of operations research and how it could help serve Army needs. Academic administrators at JHU and elsewhere had profited from a decade's experience with the problems of relating science and technology to the needs of the nation in the fields of national security. Much more was known about how a university could support research and analysis related to many aspects of security needs, through applications of hard science and technology to making policy studies of public issues. Much more was known about how such efforts could be reconciled with accepted academic standards of independence, objectivity, and freedom of research. More types of institutions had grown up to meet these needs in a variety of ways.

In 1959, the Assistant Secretary of the Army for Research and Development commenced a review of the Army's overall need for scientific advice. Part of the review dealt with the pros and cons of setting up a single organization to centralize all research and development within the Army. The review noted that the Army's needs for operations research and other scientific support varied both as to time horizon and as to depth and detail of the scientific and technological questions addressed. Some issues called for long-term study and choice of alternatives from a wide though uncertain range of possibilities and probable applications. Such studies included forecasting developments in future weaponry and logistics systems that would capitalize on emerging basic knowledge and its technological and engineering applications. Other questions—for example, how best to make immediate improvements in tactical use of weapons already available—were short-term in nature, would not be affected much by prospective long-term developments, and called for intensive operations analysis best done in close conjunction with the Army staff. The gamut of tasks and time horizons implied that any single organization designed to respond to them would have to be multifaceted, or that several sorts of organizations would be needed.

Both from the standpoint of the university connection and of Army sponsorship, there was another important dimension to be considered—that of the public policy implications of studies and findings. While ORO had never sought a major role in affecting policy and tended to concentrate on answering questions of how best to do things already sanctioned by policy, nevertheless ORO dealt with problems from time to time that did have major implications for issues of public concern. One was the issue of racial integration in the Army—a problem

addressed by ORO in the context of its studies of operations and morale during the Korean War. Other issues, such as the feasibility and desirability of creating tactical nuclear weapons systems and thus expanding the options open to the United States in case of crisis, also had strong significance for public policy.

Such studies showed that serious work on important Army problems was almost certain to have a policy dimension. And the Army, characteristically, continued to reserve its own counsel about how best to deal with policy questions from identification through response to implementing action. While remaining disciplined in its responses to policy direction from higher levels of government and from the Congress, the Army had never sought to shape these preferences or its solutions by commissioning studies of policy implications to be done outside its ranks. In considering its needs for studies and advice in connection with the optimum design of a research agency, it followed this tradition in the formation and application of policy.

ORO's public role in controversies over public policy raised special questions for JHU. A university could readily accept special arrangements for sponsoring work in basic science, technology, or engineering that did not have a salient policy dimension. But if the specialized agency were to play a prominent role in work bearing on controversial public issues, with strong ties to government, the university might find its general position on academic freedom challenged or appear to favor one side or another.

In 1960, as the examination within the Army of the probable future of ORO continued, the situation continued with some turbulence, but the stresses seemed tolerable. The Army funded a reasonably comprehensive work program for ORO with some leeway for ORO to do some of the large-scope conceptual studies it thought necessary; the University seemed willing to live with the public problems called forth by occasional public dispute between the Army and some ORO personnel. Although ORO's budget had been closely scanned with an eye to limitations and cuts, funds were provided to maintain operations on a substantial scale, and most of ORO continued to perform its studies and analyses.

By late in 1960 the personal relations between Dr. Johnson and the Army were strained to the breaking point. Army officials responsible for research and development approached Johns Hopkins to see what should or could be done. Johns Hopkins recognized there were serious difficulties in the current situation and agreed that one way to cope with them would be to replace ORO's Director with another more in sympathy with Army views and ways but of comparable scientific stature and competence in operations research. The University was flexible on the question of whether ORO should continue as a part of it or be established elsewhere. But because of the University's responsibilities and status in the academic world, it could not accept arrangements that would put it in the position of appearing to carry out the Army's orders. The University could take care of the problem, but it would have to be free to do it in its own way without pressure from any external source. University officials recognized that it was no longer possible for Dr. Johnson, the University, and the Army to maintain the old relationship.

Another solution was to dissolve the contract between the Army and Johns Hopkins and to reestablish ORO's staff and resources in some new form but with someone else as Director. This in effect was what was done. The University and the Army decided to close out the Army/Johns Hopkins contract. The President of Johns Hopkins, the Secretary of Defense, the Director of Defense Research and Engineering, the Secretary of the Army, and the Army

Chief of Staff all concurred in this decision. The Army then proceeded to bring into being a new corporation as the best way of preserving the needed combination of competence, objectivity, independence from proprietary biases, flexibility, and responsiveness. This new organization would not be expected to provide the full range of scientific, technological, or other research services the Army decided it needed.

The first step in creating the new organization and arranging for the transition from ORO was to assemble a Board of Trustees. The Army asked John T. Connor, the President of Merck & Company, to take the lead in identifying appropriate members. He, along with John Forrest Floberg, General Counsel of the Firestone Tire and Rubber Company, and J. H. Pickering, of Wilmer, Cutler and Pickering, identified appropriate candidates, determined their acceptability to the Army, and in conjunction with the Army approached them and persuaded them to become Trustees. An early choice was Dr. Hector R. Skifter, President, Airborne Instruments Laboratory, who became the first Chairman of RAC's Board. The other initial members, in addition to Mr. Connor, were Dr. Hendrik W. Bode, Vice President of Bell Telephone Laboratories; General James McCormack, Jr., Vice President, Massachusetts Institute of Technology; and General Omar T. Bradley, Chairman of the Board of the Bulova Watch Company. At its first meeting, in June 1961, the Board elected Mr. Pickering Secretary.

This Board faced several immediate problems: to select a president to succeed ORO's Director; to arrange for orderly negotiation of the work program for the ensuing year; to arrange for financing to carry the organization through the transition from its predecessor; to sustain staff morale; and to minimize any losses of trained and competent personnel. For personnel were ORO's chief asset, just as they were to be RAC's.

On June 7, 1961, Dr. Skifter was designated Chairman of the Board and Acting President of RAC. At its second meeting, a month later, it elected Frank A. Parker as President of the new corporation and made him a member of the Board. It also announced that General McCormack had resigned. Dr. Ellis Johnson, ORO's Director, resigned in July 1961. Dr. Lynn Rumbaugh became Acting Director and negotiated the next year's program of work with the Army during July and August. The new contract between the Army and RAC took effect on September 1, when the research program planned and conducted by ORO was transferred to RAC, along with the personnel, physical assets, leases, and contracts for computer services and other supplies and services.

All ORO personnel were transferred to RAC without change in their salaries or other conditions of employment. There were some resignations, but the new organization's essential capability to continue work already under way or planned was unimpaired. There was some temporary loss of momentum, owing to uncertainties about the future and the need to explain to clients the significance of the few changes in the new organization.

RAC inherited a staff of 132 operations analysts and 14 research assistants coming from various disciplines, and 284 administrative and technical support personnel. More than half of the technical staff (56%) were physicists, mathematicians, and engineers. The remainder (44%) had been trained in the social sciences and the life sciences. Among the professionals, 30 had doctorates, 50 master's degrees, and 47 had bachelor's degrees. Over three-quarters of the analysts had had three years or more of service with ORO on the date of the transfer.

In addition to regular staff, ORO had built up a roster of 149 consultants, all with security clearances, oriented to the nature of ORO's work and to related

Army problems, and ready to provide specialized talent and insight without undue procedural delays.

The staff and consultants brought more than scientific and technical competence. They brought the immediate benefit of experience in working with the Army.

The initial Army contract with RAC was for $4,600,000–that is, at about the same level as provided for ORO's last work year. But the contract also contemplated additions to funds and work if mutually agreeable to the Army and to RAC. Both parties envisaged growth as confidence increased and as changes in the Army's role in national security warranted.

The new contract embodied two new features of long-run importance. One was a provision for funding "Institutional Research"–work on subjects of interest to the Army but initiated by RAC. The other was provision of a "fee"–a certain percentage of the estimated value of the contract that could be used by RAC at its discretion to further its corporate purposes.

Institutional Research (IR) funds were provided so RAC could explore new areas, new ways of solving problems, and new conceptions of solutions to recognized or foreseeable Army concerns. It was understood that these IR programs and projects would be carried out without interference with the authorized annual work program. The level of funding was set at 10% of the estimated value of the contract.

Funds generated by the fee provision were to be used (1) to provide a degree of financial stability through a modest buildup of working capital and the creation of an equity position, (2) to acquire certain capital assets, and (3) to support research that RAC considered worth doing in the public interest irrespective of any immediate apparent interest or value to the Army.[1] Establishment of financial stability took immediate priority over funding of research, although IR projects were set up from the outset. It was recognized that RAC needed to build up the capability to carry on operations at a stable rate, even if there were fluctuations in income owing, for example, to failure to complete contract negotiations in timely fashion, or occasioned by special charges or expenses not reimbursable under RAC's contract. In RAC's first year the Army advanced $1 million as operating funds; this was repaid over the next several years in installments as RAC accumulated sufficient equity to provide its own working capital. RAC thus fulfilled the Army's expectation that accumulated fee would obviate the need for advances in future.

Fee was used to accomplish another major improvement important for RAC's efficiency. RAC commenced operations in the five separate facilities that housed ORO. It was clear that operations would be improved if all RAC's staff and functions could be housed in a single building, designed for RAC's special requirements. Planning commenced immediately, looking to the creation of quarters that RAC could lease. The existence of the fee provisions in RAC's contract with the Army made RAC a financially attractive tenant. Without the prospects of fiscal stability promised by the fee arrangement, it was doubtful if a landlord would have been willing to design a specialized facility suitable for long-term occupancy by a

1. Testimony of Frank A. Parker, *Hearings*, Systems Development and Management, Part 4, before a Subcommittee of the Committee on Government Operations, HR, 87th Congress, 2nd Session, August 14, 1962, p. 1434.

novel sort of tenant. In the event, arrangements were made and RAC moved into its consolidated quarters late in 1963.

At the outset the Army told RAC that it should employ fee in the best interests of the operation as determined by its Board of Trustees. The Army expected that the amount of cash accrued by virtue of fee should be adequate to meet reasonable requirements of operating capital and net worth, as reflecting stability and good credit rating.[2]

RAC's target was to accumulate enough funds from fee to enable it to carry on operations for six months if income failed, to explore new research perspectives, and if need be, to liquidate the company in an orderly manner with adequate provision for the transition of its personnel to other employment. (The target of six months of viability if support were cut off was never met, but the other goals were substantially achieved.)

ORO had experimented with a variety of principles as a basis for a structure to conduct its operations–whether to organize on the basis of disciplines, or projects, or broad classes of work. No one principle proved clearly preferable. At the time of the turnover to RAC, ORO was managed by a director, who had in his office several associates and assistants performing line functions, and staff including a Technical Council, a Management Committee, several *ad hoc* technical committees, and a staff assistant to the director. His office also embodied the Office of the Senior Military Advisor, who headed up military liaison for technical contacts and communication of guidance and advice. Operations came under seven technical divisions (Information and Control Systems, Operations, Weapons Systems Evaluation, Military Economics and Costing, Management Systems, Strategic Research, and Basic Research). These were assisted by a Computing Laboratory and an Electronics Laboratory, and supported by units for adminsitrative services, editorial services, personnel, and library. There were several field activities.

At the time of the turnover, the new RAC Board of Trustees asked the President to take a look at the problems of corporate structure. At the outset, a management study commissioned by the Trustees in the summer of 1961 suggested that changes might have to be made to improve management decisionmaking, communications, control, flexibility, and responsiveness to the needs for change as new tasks appeared. But several months later, after the President's review of the situation, he and the Trustees decided to make no major change. The basic structure continued for some time after the turnover. Later on it was adjusted from time to time to take account of changes in key officers and staff and changes in emphasis in the kinds of work RAC was doing or expected to do. Major line operating structure was based chiefly on program and project. Disciplines were allocated to organizational units in accordance with their needs to perform their work. As in its later years RAC came to serve a more diversified clientele and hence broadened its kinds of work, organization came to reflect client orientation to some degree as well. Changes in top management were made as new emphases, such as the creation of strong capabilities in science and technology, arose in response to the Army's stated needs and to RAC's needs for diversification.

2. Letter from Arthur G. Trudeau, LGEN, USA, Chief of Research and Development, to Dr. H. R. Skifter, Chairman, Board of Trustees, RAC, dated August 19, 1961. The letter also stated that in determination of the amount of fee in subsequent years the amount of cash accrued by virtue of the fee from preceding years would be a consideration in the negotiations.

TRANSITION

By late 1961 the transition from ORO to RAC was virtually complete. The Army had decided on the new form of organization—an independent not-for-profit entity governed by its own Board of Trustees. The new organization was incorporated; its Board was functioning under its articles and by-laws; it had selected a President; a work program was under way; and a contract between the Army and RAC had been drawn up. Funding was adequate, and there were flexible provisions to increase it if necessary. Provisions for independent research and for an appropriate fee were made in the interest of fiscal stability, staff independence and morale, exploration of new forms of service and exploitation of possibilities for sound growth.

Chapter IV

AN OVERVIEW OF RAC's ACTIVITIES

The Research Analysis Corporation (RAC) commenced operations on September 1, 1961.[1] On that day RAC in effect provided a new legal form under which the staff of the Operations Research Office (ORO) of The Johns Hopkins University could continue to make their services available to the United States Army. RAC inherited not only ORO's tangible assets but also the established working relationships with professionals at various levels of the Department of the Army. Through its thirteen years of existence, ORO had built up a varied and largely novel program of work. That program continued virtually without interruption under RACC. At the time of transition, virtually all of ORO's work was done for the Army and for General Staff agencies. During RAC's life less of its work would be done for the Army, although the great bulk of it, prior to the late 1960's, would be done for the Army and for other Defense agencies. As various threats to the viability of the special relationships with the Army became apparent by the middle of the decade, RAC sought to diversify its capabilities and its clients. As a result, RAC's activities fell into two major classifications: that done for the Army or for other Defense clients, including the Arms Control and Disarmament Agency; and that done for non-Defense clients. Three chapters deal with military research and studies. The following chapter describes non-Defense research.

Whether for military or for other clients, RAC's activities took several forms. These included studies, analyses, and model building; publications; collaboration; and the building and installation of systems. Trained people were important, too, as former RAC personnel active in government, universities, industry, and elsewhere, contributed their skills and insights to the solution of all sorts of analytic problems.

Publications took various forms: formal reports, technical papers, informal reports to clients, and individual papers. A sizeable portion of them were classified as confidential or secret and thus immediately available only to those with appropriate clearances. Some were privileged reports to clients, involving sensitive information, and therefore distributed as the client directed, usually in abridged form. But most of RAC's publications were available to the interested professional public in one form or another.

Many of the most important studies were possible only because of the opportunity offered by RAC's nature and framework for intensive collaboration with the client. Such collaboration was sometimes short-run, sometimes long-run, and at times most intensive when the client had an urgent need for the development of new ways of dealing with pressing

1. Articles of Incorporation were filed with the District of Columbia on June 6, 1961. The first meeting of RAC's Board of Trustees took place the next day.

problems, and for the conception and elaboration of new systems to apply fresh approaches to on-going operations. Sometimes collaboration called for work with other suppliers of studies, tests, and advice who were working on the same projects.

Building new systems–usually computer-assisted–bulked large in RAC's work throughout its life. Such systems were usually designed to perform large, detailed, complex, and usually recurring tasks for the client. Typical tasks included the design of optimum military force structures (i.e., groupings of military units to execute given missions in the most cost-effective manner), involving a need to handle complicated arrays of data with manifold interrelationships bearing on cost, effectiveness, deployability, and flexibility. Other tasks lay in the field of manpower, where the Army asked RAC to help answer questions arising from the draft–its size, its needs, and its capabilities in providing appropriate quantities of the right kinds of manpower. Many such queries were in the form of so-called "what if?" questions–for example, what would happen to the quality of inductees generally if draft calls were increased in size, or special inducements were offered in trying to draft or recruit manpower with special qualifications? Other manpower work was designed to help personnel management, for example, by estimating the effects of alternative promotion policies on the composition of the Army's skills, on morale, and on prospects for retention of desired personnel in the Army. At the outset, the Army might call for "quick fixes"; but these efforts often led to the design and installation of comprehensive systems that could handle such questions in day-to-day fashion.

On completion and testing, such systems were usually turned over to the Army for continuing operation. In some cases, the Army's needs called for RAC to provide interim operation and make final adjustments to the system being put into the Army's hands. Often as a result of the previous collaboration and the subsequent operation, new tasks for research became visible, new refinements in system design and output became feasible, and thus new and fruitful areas for future collaboration were laid out.

The phases of design, building, and initial operations frequently provided important training both for the Army and for RAC personnel. All these aspects of collaboration shaped major parts of RAC's programs of work. They helped build at RAC a capability in being, ready for further growth and development, to which the Army could turn for immediate help, confident that RAC was already aware of the major dimensions of the Army's needs and problems. As the capability for dealing with on-going problems developed, so did RAC's potentiality to help the Army deal with emerging problems. Whether that potential would be realized depended on the Army.

It is not possible in short compass to describe all the many facets of RAC's work in defense and defense-related activities. It is possible, however, to indicate their broad scope and nature by reviewing some of RAC's major research projects and service activities. This review is neither exhaustive nor representative. It is intended to be illustrative and to suggest how RAC's concentration of effort in fields of work and research emphases changed during RAC's existence.

RAC's major client throughout its life was the Army which funded four-fifths of RAC's activities. RAC served other clients also: the White House and the National Security Council; the Department of Defense; nine other govenrmental agencies with national security interests; some forty other governmental agencies of all levels, and

private foundations whose primary interests lie outside the field of national security. This variety of clients, and their varying interests and requirements for research support, broadened RAC's resources of data and knowledge, analytic capability and interpretative skills. This broadening permitted reinforcement of RAC's capabilities to serve its major client. Work done on foreign aid and development enriched RAC's capabilities to deal with the Army's problems arising from its role in the developmental and security processes in the "Third World"—that great segment of the world's area and populations, as yet undeveloped in many respects, where democratic and communist systems have been struggling to shape society, economy, and the political order. Work done for urban clients on problems of juvenile delinquency and dissidence enriched work done for the Army on tensions and conflicts between civilian and military value systems, while pointing to ways in which dissidence and dissent could best be managed in both kinds of institutions.

Work on long-range problems helped develop RAC's capability to assist its clients with quick responses on items of urgency. Work on very large systems, such as worldwide logistical and transportation systems, built capabilities to deal with particular problems with an eye to how alternative short-run solutions would fit into larger, longer-range systems and affect broader issues. Work done on a conceptual basis, such as RAC's studies of air mobility for army forces, led to specific evaluations later on, after such systems were built, deployed, and put to work, thus creating bodies of hard data suitable for operations analysis. All these gains were possible chiefly because of the continuity of experienced personnel.

Throughout its existence RAC conceived its major mission to be service to the public interest, chiefly by providing to the Army services, studies, research, and advice based on operations research and systems analysis. RAC concentrated on force structure analysis and planning, logistics, military manpower, resource analysis and cost studies, military systems and military gaming and simulations. These studies encompassed problems of operations, planning, intelligence, and research and development. In addition, RAC made studies of the nature and purposes of insurgency, counterinsurgency, and operations undertaken to stabilize societies under threat. RAC examined the politico-military aspects of these regions where US land forces were already operating or providing advice and training, or might be called on to do so. These studies considered both current and projected environments. RAC set up field offices to study problems on the scene and to provide analytic support in direct conjunction with local tests and local operations.

RAC's work in science and technology was geared chiefly to the assessment of weapons requirements and of the comparative effectiveness of competing weapons systems. RAC engineers and technologists also sought to improve the management of military research and development, seeking more efficient ways of allocating uncommitted resources to research and development projects. RAC analysts dealt with military communications, proposing new ways to allocate radio frequencies to military users and to improve the dependability of communication nets.

Work in advanced research and basic methodology, including developments in linear and nonlinear programming, bore on better ways of assessing the costs and effectiveness

of weapons systems and mixes of weapon systems. Such methods proved very useful in coping with questions of optimum weapons deployment and the preferred design of missile-launching vehicles.

Later in RAC's work came economic, political and social science studies of problems arising outside formal military institutions. Most prominent were studies of public safety problems, the administration of justice and control of crime and delinquency, and economic and social development at home and abroad. These grew logically out of RAC's work for defense clients.

CHAPTER V

RAC'S ACTIVITIES: FORCE PLANNING; LOGISTICS; MANPOWER AND PERSONNEL

Prominent in RAC's work on military subjects were the fields of force planning, logistics, and manpower and personnel. All three of them, as well as those areas treated in the chapters that follow, were traditional areas of military concern. But during the decade of the 1960's, problems of force planning were given special emphasis by the Army. Problems of logistics came to include new emphasis on supplying forces and operations in Asia as well as in Europe. Problems of manpower and personnel also took on new dimensions, under the impact of Vietnam, the draft, and the shift to an all-volunteer army.

FORCE PLANNING

A continuing problem facing the Army in an era of changing national security requirements, weapons technologies, and military systems is the task of designing forces—that is, specifying their composition, strength, weapons and support—to assure the security of the United States, in conjunction with other national forces and with those of allies. Planners must be capable of rapid and realistic estimation of the size, composition, costs, and capabilities of existing and planned forces. They seek maximum capabilities and effectiveness within the overriding limits of budgets and available manpower and weaponry, both in the present and in the future. In a world of increasing complexities, constraints, and competition for resources, in which the planner is always in a race against deadlines, it is patently impossible by manual methods to consider more than a few major alternatives or to deal with each in detail. But with help from computers, and improved understanding of methods and models of programs and systems analysis, wider ranges of alternatives can be examined, and Army planners can come closer to rational force choices.

RAC dealt with component parts of this problem in its early years, enhancing capabilities in wargaming, similation, modeling, and computer programming that would make possible comprehensive systems to deal with all parts of this force planning task. In mid-1967 work commenced on Project FOREWON: a computer-assisted, largely automated planning system for determining future US requirements for Army forces and for predicting the capabilities of those forces under varying future conditions. This system was designed not to replace, but to give powerful assistance to force structure planners, enabling them to apply trained judgment at the right points in the planning process, and to save time.

While the future is impossible to forecast precisely, it is possible to postulate certain future situations that are more likely than others and more relevant to problems of force requirements and force design. Thus the planning system would have to accept several alternative concepts of the future that would set functional requirements for military forces.

It would also have to recognize limits on resources. It would have to include measures of effectiveness of forces operating in a variety of combat conditions, in one or more overseas theaters, at varying levels of force involvement. Finally, it would have to have automated means for specifying the size, composition, weapons, support systems, and other necessary elements of forces that would produce a first approximation of a force designed to meet the specified requirements and that could offer quick answers to a great variety of special forms of the basic problem.

Accepting constraints on the size and cost of a force, the FOREWON system was designed to produce, within the limits imposed, specified force designs (objective forces, in the military planner's terms) capable of achieving satisfactory results under any one of several major conditions chosen by the force designer. Thus a FOREWON-designed force could be tested against the requirements of operations in a single overseas theater, with or without mobilization at home; or in two or more overseas theaters simultaneously. FOREWON permits designation of overseas theaters as prime theaters or holding theaters, allowing the force designer to assign minimum forces to hold in the less important areas, calculating the remaining force available for prime theater action, and predicting the capability of that residual force. FOREWON does this by incorporating a computerized combat simulator, ATLAS (A Tactical Logistic and Air Simulation), developed from the earlier RAC-designed Quick Game (a manual method of estimating the results of theater combat).

By use of linear programming, a Preliminary Force Designer determines how best to provide forces to the prime theaters, and automatically provides the best possible troop arrival schedule in those prime theaters, along with an explicit description of the system required to transport the force. FOREWON then determines the support requirements for the combat forces, and sums up all the forces required for all theaters, producing the minimum force predicted to be capable of success in any one of the operations included in the multi-theater group of such operations under study. This is the "objective force"—portrayed in numbers of units by type and by active or reserve category. Finally, the cost of this objective force is determined by a computerized Force Cost Assessor. This Assessor can calculate the cost of a specified Army force to be created at a given future time from a given existing force. Costs so determined include investment costs of people and equipment and costs of maintaining the force for a specified number of years.

FOREWON was designed to aid the Army in preparation of major documents in the Army planning system—the Army Strategic Objectives Plan (which presents alternative objective forces for consideration by top Army officials as potential Army inputs to the Joint Strategic Objectives Plan) and the Army Force Development Plan. This latter plan displays in detail the force units, manpower, and dollars in the Army objective forces that has been approved by the Department of Defense.

In summary, FOREWON permits, with the same staff resources and in the same time, preparation and submission of a larger number of alternative objective forces for consideration and approval. Each such alternative can be tested for performance in a group of missions, rather than a single mission, i.e., prescribed Army action in a given combination of theater operations. Once the Secretary of Defense approves a force, FOREWON can help the Army to determine the resources required for it and to assess its capabilities.

The FOREWON system was designed, built, and made available for Army operation—with full documentation and advice on operation—by the middle of 1970. It was RAC's largest single project, lasting for three years, and involving 50 man-years of technical services

from RAC professionals. It provided the Army with a unique new capability to design and specify overall forces and to assess their capabilities. Moreover, its components can be used separately to estimate costs and to work out details of deployment, rounding out combat forces with support elements.

The kind of institutional capability, flexibility, and responsiveness displayed in the FOREWON task qualified RAC to help the Army deal with another major question of force design—that of a preferred Conceptual Design for the Army in the Field (CONAF) to be operational from 1975-85. In February of 1971 the Army asked RAC to help assess the costs and combat capabilities of alternative arrays of forces specified by the Army to be the core of its future Army in the Field. RAC reprogrammed personnel and resources, adjusting its responsibilities for work to be done for the Army, so it could accept this task. RAC adapted available means of estimating the costs and effectiveness of the alternative forces, relying not only on its technical knowledge, but also on its large holdings of data about the costs and capabilities of major forces operating in several environments, in combat of low, middle, or high intensity.

The job required RAC to design new models and to apply the resultant computer-assisted modeling system to the evaluation of the specified alternative forces and concepts. As a basis of evaluation, RAC devised qualitative and quantitative measures of the degree to which each alternative force could perform the functions of land combat in a specified environment, operating at a specified level of intensity, against specified enemy forces and with specified missions. These measures of effectiveness included measurements of the effects of varying mixtures of materiel, including materiel expected to be available during the period when the conceptual army would be operational. The models also considered the effectiveness of close air support. The development of methodology emerged as a significant RAC objective in itself over and above the estimate of relative effectiveness of alternative forces. Such methods would have to ensure that each alternative force would be measured in a manner consistent for all forces and equally valid for all variations of mission. Because of the size and complexity of the forces and their interactions, it was necessary to expand existing methodologies to accept the full array of alternative forces and treat them in a consistent fashion, taking into account not only combat interactions but also the effects of materiel, logistics, command, control and communications, and intelligence.

The CONAF exercise was still going on when RAC became part of the General Research Corporation.

LOGISTICS

Some accounts of wars are written as if armies and battles were the whole story and as if tactics and strategy were all that affected the outcomes besides the strength of forces. But any army of any age is dependent upon its system of supply of everything needed in war or peace that is expended or that can be worn out or damaged. Men too must be moved and replaced. In peace the development of suitable and adequate logistic systems for all supply and transport and storage and management goes hand in hand with the planning of future forces.

The logistic operations of the Army are of enormous complexity. In recent decades, with the advent of the computer and electronic methods of data storage and retrieval, they have been brought under highly developed analytic management. The technical capabilities for collecting and organizing data have been vastly improved, to the point where qualitative aspects—the accuracy and relevance of data—pose worse problems than the tasks of handling huge quantities of information. But improvements have been impressive, leading to great gains

in the relevance and usefulness of analytic conclusions and insights as guidance to command. The very size of logistical management problems has stimulated major advances in methodology and technique. The present degree of mastery over them has already necessitated a great growth in capability in the mathematics of linear and nonlinear programming, mathematical modeling, war gaming and combat simulation, and in systems for data recording, collection, organization, storage, and retrieval.

RAC's objective was nothing less than to create the special capabilities for the collection and manipulation of data and the simulation of alternative systems in terms realistic enough to permit the analyst, the system builder, the logistician and the policymaker to see clearly the implications for cost, efficiency, and ultimately for combat effectiveness, of alternative policies and procedures for dealing with logistics.

In concrete terms, the problems of logistics arise from deciding how and when to repair materiel, how to devise supply networks, and how to regulate stockage, how to calculate need for the hundreds of thousands of items that enter into the Army's lists of supplies, and how to maintain, transport, store, and issue them so they will be in the right place at the right time. Logistics covers medical support and transportation for personnel, as well. RAC was active in all of these fields. In the course of its activities it built up comprehensive data banks found nowhere else.

Logistics policy and operations must distinguish between major and secondary items of equipment, between high-dollar-value and low-dollar-value items, between items in frequent and infrequent demand and between items of greater or less criticality to various military functions under varying conditions of combat or peace. The possibilities, gains and risks, costs and efficiencies associated with alternative policy choices and operational procedures, are in constant need of identification and study. RAC's simulations and analyses were brought to bear on all these matters. RAC not only dealt with data coming through Army reporting systems, RAC helped analyze and redesign those systems. And RAC itself engaged in extensive data collection and spot analyses in the field.

RAC's work in logistics operations led to the creation of a system of models known as MARS (Models of ARmy Supply). These deal with the classic problems of procurement, stockage, and issue of myriads of supply items. Prominent among the models are the Prescribed Load Optimization Model, the Supply Point Simulation Model, and the Multiechelon Supply Model. These can be used singly or in combination to deal with problems of choice of items and quantities of items to be stocked at each military level or echelon, so as to realize the best satisfaction of critical supply needs, minimum fluctuation in the stockage list, and economy of operation. They are in daily use in the Army today.

Some of RAC's work in logistics stressed analysis of lifecycle management, that is, fashioning and applying policies governing decisions on maintenance, rebuilding or replacement of equipment and materiel. In periods and places free of major military combat operations, such decisions depend chiefly on cost—in particular on optimizing the balance between cost of new acquisition and cost of maintenance and rebuild over the effective life of a piece of equipment. Relating these costs to time and to vehicle usage will determine when overhaul is cost-effective and when vehicles should be scrapped and replaced. Even in active military theaters, cost considerations are salient. RAC examined these matters with respect to tanks, personnel carriers, jeeps, several sizes of trucks, and tank recovery vehicles.

These studies tended to disprove the persistent belief that an overhauled vehicle has a life equal to that of a new one. In the case of the jeep—the most dramatic—it was found that

an overhauled vehicle had only half the effective life of a new one. Similar evidence was accumulated from the study of tank tracks, for example, and major components. The cost implications of these findings were obvious and led to major revisions in overhaul and replacement policies.

Dramatic improvements were also made in systems for the supply of repair parts which are critical to the readiness of units. Repair parts supply, involving the procurement, stockage at several echelons, inventory control, and usage prediction of hundreds of thousands of items, constitutes one of the most complex and onerous of the Army's problems. RAC's studies, extending over several years, entailed collection, processing, and analysis of masses of data on supply actions, most of which were manageable only through mechanized storage and retrieval of data, using computers. Results of these studies led to changes in the criteria for stockage at various levels and depth of stockage, the provision of automatic data processing at lower units, and the extension and standardization of self-service in overseas theaters to obviate the time-consuming process of formal requisitioning and accounting for rapidly moving low-cost items.

Size, complexity, and worldwide distribution pose as formidable problems for logistics planning as they do for operations. Again, RAC called into play the computer, the model, the game and the simulation to make more comprehensive and rational planning decisions possible. RAC's answers have taken the form of models used singly or in sets, leading to better understanding and improvement of techniques for planning and evaluating alternative concepts of logistic support.

First to appear among these fully automated or computer-assisted sets of models was SIGMALOG (Simulation and Gaming Methods for Analysis of Logistics). This is a largely computerized system of models that makes possible the rapid determination of logistic resources needed to support given military operations and the Army's capability to provide them. The system has two parts. SIGMALOG I consists of nine models that can compute the time-phased logistic requirements implied by a contingency plan or study. These needs comprise replacements, troop movements, materiel resupply, intratheater transportation, construction, and combat service support. SIGMALOG II matches requirements with available resources revealing any shortfalls or excesses. It can indicate, for as many as three plans concurrently, the probable shortfalls in combat service support, major items of equipment and ammunition, and intertheater transportation, all related to the development of the plans through time.

MAWLOGS (a Model of the Army Worldwide Logistic System) is a modeling system that can analyze all aspects of logistics on a worldwide basis. It offers unprecedented flexibility in combining modules representing a large variety of logistic functions used in different ways for different purposes. Analysis of the consequences of combining these modules in various ways can help to clarify the role of component parts in the total system. As a tool it can help the Army to evaluate alternative concepts of support and operating methods.

A worldwide logistic system implies worldwide transportation networks. The varying capabilities and costs of transportation technology, on land, sea, and air, call for comprehensive analysis in the interests of minimizing costs and maximizing service by taking advantage of the best combinations of airlift, sealift, and land transportation. At bottom such problems are network analysis problems, and RAC addressed them first, starting in 1964, by devising a computerized mathematical model to analyze problems of transportation within a

single military theater. Called RACAT, for Resource Allocation and Chain Analysis Techniques, this system solves problems of multicommodity network flows under resource constraints. Completed in 1966, this model is central to a larger model for analysis of transportation networks in the European theater (ETNAM). More, it is a general system that can be applied to a very large class of problems, within and without military systems, in which the objective is to maximize flow or to minimize cost or time, given limits on resources.

The second model—called POSTURE because it deals with military postures or deployments of men and materiel—is a linear programming system, permitting simultaneous consideration in a single model of several alternative sets of contingencies occurring throughout the world. POSTURE can determine the system capable of meeting any one such contingency, or any specified combination of contingencies, at the least cost. To date it has been employed chiefly for agencies of the Department of Defense (DOD) to deal with problems of combinations of airlift and sealift. DOD turned to RAC to develop this system not only because it possessed the technically qualified personnel and other essential resources but because it was neutral with respect to the interest of services providing airlift and sealift. The results of POSTURE have been used in the preparation of specific recommendations for programs for airlift and sealift, in Draft Presidential Memoranda—key documents addressed by the Secretary of Defense to the President bearing on critical budgeting and systems acquisition issues.

RAC made other approaches to problems of long-range transportation. Notable, in dealing with the economics of use of aircraft, was a study analyzing the impact of large logistic aircraft (of which the C-5 is an example) on costs and efficiencies of logistic support. This study, "The Economic Use of Military Airlift and Sealift for Overseas Shipments in Peacetime," devised methodology based on a concept of total distribution costs. This methodology determined overall costs of transporting military commodities by sea and air, measured the demand for air and sea transport for such shipments, and estimated the economic value of air shipments in peacetime as a means of judging the acceptability of the costs of acquiring large logistic aircraft of specified characteristics. Another on-going study examined what commodities, under what conditions, could be economically shipped by air on a routine basis; and the method it developed is now in use by the Army in determining what items should be shipped regularly by air.

In recent years reductions in budgets and manpower have generated great pressure to rationalize logistic structures, systems, policies and procedures. Prominent among RAC's efforts to cope with such problems was a two-year study of stockage policy and the system for handling secondary items of supply, utilizing RAC-developed simulations and data banks to clarify the consequences of alternatives. The Army's Deputy Chief of Staff for Logistics (DCSLOG) asked RAC to examine intensively the merits and demerits of two widely differing stockage policies: demand-based or economic-based. And the Joint Logistics Review Board (the Besson Board) established early in 1969 by the Secretary of Defense also called for significant reexamination of alternative supply systems and policies. In searching for ways to minimize requirements for logistic resources in an area of conflict, the Besson Board made important recommendations calling for drastic reductions in the number of items stocked in overseas areas, for reducing intermediate supply echelons to a minimum, and for increasing reliance on air transportation to move secondary items. In substantiating these recommendations, the Board relied heavily on RAC data banks, methodologies, and related on-going investigations.

MANPOWER AND PERSONNEL

Particularly in the late 1960's, problems of military manpower (numbers) and military personnel (motivation, morale, dissidence, dissent, and propensities to enlist or re-enlist) took on new and more complicated and worrisome forms. The draft and draft-supported enlistments provided enough manpower to support military requirements in that decade, but the draft and Vietnam led to many problems. Dissidence and dissent in the country as a whole, particularly among the country's youth, seemed to go hand in hand with dissidence and dissent within the Army. The resulting disaffection and alienation threatened not only to reduce manpower available to the Army, but also to reduce the usefulness of whatever manpower became available, whether by draft or by volunteering. The prospect of a zero-draft and an all-volunteer army in the 1970's made the probabilities of enlistment look less favorable and the consequences for the Army more critical.

RAC addressed both the quantitative and qualitative aspects of manpower problems. In the middle 1960's, as manpower problems loomed larger because of demands of the Vietnam war, top Army officials asked RAC to provide short-term help in answering urgent questions arising from the draft. Such immediate operational help, in which RAC staff members worked closely with Army counterparts on current problems, led to the building of models and projection procedures into operational systems for the Army to run by itself. In 1969, the Assistant Secretary of the Army for Manpower and Reserve Affairs asked RAC to develop some mathematical models to help the Army foresee and assess the probable implications of a number of alternative manpower policies. Foremost in the Secretary's mind were problems of projecting the number of men that would be available to the Army under several conditions. A secondary consideration was assessment of the potentials for promotion for all grades in the Army.

RAC, building on its previous work on Army manpower projections, produced three models. First was COMPLIP (Computation of Manpower Programs Using Linear Programming). Second was POPP (Projection of Promotion Potential). Third was CHAMP (Chance-Constrained Adaptive Manpower Planning).

COMPLIP is a very powerful automated tool for examining alternative manpower programs, by month, for a period of three or more years. In 1970, the Secretary of the Army directed that COMPLIP be adopted as an official tool for producing manpower programs; it is the mainstay of the Army's current efforts to project manpower numbers in a systematic fashion. Already in operation on Army computers, COMPLIP has produced many programs (over 500 by 1971) that have been used by the Army Secretariat to explore the effects of alternative policies and environments on the size of the Army and the effects on projected Army strength of various sizes of draft calls. CHAMP builds on COMPLIP to take account of the facts that projections of manpower gains and losses are subject to uncertainty and that manpower decisions are made in sequence and adapted to current and foreseen developments. CHAMP constrains manpower predictions by introducing elements of chance. RAC analysts used probability theory and mathematical programming to convert this type of problem into an equivalent deterministic one. Once in this form, the problem of forecasting manpower can be dealt with by a nonlinear programming algorithm called SUMT (Sequential Unconstrained Minimization Technique), discussed later in this chapter. An improved version of CHAMP was being designed.

POPP, although more restricted in scope, has also been used extensively by both the Army Secretariat and the Army's Chief of Staff to examine promotion potential encompassing all grades and ranks.

RAC also worked on a model called ELIM (Enlisted Loss Inventory Model) designed to project losses to the population of enlisted men. The output of ELIM can be used as inputs for CHAMP and COMPLIP.

A tool of somewhat more general application is called IMP (Integrated Manpower Programming). This program was devised to take account of the fact that the Army recruits and assigns its civilian and military personnel in different ways. The objective was to develop an efficient means of integrating the programming of military and civilian manpower authorizations and to develop display formats and rationale for explaining and defending these authorizations. The study revealed points at which the various classification and authorization programs in use in the Department of Defense and the Department of the Army were not completely or consistently integrated and showed how this could be done. Application of the findings permits the Army to consider, in a rational manner, the comparative costs and values of using military or civilian personnel and to present its needs for manpower to the Department of Defense, the Office of Management and Budget, and to Congress in a comprehensive and unified fashion.

Concurrently with the development of these tools for policy analysis, RAC sought to provide tools for automatic prediction of future Army enlistments based on certain prescribed conditions and assumptions. Applying methods developed in earlier manpower studies to known historical time series on Army enlistments, RAC developed a mathematical model that could accurately project new enlistments as a function of the number of men to be drafted during any given month. RAC also developed a model to predict re-enlistments.

Under zero-draft conditions, however, models based on the draft would be of limited usefulness. RAC developed new ones, incorporating appropriate current policy assumptions. Such automated manpower prediction procedures—or even the semi-automated ones—depend on the relevance of assumptions and validity of data for their value. Even though they are flexible and responsive to the interests and needs of those who use them, the users themselves need information to guide choice of assumptions and to direct the collection of data.

In the late 1960's, using institutional research funds, RAC started to investigate dissent and dissidence at various Army posts, looking for ways in which civilian and military value systems might conflict so as to provoke indiscipline, breed dissidence, and in other ways depress rates of enlistment and re-enlistment and impede efficient functioning. Concurrently the Army launched a program to experiment with various ways of improving morale and recruitment, the so-called Volunteer Army Experiment, or VOLAR-E. RAC helped the Army assess the meaning of its findings and the probable cost-effectiveness of various innovations at various posts, as indicated by the expressed willingness of Army personnel to enlist or to re-enlist at the conclusion of their current terms of service. Preliminary results were so helpful and encouraging that the Army asked RAC to support a much broader program of evaluating how the Army would fare in all-volunteer, no-draft-calls situation, by examining the probable effectiveness of a variety of Army programs, launched in 1971, in promoting enlistments and re-enlistments, preserving skills, and fostering good performance among Army personnel.

These Army-devised programs included a pay raise, increased advertising and recruiting efforts, and special options granted to persons enlisting in the combat arms—choice of unit or geographical area of service and training options. Other factors examined included the winding down of the war in Vietnam and reductions in the draft. To carry out this analysis RAC devised a method for estimating the number of true volunteers both in a declining-draft and in a projected no-draft environment. RAC, using linear programming techniques, designed an optimization model incorporating the results of its estimates of the rate of true volunteering and data about program costs to show the costs and effectiveness of the total program. RAC's models and procedures permitted incorporation of alternative program changes and calculation of the expected payoffs. There were significant gains in understanding of recruitment, re-enlistment, and the penalties to the Army in terms of training costs if re-enlistments are not adequate to maintain manpower levels. The Army can now make better estimates of the probabilities and consequences of shortfalls in its manpower requirements in a volunteer environment and have a better set of ideas about how to avoid or overcome any shortfalls at least cost.

Chapter VI

RAC'S ACTIVITIES: COST ANALYSIS; WAR GAMING; WAR STUDIES

ORO had pioneered study of military costs and cost analysis, as well as war gaming and simulations. ORO had also launched studies of strategic and limited war. RAC continued, improving methods and exploring further the possibilities for applying more sophisticated and powerful analytic procedures to the unfolding problems of the 1960's. RAC continued studies of the field of arms control and disarmament, and inaugurated a broad range of politico-military studies relevant to the needs not only of military planners, but also of those concerned with broader questions of national security.

COST ANALYSIS

Despite heavy emphasis laid by decision makers and managers on cost information, and the availability of huge amounts of cost data, it is widely recognized that cost information is often incomplete, inconsistent, difficult to analyze and to use. Historical costs often possess all these shortcomings and are thus unsuitable for many purposes as they are rarely collected on a uniform basis. Hence a great emphasis on the development of comprehensive and dependable cost factors and cost estimating relationships has accompanied the increased uses of cost information in recent years.

RAC analysts examined mathematical and statistical methods of establishing systematic relationships between real costs and estimated costs through the life cycle of weapons, equipment, or other major items of military supply. Their objective was to establish cost estimating relationships (CER's) of particular usefulness to Army force planners and materiel managers. RAC attacked the continuing problems of data availability and sought the optimum use of computers to produce cost information automatically and to relate it to major planning and operating processes. RAC spent considerable time in trying to clarify, justify, and validate estimates of costs in situations in which those agencies generating costs in producing different kinds of weapon or logistical systems, under different sponsors, keeping cost records on many different bases, have produced data of widely varying usefulness and dependability.

RAC studied the cost of overhauling equipment at depots, finding weaknesses and questionable practices in the measurement and reporting of costs. A study of fuel and oil costs for the Army led to improvement in the accuracy of published factors of fuel consumption–a seemingly minor set of changes that can lead to important savings, since these factors are applied throughout the Army.

Wars and military operations are often cited as the best source of data about resource uses and their costs, as well as the best laboratory to test and examine them. There is great

danger, however, that data so generated will be lost, garbled, dispersed, or simply go unanalyzed. RAC made comprehensive efforts to gather, order, analyze, and report on the distribution of resources by the United States to the armed forces of the Republic of Vietnam (RVN). Such data can markedly improve understanding of how resources did figure in the Vietnam experience and may bear on the costing and planning of similar operations that may be required at other times and places. RAC's work covered all of the RVN's armed forces—the regular Army, the regional and popular forces, the Navy, and the Air Force. Of even more usefulness perhaps than aggregated data are cost factors; and RAC derived them for major items of expenditure for Vietnamese operational costs funded by the US Army. The resulting capabilities for cost analysis have been used not only in the Army but also elsewhere in the Department of Defense.

RAC contributed to the training of others in understanding and applying cost effectiveness analysis. In 1964, using institutional research funds, RAC undertook to prepare a guide to this subject. In 1965, the Army sponsored additional work. The result was a "Guide for Reviewers of Studies Containing Cost Effectiveness Analysis." The Guide was reprinted five times by RAC and many times by the Army's Combat Developments Command and by many service schools. It has been used as a text by the Army War College, the Air War College, and the Civil Service Commission.

WAR GAMING AND SIMULATIONS

War gaming and the simulation of combat provide the basis on which one can approximate answers to many analytic questions. What could a specified US force accomplish against a given enemy in a given country? How much difference would this or that change in the size or composition of the force make? How much difference would it make if the whole force could be assembled in a shorter time? Given that all choices involve costs that can be estimated, how can effectiveness be assessed so as to arrive at relative cost and effectiveness of all choices?

Analytic war gaming is designed to seek answers to these and many more such questions. The development of such gaming at RAC involved the long continued growth of staff, skills, techniques and theory, and of amassing relevant data.

Games can be either deterministic or stochastic, and RAC has devised both kinds, to be used as appropriate for various purposes of analysis. In a deterministic game the outcomes do not depend on chance but are determined by the conditions and assumptions built into the game scenario and rules. In a stochastic game the procedure takes account of chance and probabilities. Such games are necessary to study many forms of military interactions, because war is full of uncertainties and the intervention of unpredictable but nevertheless critical events.

In a stochastic game the method becomes a mathematical model or simulation, and a given case is run through the computer enough times to provide a statistical basis for the probability of a given result. This is usually done by the use of Monte Carlo techniques in which the role of chance or uncertainty is simulated by the roll of dice or by other means of representing probabilities. RAC's special application of this comes in its CARMONETTE series (little games using Monte Carlo techniques)—a series carefully constructed through several aggregations to simulate small unit combat—at first, between tanks and antitank forces, including artillery; then with infantry added; then with air support added; and finally with

communications and night vision added. (The CARMONETTE series was developed from original work by Richard Zimmerman at ORO that won the Lanchester Prize in 1956.) Some of the most detailed combat models are of this type, conducted without active "players." The number of runs required for statistical validity imposes restrictions of time and cost on the use of CARMONETTE, but reasonable investments have been more than repaid by the extent to which this small-unit simulator can provide detail and visibility to the analysis of large-scale simulations. The games and the combat situations make a versatile system in combination which can provide results quite impossible without the whole set.

The cardinal virtue of gaming and simulation for purposes of research and analysis resides in the ability of the user to specify different combinations of types of units, types of weapons, kinds of terrain, modes of battle (involving land, air, or sea forces) and nature of engagement (attack, defend, delay). Game play can then be used to indicate the relative effectiveness of alternative components in contributing to success on the battlefield. And not only the outcomes, but the records of play and the course of engagements can be traced and studied.

In the early 1960's, RAC developed a computer-assisted, manually played game called TACSPIEL for the evaluation of combat organization and equipment. In the later 1960's, this game was broadened into the Division Battle Model (DBM) designed to evaluate organization and equipment at the division level. At that time RAC also developed a package of game models called TBM-68 for the Joint War Games Agency of the JCS (later the Studies, Analyses and Gaming Agency). This package included warfare models.

To analyze warfare at the theater level, RAC first developed THEATERSPIEL to assess the requirements for limited war operations in an entire theater. This led to elaboration of a corps battle model, able to resolve engagements down to the battalion level and providing support for an innovative political-military game entitled POMEX. To accommodate situations in which speed of results was more important than detail, RAC devised a Quick Game and then automated it for inclusion, as ATLAS, in the FOREWON system. RAC adapted this also for use by the Joint War Games Agency of the Joint Chiefs of Staff. In 1970 RAC made the ATLAS model available to the staffs in NATO and SHAPE, where it is now being used in studies of Allied capabilities in Europe.

In 1970 work also commenced on linking the CARMONETTE game with the Division Battle Model (DBM), a computer-assisted division level war game that emerged from TACSPIEL. This linkage was prompted by a request from the Army's Deputy Under Secretary for Operations Research to analyze trade-offs comparing various antitank weapon systems with artillery. Neither CARMONETTE nor the DBM alone could perform this task; the new composite model offered an opportunity to replace the weak firepower calculations in the DBM with a body of assessment rules based on a series of CARMONETTE simulations. The outcome was a major advance in the state of the art of gaming. Indeed, the Army Models Review Committee labeled the concept as the most promising current development in gaming.

An imaginative although not widely applied use of the gaming technique appeared in the ADVICE study. Everyone knows that information and intelligence are vital in war, but few have tried to measure their value quantitatively. Some RAC analysts did in the late 1960's. The occasion for this frontal assault on an apparently intractable problem was a simple challenge—how to help the Army decide whether it should spend money for the improvement

of battlefield information by buying computer-assisted systems to provide tactical information. To do this, RAC analysts devised ways to provide a man-machine interaction with an on-line computer that would simulate combat at the division level and reflect the interplay between the flow of combat information and human decisionmaking.

A presentation on ADVICE II at the 24th Military Operations Research Symposium, in 1970, won the prize for the outstanding conference paper submitted to the Symposium.

In all its work on gaming and simulation, RAC has been guided by a point of view that gained persuasiveness with the deepening of RAC's experience—that gaming and simulations do not make military decisions, but they can help decisionmakers to assess broadly, in a systematic way, the potentials and risks of contemplated operations and uses of men and materiel without the human and material costs of war itself.

Games and simulations provide a realistic tactical context for testing innovations in weapons or doctrine by looking at dynamic interactions rather than making simple static numerical comparisons. To make clear why dynamic analysis is more powerful than static analysis, it is sufficient to point out that static comparisons of the probable military results of the battle between two forces described in terms of aggregate firepower, numbers of various types of weapons, and numbers of various types of units (divisions, armies) usually conclude that larger forces will defeat smaller forces, in similar types of engagement. Static analysis can apply broad rules—such as the rule that for a successful attack against a prepared defense the attacker must have a three-to-one advantage in forces. Static analysis allows for the application of many such special qualifications, and they can be made explicit. But static analysis cannot handle a flow of interactions through time, so an engagement can be followed through with its important changes specified by the determination of the outcomes of phases and subordinate engagements. Dynamic games are specifically designed to deal with such sequences. While dynamic games and simulations do not provide single, definitive answers to force assessments, they do provide the only feasible means of analyzing some highly complex operational systems and concepts.

ANALYSIS OF STRATEGIC AND LIMITED WAR

Strategic warfare, in current usage, is nuclear battle involving the homelands of superpowers. More generally, strategic warfare refers to warfare involving atomic weapons in conflicts of high intensity. Strategic warfare can also be affected by the use of atomic weapons in a more restricted manner. Since atomic weapons have not been used since 1945, the problems of strategic warfare cannot be analyzed on the basis of experience in war. They call for analysis based on studies of weapons effects and weapons technologies as they are hypothetically related to possible forms of combat. Much of the work on strategic warfare has been politico-military in nature, considering the problems and prospects of comparative strengths in weapons, of deterrence, and defense. RAC paid less attention to this field than did some other research organizations, but RAC did not ignore it.

In their ORO days RAC specialists considered broad conditions of nuclear battle and the problems of the defense of the Continental United States from nuclear attack. In particular, they addressed the usefulness of nuclear weapons to land forces. In RAC's time they studied the political as well as the military and economic aspects of the use of atomic demolition weapons (ADM's), or small atomic explosives for engineer-type demolition tasks, to clarify their military worth as well as the probabilities and modalities of their use.

As part of their studies for the Arms Control and Disarmament Agency, RAC analysts considered both the propensities of various powers to acquire a nuclear capability, and the effects on the security balance and prospects for arms control agreements and compliance with them. RAC applied significant advances in nonlinear programming to determine the optimum roles of NIKE-X system in nuclear defense, and explored ways of optimizing weapons use and effectiveness while minimizing cost in the course of nuclear exchanges in a great-power conflict. The methods elaborated to illuminate these latter questions are of great flexibility and adaptability to the consideration of other problems of weapons deployment and use, as well as questions of allocation of scarce resources to the purposes of peace-time activities.

RAC spent much time on questions of less-than-nuclear war, from limited warfare and exchanges in Europe, to problems of counterinsurgency in Vietnam and Thailand. As the Kennedy administration focused major attention on problems of insurgency, RAC responded, providing specialists to work with White House staffs and opening field offices in Saigon and Bangkok. RAC explored the weaponry, strategy, tactics, and politico-military operations peculiar to that form of warfare in the light of available experience in Thailand, Vietnam, and elsewhere.

RAC explored ways of improving the selection and training of US military advisors serving in Asia and Latin America. Late in the decade, RAC reduced its attention to these fields, as the nation's interest in counterinsurgency waned and shifted towards operations more directly designed to promote stability and economic and political development.

Limited war in a European environment posed quite different problems. There were crises such as broke out in Czechoslovakia in 1968, and tension areas such as Cyprus, but there were no ongoing hostilities such as marked the Asian world to focus world attention and to demand immediate solutions. Problems in the European environment tended to be conceptual in nature. Politics and economics played large parts, although in different fashion from their roles in Asia. Threats of hostilities, the politico-military problems of alliance structures, and the symbolic confrontations between the NATO and the Warsaw Pact powers, bulked larger than actual violence.

Much of RAC's effort in this area went to problems of arms control and disarmament. Some of these concerns were factual and technical. One of the more intriguing was participation in operation FIRST LOOK—field exercises in Britain designed to show how violations of arms control agreements might become visible to intelligence operations during the initial stage of general purpose ground and air force action.

Other work in arms control dealt with regional problems, such as a broad assessment of the prospects for arms control in Europe. RAC analysts looked at trends in security and defense policies, analyzed possible future pressures for development of nuclear weapons by individual states, forecast likely initiatives from the various European nations, estimated their receptivity to various arms control measures, and explored the extent to which those measures likely in Europe would be compatible with the interests in the United States.

On the basis of these comprehensive studies, RAC developed guidance and suggestions for US arms control policy toward Europe. RAC evaluated selected measures according to these criteria: (a) Did they offer real promise of reducing the risk of war or its destructiveness? (b) Were they unacceptable to the Soviet Union and the Warsaw Pact

countries? and (c) Could they be accepted by NATO countries and not divide them? RAC also produced five special studies on issues of mutual force reductions for immediate use by NATO planners. In these and related ways RAC laid groundwork for coping with problems of arms control—in their political and economic as well as military phases—embodied in the SALT talks and the current drives toward mutual and balanced force reductions in a period of parity between the nuclear superpowers.

The drains of Vietnam and the constraints of prospective limits on budgets and resources, sharpened by inter-service competition, made increasingly difficult the problems of force planning and of establishing the tasks and missions for planned forces. One approach to these problems called for estimating the contributions to established missions that could be made by alternative sets of forces from the Army, Navy, Air Force, and Marines, and costing them to see how best to maximize military capability within given or declining budgets for military spending. One study sought ways to assess the performance of alternative force designs that would indicate significant break-points in capabilities as forces were reduced. Another launched comprehensive analyses on how strategic nuclear forces and general purpose forces (including battlefield or theater nuclear forces) can reinforce one another, and what opportunities there are to gain effectiveness by trading one kind of weaponry for another within equal budgets. A third study estimated, in a semi-automated fashion, the overall combat capability of alternative force structures, involving components from all US military services, with the whole not costing more than planned 1972 outlays for all the forces involved.

POLITICO-MILITARY STUDIES

Strategy must be executed in a politico-military context, however difficult to define, let alone predict. Analysis bearing chiefly on studies of force structure, deployment, and operational capabilities within limits of costs and manpower, must be rounded out by consideration of the current and probable future environments in which those forces will be active. This is the case because the utility of given forces and weapon systems, their credibility, and hence their contribution to war-fighting capability and deterrence are affected by the political, social, and economic characteristics of the environment, as well as by net assessments of comparative military capability of alternative arrays of antagonists. Hence RAC, during the middle and late 1960's, conducted a series of regional strategic studies setting forth the major relevant features of the current environment and projecting them into the future to consider the probable contexts of war in the period from 1990 to 2000. The first of these studies dealt with Latin America. Others dealt with Africa, South and Southeast Asia, North Asia, the Middle East, and the northern tier of Warsaw Pact countries.

Those studies dealing with Southeast Asia paid special attention to emerging regionalism in an area where the economic and political lines of force in the post-colonial era still tended to follow the old colonial patterns, with colonies more closely related to their metropoles than they were to each other. Such studies were especially timely with the announcement and unfolding of the Nixon Doctrine in its relations to Asia. One considered the likelihood and consequences of a strategic gap if the United States withdrew its military presence more rapidly than other forces were brought into being to maintain an acceptable political and military balance. RAC studied the prospects of regionalism by examining the size and change of the military, political, economic, and communications linkages among the non-Communist countries of Asia from Burma to Japan.

Another study focused on the probable future security role of Japan in Asia, studying at first-hand the pace, direction, and probable significance of Japanese military development as shown in her then-emerging Fourth Defense Plan. This study pointed to the probability that Japan would not change her military armament or role in any significant manner in the next few years. It warned that any pressure by the United States on Japan to take up slack in a combined military posture would fail while increasing political stresses.

Russian studies commenced with attention to the economic structure and capabilities of Soviet Russia, in the late 1950's, using the tools of economic input-output analysis. The initial objective was to improve Western assessments of Soviet military capabilities, trying to overcome Soviet secrecy in part by estimating how much of the Soviet Union's total economic capability was being devoted to defense in general, or to important defense sectors in particular. This initial goal was not attained, but in the process RAC analysts learned a great deal about the internal structure and stresses of the Soviet economy, especially the struggle over priorities on resources for heavy industry and armament, or for light industry and consumer services. The outcome remains crucial to the determination of the pace and direction of Soviet investment in armament—including spacecraft and missiles—and hence of Soviet military capability. Groundwork was laid for a better comprehension of the interactions that might cause Russia to play a less overtly provocative military role, in an era of relative nuclear parity and defense balance, when alternative uses for the resources now devoted to defense might come to look more feasible and attractive, even if not necessary for the maintenance of political cohesion and morale in the Soviet Union. RAC analysts, in their Russian studies in economics, collaborated directly with the highly qualified staff of the Joint Economic Committee of the Congress in producing periodic assessments of Russia's economic capabilities and problems.

While RAC's military analysts devoted sustained attention to problems of the present and future military balance between Rusia, the Warsaw Pact, and NATO and the Western powers, RAC's political analysts kept under review the developing political context affecting the deployment, weaponry, military effectiveness and deterrent value of forces in the European arena. Prominent among these were studies of West Germany's role in the Western alliance system, with special attention to the impact both on East and West of West German Chancellor Willy Brandt's efforts to achieve better relations with Russia, i.e., his *Ostpolitik.* Economic dimensions were assessed as well, seeking answers to questions of how changes in economic relations between Russia and West Germany might affect detente and the cohesiveness of the Warsaw Pact countries as well as of NATO.

The advice and wisdom of former ambassadors and generals, working as RAC consultants in collaboration with RAC staff analysts, helped to shape assessments of problems of treaty negotiation, such as the Panama Treaty. Special consultants contributed as well to the relevance and timeliness of RAC's studies of Mediterranean, Middle Eastern, and Indian Ocean questions—problems occasioned by the British withdrawal from the Persian Gulf, problems arising from confrontations between Israel and the Arab powers, and problems arising from Greek-Turkish conflicts involving Cyprus in particular and NATO in general.

Chapter VII

RAC's ACTIVITIES: BASIC RESEARCH; SCIENCE, TECHNOLOGY AND ENGINEERING

RAC inherited from ORO a strong program of basic research into fundamentals of methodology for analysis of a wide variety of problems. RAC continued them, building on existing knowledge and state-of-the-art in linear programming, and extending knowledge, methods and practice into nonlinear programming, thereby greatly extending the range and power of analytic methods suitable for dealing with a wide variety of problems of interest to defense and to the civilian world as well.

RAC launched work in science, technology and engineering with the active sponsorship of the Army. During the decade RAC's capabilities were put to work not only for the Army, but for higher agencies in the Department of Defense, concentrating on problems of evaluating cost effectiveness of weapons and logistical systems, and participating in the analysis of other problems in which scientific, technological and engineering aspects were prominent.

BASIC RESEARCH

By the time RAC had taken over from the Operations Research Office, a program of advanced research studies was well under way and maintained momentum throughout most of RAC's existence. This continuation was not without conflict, both within the Army and within RAC, since there were serious differences of opinion about how much effort if any should be devoted to basic research as opposed to applications of existing techniques and methodology that would be clearly useful to the Army in the short run. At the outset, top Army officials decided that such a program was needed and suggested that it form about 10 percent of the total effort under the RAC-Army contract. They felt it was necessary to explore the ways in which advances in basic methodology might be used to deal with short-run problems, and the Advanced Research group devoted considerable attention to applications while it continued to make advances in mathematical programming and statistical theory. Two young mathematicians, Anthony Fiacco and Garth McCormick, wrote a book on nonlinear programming that won the Lanchester Prize in 1968. As a group, the Advanced Research people were highly qualified and widely respected. And the group maintained and sustained a homogeneous program of concerted, integrated research throughout most of RAC's life.

The Advanced Research group concentrated on improvements in linear and nonlinear programming and in analytical techniques like branch-and-bound methodology, while searching for clearly relevant and operationally significant applications. The group also devoted long-term study to fundamental questions of value as applied in the so-called "prescriptive sciences."

In the 1950's, practitioners of operations research spent much time on linear analyses, in part because computer codes to aid analytic study of linear models were widely available, and because many interesting problems could be expressed and solved in linear form. However flexible and powerful, the linear approach did not seem to fit easily or conveniently into the solution of some important problems of strategy, tactics, and resource allocation. Operations researchers looked for alternative mathematical methods and algorithms, and alternative ways of using computers to overcome these limitations. By linking computer programs sequentially, it became possible to deal in a dynamic fashion with problems involving change, including problems that changed their form during the course of solution as well as through natural developments in space and time. By breaking problems down so the analyst could consider particular portions of them in linear form at critical parts of their conformation, linear programming could be applied to a much wider class of problems than those initially addressed. But even these adaptations would not suffice, and a clear break beyond linear methods had to be made so the analyst would no longer be restricted in applying computers or in modeling to essentially linear phenomena.

A linear phenomenon, as expressed in a graph, rises or falls in a continuous straight line. An example would be the cost of a product if there were no economies or diseconomies of scale: that is, the first item would cost a unit amount; one hundred items would cost one hundred times that amount; a thousand would cost a thousand times the initial amount; and so forth. A nonlinear phenomenon, also expressed on a graph, could be continuous or discontinuous, and it could arc upwards or downwards. An example would be the cost of a product in which there were economies of scale: the first item would cost a unit amount; twenty-five items might cost only twenty times as much; a hundred items, only fifty times the initial unit cost; and so forth. If it were necessary, however, to incur major new costs, say for research, development, or machine tools, a discontinuity would result. That is, in order to produce output exceeding current capacity, a thousand items might cost more than a thousand times the initial unit cost, but five thousand might only cost two thousand times as much.

Nonlinear programming applies to a much wider class of problems than linear programming, and more to the point, it applies to some of the most interesting and important problems of optimum allocation of scarce resources among a multiplicity of tasks. But nonlinear problems are difficult to express and often call for extensive computation. It is usually difficult to relate them to computer capabilities. In 1961 RAC scientists came upon the idea of handling problems of minimizing a continuous function subject to constraints expressed by other continuous functions by treating them as a sequence of unconstrained problems. The result was SUMT, or Sequential Unconstrained Minimization Techniques.

SUMT is used chiefly to deal with what mathematicians call convex programming problems – those in which there are increasing marginal benefits, at least at the points which are critical to the analysis of the problem. At RAC, SUMT was used to clarify the most advantageous deployment, targeting and use of nuclear weapons, as well as the solution of problems arising in Army manpower planning. The procedure has been applied elsewhere to civil and military engineering problems which can be formulated as nonlinear programs. In 1962, advances in both theoretical validation and in computational techniques proved applicable to a resource allocation problem involving weapons assignment posed by the US Air Force. This problem involved a highly nonlinear objective function (an objective function is a value to be optimized, or a payoff) and linear constraints.

Another set of techniques, so-called branch-and-bound techniques, has also been developed and applied by RAC scientists. These methods are computationally efficient for dealing with non-convex problems, such as those with decreasing marginal costs. Branch-and-bound techniques consist of searching for the best solution by systematically partitioning a given problem into subproblems. Each subproblem is chosen because it is expected to contain an improved solution – one better than might be found in other parts of the problem. This procedure continues until only one subproblem remains. The solution to this subproblem then yields the "global" answer – that is, the best single inclusive answer – to the problem at hand. These procedures permit analysts to deal with problems embodying sharp discontinuities, and recent techniques are indifferent to the form of the objective function (the payoff) and the constraints (the limiting functions). They can deal efficiently with functions that possess both convex and nonconvex characteristics.

Branch-and-bound techniques have been used to guide such choices as whether to buy more of the same model helicopter, to spend money for product improvement of the existing stocks of the helicopter, and whether or when to scrap the inventory and start with an essentially new helicopter, accepting the costs of research, development, test and engineering, tooling and manufacture, and eventual scrapping. Branch-and-bound techniques have also been useful in making cost effectiveness analyses more precise and rigorous. To revert to the helicopter example, this technique can (1) consider explicit information about the probable effectiveness of a small number of helicopters or tanks against a given enemy force; (2) show the rate of improvement in effectiviness as more weapons are deployed in the battle; and (3) reveal the points at which the addition of more weapons has decreasing value per unit. This procedure can help the decisionmaker in deciding on the minimum and maximum number of weapons that should be committed to an operation or its parts. The branch-and-bound demonstration does not make the decision. It can only show the decisionmaker what the cost implications of varying his mix of weapons (or weapons buys) are so he can compare the price of given mixes, some more costly than others, against the values to be derived.

Another dimension of RAC's work in advanced research was a philosophical study and critique of the foundations of the prescriptive sciences, that is, scientific disciplines adapted for use in shaping real-world policies and decisions. RAC specialists in basic research observed that science so used had a prescriptive dimension not fully explored or understood within the world of classical science. Through this program RAC built and maintained links to many specialists in the policy sciences. In often intangible ways, this program helped others in RAC to examine the value or effectiviness side of cost effectiveness problems with sharper analytic tools.

SCIENCE, TECHNOLOGY, AND ENGINEERING

One of the most widely accepted tenets of our time is that developments in basic and applied science, resulting in developments in technology and thus the tools of war (and peace), lead to critical and not always fully foreseeable differences in military weaponry, systems design and performance, doctrine, tactics and strategy. Therefore it was appropriate that RAC, with Army backing, should develop a program of work in science, technology, and engineering. This program came to encompass not only the design and utility of specific items of military weaponry or equipment but also the systems of which they were part; not only the technical characteristics of system performance but also their cost-effectiveness in discharging military tasks and missions.

RAC's ACTIVITIES: BASIC RESEARCH; SCIENCE, TECHNOLOGY AND ENGINEERING

By considering questions of engineering design and technology along with present and potential relationships to military missions and tasks, and cost, much of the basis can be laid for sound policy choices and management decisions governing the procurement and use of weapons systems, and major logistical equipment and vehicles. These problems are almost always very large-scale problems. Hence RAC, with relatively modest resources, usually served as collaborator and contributor to studies managed by Defense or Army staff agencies, often virtually as an extension of the staff. In most of these studies other contractors and appropriate study groups within government also contributed.

Despite this formally modest collaborator's role, RAC provided distinguished and innovative service. RAC's specialists in engineering, technology, and cost analysis often drew on the basic methodological developments emerging from RAC's program of basic research in nonlinear programming and the mathematical procedures for branch-and-bound analysis, described above. RAC's specialists also brought emerging computer hardware and technology to bear on management procedures as well as using them to improve their own analytical capabilities. RAC analysts brought about major advances in radio frequency management for military communications. They also carried out major tasks in the evaluation of competing weapons systems. RAC reviewed the analytical methods available to the Army for determining the proper requirements for tactical vehicles – and building on this analyzed afresh the concepts and opportunities for pooling vehicles, getting better mobility for less cost. In the somewhat esoteric field of intelligence, RAC provided a key analysis of the technology for data linkage. In the course of government efforts to develop a better crisis management system, this analysis would have available, at the national level, the intelligence needed to deal with sudden major threats to national security. RAC analysts devised for the Army's Office of Chief of Research and Development (OCRD) faster and more flexible ways of allocating funds to research and development tasks, to be applied to those projects whose funding was not already fixed in the military budget or by high policy. RAC analysts also made significant contributions to the Army's studies of its needs for avionics (i.e., aviation electronics). The studies in avionics went along with studies of the Army's need for aircraft specialized to acquire targets and keep areas of interest under surveillance.

An important series of studies was begun in 1967 that made contributions not only to the evaluation of weapons systems and equipment, but also to the basic methodology for evaluating investment decisions in a comprehensive and realistic manner. The evaluations bore on the Army's decision concerning the best design of a major new helicopter system. The methodological advance had begun with the so-called "candidate families" approach in which a particular weapons system would not be evaluated by itself, but instead an *array* of related weapon systems capable of performing a spectrum of military missions would be evaluated. Such an array constituted a "family" of systems. RAC developed time-phased methods for evaluating system performance and estimated costs for families of weapons with each mix considered as a "candidate" for acquisition and use.

These methods rested on the fundamental judgment that it makes no sense to evaluate the cost-effectiveness of a particular system without taking into account the other systems capable of contributing to the accomplishment of the total spectrum of missions, and without taking into account the capability of a mix of systems to discharge all the missions or tasks which the family would be called on, now and in some future time, to carry out. Moreover, it was deemed essential to take into account the kinds of systems the Army had on hand (i.e., its

"inherited assets") in order to decide what mix of systems would be most effective at some point in the future. Previous methods had simplistically approximated the inherited asset position. RAC's newly developed method took explicit account of them; it went further and took account of the effects of introducing new and more cost-effective systems at a later date. It included procedures for determining when new equipment should be phased in (and old equipment phased out). Thus it could show when, and how much, improved hardware should be introduced to maintain the most cost-effective family of systems through a time period reaching into the future for as long as twenty years.

This later-expanded and more powerful method was called OPT – Optimal Planning Over Time. Of enormous potential power and utility, the method needs a major field of application to make its full contribution to analysis and system development, acquisition and utilization. It was of use in helping the Army decide whether to acquire a new helicopter or a modification of the latest in the UH-1 series; or whether to establish a design requirement (a so-called Qualitative Material Requirement or QMR) for a vehicle somewhere between the ultimate goal and the UH-16. Earlier versions of the basic method had been used in the choice of a preferred light observation helicopter (LOH).

These methods could also be applied to decisions about acquiring, configuring, and using other systems, for example, of wheeled vehicles, to assure adequate or improved Army mobility at less cost.

In mobility studies, RAC engineers identified and explored possibilities offered by surface effect vehicles (SEV's, or hovercraft) for the defense as well as the economic development of Alaska. Some RAC tactical analysts considered how such vehicles could be designed and used in a conflict in Europe under the threat or use of battlefield nuclear weapons.

An early problem in engineering and technology on which RAC field analysts worked was whether the Pershing missile could or should be designed to serve as an element of NATO's nuclear strike force, in addition to its use in support of field armies. RAC furnished scientific advisors to the group of Army and Air Force specialists who conducted field tests in West Germany. These advisors contributed to the collection and analysis of data and preparation of the final test report and findings. Later on, RAC analysts used data so gathered to illuminate the question of what configuration of the Pershing force would best meet its operational tasks, with appropriate cost-effectiveness.

As early as 1965, the Army began intensive consideration of the best helicopter to embody in a system to provide utility tactical transport for the Army in combat (the UTTAS vehicle). The underlying question was whether to improve the existing helicopter – the so-called Huey or UH-1 series of helicopters – or to design and field an essentially new model. Studies showed that an improved Huey, the so-called H+, would be capable of carrying a basic complement of 11 men. Army studies also indicated the vehicle should be capable of carrying 15. The H+ could be fielded quickly and relatively cheaply. The new, larger design would cost more and take more time to get to troops in the field. Moreover, long experience showed that unforeseen problems were sure to crop up during design, development, testing and engineering, and production. RAC analysts participated in the studies that led to the decision about what new craft to build. These studies showed it would be possible to design a craft capable of carrying 15 men, but that with currently available technology it would be difficult to provide sufficient engine power for that load with appropriate efficiency and economy. The ultimate

decision was a compromise: to build an aircraft adequate for short-run needs, but to make it improvable so if the tactical situation required it, seating for 15 could be installed and power increased, or other changes made without risking undue delays, uncertainties, and costs.

Later on, RAC collaborated in evaluating the nuclear and antimissile capability of surface-to-air missile defenses (SAM-D) and in appraising capabilities for close air support of troops. The SAM-D study as a whole sought the best method of using missiles to counter nuclear and missile threats to a wide array of targets. RAC concentrated on problems of the defense of the Army in the field. Other agencies dealt with the defense of the continental United States and with technical and engineering issues. RAC developed an Air Defense Evaluation Model to assess SAM-D's effectivness in protecting the field Army. To do this, RAC had to define what the critical assets of such an army are, and to specify analytically meaningful and useful criteria for deciding how much defense is enough.

Another aircraft study arose from an Army development objective to get a new design that would improve battlefield surveillance in general, as well as the acquisition of specific targets. The system concept was given the acronym STAAS (for Surveillance and Target Acquistion Aircraft System). At the outset, this task seemed to require only a trade-off analysis involving alternative emphasis and spending on the airframe itself, or on the electronics to go in the craft, or on the sensor equipment to perform surveillance. However, it soon became apparent that some prior essentials were lacking: doctrine for the conduct of these functions, a statement of missions to be accomplished, and the availability of alternative aircraft to be selected. The STAAS study had to remedy these deficiencies first. Then it considered the operational requirements for the system and the environment in which it would operate. After analyzing the relationships and tradeoffs between operational requirements and the technologies of aircraft, propulsion, sensor, data processing, and support subsystems, the study determined preferred mixes of sensors and avionics configuations. The study report provided the primary reference base of data and analytical techniques for subsequent Army endeavors in tactical aerial reconnaissance and surveillance, including the Manned Aerial Vehicle, Surveillance (MAVS).

Following the STAAS study, RAC continued its work in avionics. In 1967 RAC produced for the Office of the Chief of Research and Development a study of the management and content of the Army's avionics program and made recommendations for its improvement. The study investigated difficulties and delays encountered in phasing relevant state-of-the-art electronics into aircraft. It investigated avionics reliability, comparing present and predicted reliabilities and comparing Army, Navy, and Air Force reliability experience. It offered conclusions and recommendations for improved application of technology in several key areas and for better substantiation of avionics operational requirements and for better R&D leading to simplified, low-cost, functionally integrated avionics systems specifically designed for Army helicopters.

In 1968 RAC prepared a five-year accelerated program in basic avionics for the Army's consideration. In 1969 RAC specialists assisted the Army Electronics Command in several ways. They drafted charters for project managers for a navigation and control system (NAVCON) and special aviation electronics (SLAE); they provided a critique of the automatic data processing systems used for navigation and air traffic control. They participated in review and revision of qualitative material development objectives and requirements, and small

development requirements. They also provided technical direction to three teams of summer consultants working on simulation, reliability, and testing. RAC scientists also helped develop data in support of efforts to establish an Air Mobility Research and Development Center.

RAC's last large avionics study was done for the Assistant Chief of Staff for Force Development. It developed tradeoff data for alternative solutions to the problem of enhancing the capability of Army aircraft to conduct combat operations under conditions of reduced visibility. This comprehensive study provided a definition of aircraft missions and an analysis of the instrument flight functions needed in each type of mission. Meteorological conditions requiring instrument flight for several type geographic areas, and interactions of darkness, meteorological conditions and terrain were also analyzed. It also assessed current and near-term technological capabilities to provide avionics proposed for the required instrument flight functions, together with estimated production costs and assessed probable electronic warfare threats against the proposed avionic systems. The study enabled the Army planner to determine the increased mission performance attainable with additional avionics and the consequent increased dollar cost.

Chapter VIII

RAC'S ACTIVITIES: ECONOMIC, POLITICAL AND SOCIAL STUDIES; SPECIAL STUDIES

Emerging from RAC's concern with the economic, political, or social aspects encountered in many of its projects was a decision to concentrate on improvement of capabilities and methodology for work in economic, political and social scientific studies on their own. This was triggered in part by the search for diversification of staff capabilities, and the capacity to be of service to a wider variety of clients.

In the field of special studies, two illustrations are given of RAC's contributions to pioneering military studies, and later on, to the conception and solution of problems encountered in lowering the costs and improving the availability of housing. Finally, mention is made of two RAC efforts in the late 1960's to improve the definition of serious, enduring problems facing the Army, to help plan research needed to help the Army cope with them more wisely and successfully – and at bottom, to indicate where and how RAC research should be directed to fundamental problems, rather than to short-run efforts at marginal improvements in capabilities to deal with current urgencies.

ECONOMIC, POLITICAL AND SOCIAL SCIENCES

By the mid-1960's, RAC was actively considering diversification of its clientele and range of capabilities, in part to assure its growth and health, and in part owing to difficulties arising from its special relation to its major client. At this time there was a propitious climate for innovative efforts to apply social science research in a wide variety of fields, both in and out of military fields – more out than in. Domestic dissidence and violence called for fresh diagnosis and therapy. Such domestic issues started to overshadow issues arising earlier from cold war and insurgency. Suggestions were made in Congress and elsewhere that the specialized agencies providing military studies and advice should make their skills available to help cope with domestic ills. Moreover, at this time the disappointments and disillusion occasioned by attempts to apply social science research in Vietnam or at home had not yet displaced the initial optimism about potentialities of social science (sometimes overblown as "social engineering"). Furthermore, the Army itself recognized that it had needs for social science that were not being filled by RAC or by other agencies more specialized to meet them.

The Army decided to encourage RAC in its efforts to develop this new dimension of its capabilities but not by direct Army funding for the purpose. The Army hoped that RAC would develop its work in social science for other clients, and out of such development would come improvements in RAC's ability to meet some of the Army's newly recognized needs.

In 1967 RAC set up an Exploratory Development Group; in 1969 this became the Economic, Political and Social Sciences Group – one of three operational groups at RAC.

First and foremost came efforts to see how RAC's existing capabilities could be applied in non-military fields. Later came efforts to build new capabilities by recruiting new staff and reshaping corporate organization and programs to deal more explicitly with problems of development, aid, public safety and order, and communications for security and development. Supported by funds from RAC's corporate resources, the new group examined both the physical characteristics of cities and the procedures of municipal government, looking for changes that might reduce opportunities and occasions for crime. They made preliminary assessments of municipal fire, police and public works departments, along with civic, professional, social and business organizations, and means of mobilizing all such resources to improve public safety. They sought to bring the methods of systems analysis to bear on improving the equipment and performance of logistic facilities used in control of civil disorders. They studied command and control systems used in public safety. They looked for better or unnoticed indicators for sensing civil disorder and means for averting it. RAC supported the crime prevention and research program of the Washington (D.C.) Metropolitan Council of Governments, and participated in the work of the Attorney General's Conference on the prevention and control of civil disorder.

RAC analysts considered the dimensions of dissidence in the civil community and then applied their findings to dissidence in the military community. They sought innovations in game playing – quite different from military gaming and simulation – as means of exploration and analysis of the nature and consequences of differing role perceptions of delinquents and the personnel of public and private agencies involved in control, correction and rehabilitation. The object of such games was less analytic than therapeutic – to promote insight into the nature of the communications and interactions between players in a social drama, while heightening sensitivity and broadening awareness of the range and potency of new techniques for dealing with deviants. Public communications were examined both for their formal services to order and education, and in their informal role of fostering, modifying, and coping with conflict and resolution.

In the fields of international development, working chiefly for the Agency for International Development, RAC provided engineering, analytic, economic and management services, usually on a task-order basis that provided considerable flexibility and opportunity for quick responsiveness to emerging needs. In the course of this work RAC, using its own funds, made preliminary surveys of the development needs of certain Southeast Asian nations and selected countries of Africa. RAC sought to identify current and projected trade patterns, movements of goods and people, and transportation networks (national, regional, and extra-regional and international). RAC assessed the economic and technical soundness of capital improvements, such as proposed bridges in Sene-Gambia. RAC assisted AID's Office of Private Resources by surveying its risk guaranty programs and its investment promotion programs. RAC also supplied engineering and economic analysis in connection with AID's management of capital projects. One objective was to improve procedures and documentation with respect to electrical power and water projects. Another was to help in the design of a more efficient process of project development that would facilitate capital project identification, development, design selection, and approval for financing.

After its first exploratory moves, public safety research at RAC came to emphasize problems of corrections and rehabilitation. A study of police problems in Denver revealed needs for better coordinated community efforts to deal with problems of crime, and the recommendations of the survey pointed out specific needs for better communication and

coordination among the community's crime control agencies. The presence of the research project, as well as the functions of the project personnel, brought about an improved atmosphere in which coordination could be sought. A continuing concern was with the personal position and psychological needs of the delinquent. RAC explored ways in which the delinquent can be brought more effectively into the process of rehabilitation, helping him to recognize both the consequences of his behavior and the possibilities of rehabilitation. RAC specialists suggested that the delinquent should participate in the disposition of his own case. RAC assessed the feasibility of such participation, with respect to several kinds of delinquent behavior, and a variety of kinds of delinquents.

It is widely held that the prospects for effective police action in the urban community are shaped by the perceptions which the police have of their image and tasks, and by the perceptions the local residents have of the police. RAC explored this hypothesis through participant observation of these phenomena in a heavily Negro, highly turbulent part of Baltimore. RAC analysts rode in police cars and walked beats, talking to many police and many citizens. Insights derived were not only reported to the sponsors (the Ford Foundation and the Office of Economic Opportunity), but were often shared on the spot with police and residents.

The Denver studies pointed to the need for alternatives to court referral in disposition of cases of juvenile delinquency. Later on RAC explored the potentialities of house detention as one such alternative, in a large mid-Western city. One of RAC's latest studies assessed the extent to which development of alternative services would permit a Florida county to reduce planned capacity for a new security-detention facility and still care for the probable flow of its juvenile delinquents between now and 1985.

In 1969, RAC analysts attacked the problem of dissidence in the Army, using RAC institutional research funds. First they estimated the nature and severity of conflicts between military and civilian value structures. Then they assessed ways of coping with such conflicts and estimated the probable cost and effectiveness of alternative ways of reducing dissidence. The findings of this study led directly to further studies, Army-funded, of dissidence and of MP effectiveness. These in turn led to RAC help to the Army in evaluating the cost-effectiveness of its Volunteeer Army Experiment (VOLAR-E).

As part of its efforts to diversify, RAC set up joint relationships with other organizations. Notable was the collaboration with the Green Power Foundation (GPF), a Los Angeles based group concerned with the problems of black minorities and their identification with various movements to improve the environment and their own role in it. In 1972 RAC started to provide research support to Green Power in their work for the Environmental Protection Agency (EPA). Green Power was under contract to help EPA organize and direct the 1972 SPARE Project – a program for providing environmentally related and educational employment activities to inner city youths, through the Department of Labor's Neighborhood Youth Corps program. In this multi-layered effort RAC helped GPF design a handbook for participating SPARE cities, providing guidance on the dimensions of the EPA project and outlining elements to be included in city plans submitted for Federal funding. RAC also helped prepare a 1972 program manual, outlining in more detail program alternatives that cities might offer.

In another diversification effort, analysts working through RAC's California office helped to devise a set of environmental quality indicators to be used by the Integrated Regional Environmental Management Project (IREM) sponsored by the Ford Foundation and

conducted as part of the work of the Environmental Development Agency of San Diego County, California. This study provided descriptions, data sources, and computational methods of 12 indices of quality embodying 42 separate indicators. The indices include air, water, noise, land use shift, recreation, hazardous substances, solid waste disposal, housing adequacy, pest vectors, natural resource depletion, wildlife and vegetation, and visual pollution. It was hoped that once in use by the client these 21 indices and 42 indicators would lead to an important breakthrough in developing benchmarks of regional quality.

SPECIAL STUDIES

RAC's contributions to understanding of military tasks and issues, as well as those in the civilian domain, took several forms other than a study. Two examples show how RAC's managerial talents, as well as the facilities at its building and the use of its supporting resources, could be deployed for rapid support to an important and comprehensive task. First is RAC's support to the Howze Board; second is RAC's support to HUD's program for provision of industrialized housing. One came early, the other late in RAC's existence.

In May 1962 the Army set up a board of high-ranking civilians and general officers under the leadership of General Hamilton Howze with a broad formal mandate to consider the Army's requirements for tactical mobility. The Board quickly focused on the Army's needs for aviation in the 1970's. Its real goal was to take fullest advantage of aviation technology to enhance combat effectiveness. The Board examined the composition, costs, feasibility, and probable effectiveness of an air assault division that would be completely air-mobile, at least in a theater of operations. By war gaming, costing, logistical studies, and field testing, the Board probed deeply into these matters to derive a workable concept and doctrine for employment.

RAC mounted a considerable effort for this study. RAC's President served on the Board, and a senior staff man served as coordinator of research and planning. Fifty-five other RAC professionals also contributed in the fields of costing, logistic analysis, and war gaming. RAC also assisted in the field testing and instrumentation. RAC professionals were located at Fort Monroe so they could deal immediately with problems put to them by the Board in the course of its work.

This comprehensive effort resulted in a final report published on August 20, 1962, supported by 14 annexes and 85 appendices. Its chief achievement was to lay groundwork for creation of the 1st Cavalry Division (Air Mobile). In three years from announcement of the concept, that division was ready for battle in Vietnam. The achievement was severely tested in the peculiar environment of that struggle in which, because of terrain, enemy tactics, and the scale of action ranging from guerrilla engagements to limited conventional battles, mobility was vital to success of military operations. Questions whether the helicopter could survive in war, incompletely studied by the Board, were answered for the environment of Vietnam and the special conditions of warfare there. Other questions of the costs, the logistics, and the operational feasibility were answered in ways that promised success in other environments as well.

A longer term effort in a widely different field is illustrated by the work of RAC's California office, between 1969 and 1971, in support of the Operation Breakthrough program of the Housing and Urban Development Agency (HUD). Operation Breakthrough was a program to demonstrate the value of industrialized housing by constructing some 3,000 dwelling units around the country, utilizing new techniques for mass production, better materials,

improving building codes, and other adaptations to reduce costs and increase production and flexibility. The program needed a system to monitor the cost of the houses during the design and development phases. Cost comparisons had to be made between different technologies and methods used in constructing and erecting the demonstration dwellings.

RAC's task was to develop a cost tracking and cost comparison system, and to assist in the program management of the entire operation. HUD needed professional assistance based on long-term understanding of the construction industry, including detailed knowledge of the cost controls and the cost breakdown structures already in existence. RAC contributed to the production of a uniform cost breakdown structure based on the systems and subsystems that make up a dwelling – a novel application of systems analysis.

A final example of RAC's work, difficult to fit into any special category, was the work of IMPACT and CALCHAS, done from 1966 to 1968. The objective of these two studies was to focus attention on long-range issues that would be facing the Army, at a time when the Army-RAC relationship was placing increasing emphasis on near-term problems. Both studies were funded from RAC's Institutional Research resources – money available under the Army contract, but used by RAC to conduct work in the Army's interest, at RAC's initiative.

IMPACT was a planning conference, held for five days at the Naval War College in June 1966. Some 30 RAC senior analysts shared thoughts and reactions in order to identify specific major problems that would face the US Army in the 1980's. The conference produced over eighty suggested problems, some diverging, some overlapping, of varying significance and importance. RAC studied them further, and consolidated them into twelve major sets of problems:

- How can the capabilities of the individual soldier in close combat be improved?
- What measures of military effectiveness can be developed to guide and evaluate innovation in Army equipment, operations, tactical forces, and organizations?
- What should be the future role of the reserve components of the US Army?
- How can the Army carry out its mission in the support of national policy with a minimum of forward deployed forces and installations in overseas sites, and what system of posts, camps and stations will be required to house, train, and support the central reserve stationed in the US?
- What can the Army do to further US national policy of assisting other nations to achieve security and stability? How should the Army prepare to execute proposed roles, and which roles should it prefer and recommend?
- What should the Army propose as its own desirable social composition so that in the future the Army may maintain and improve its present level of effectiveness, retain the support of the citizenry of this country, and contribute to national welfare?
- What problems and opportunities result from advances in communications and data-handling technology?
- On what basis should the future role, size, and weaponry of armor forces be determined?
- What changes are required in the Army's logistic support system to make it responsive in theaters of operations 10 to 20 years hence?
- How should the Army prepare for the likelihood that tactical nuclear weapons may be in the hands of limited war adversaries in the 1970's?

- Do the present roles and missions of the Army for continental and theater air defense warrant extension into the 1970-1985 time frame?
- What is the best defense against air attack for the field Army 10 to 20 years in the future?

Approaches to these twelve problem areas were presented in a series of briefings to staff principals and other members of the Army general staff in October and November 1966. They engendered comment and discussion, including the identification of some added problems. All agreed that serious problems in these sectors did loom ahead for the Army, and that RAC should explore what research could be done to address and possibly alleviate them. The Army did not, however, make available any additional support for this work.

As a result, RAC launched CALCHAS – an effort supported by RAC resources to develop explicit research plans addressing these problems. The plans were not restricted to tasks which RAC could carry out. Selected groups of RAC analysts addressed the first five of the problems, in turn. But Army reluctance to accept and implement these plans did not seem to justify devoting more funds and the time and energy of the most valuable staff members to the continuation of such research planning. Nevertheless these initiatives helped RAC to shape the content and emphasis of some of the near-term research done in 1968 and thereafter. Subsequent experience showed that they embodied enduring issues for the Army's future.

Chapter IX

ORGANIZATION AND PERSONNEL

The heart and essence of any functioning organization are its members and the mode of their organization and employment to carry out their central activities. This truism applies with more force to an organization like RAC than to manufacturing or service organizations, for RAC's chief asset was its staff, and RAC's chief product their studies and services. Therefore, RAC's continuing problem of organization and management was how to recruit, organize, train and direct a corps of professionals and their necessary support, striving for the right balance of professional skills, the best ratio of professional to support personnel, and an organization that would group them so as to match professional talents flexibly with the work to be done.

Since the environment that defined RAC's opportunities for professional work changed throughout RAC's life, both the professional composition and organizational structure were adjusted to it. Since changes in the demand for services were not clearly predictable, RAC's top management and its Board took steps to ensure that RAC's development would be carefully planned and that RAC's organization included specific units charged with assisting management to forecast future demands and opportunities, and preparing to accommodate to them. The continuing question of proper balance between professional and support staff was not of concern to RAC alone, nor to its clients. Congressmen were interested in it, and expressed concern at several points in RAC's existence that this balance should be appropriate in the light of the work to be performed.

At the outset, RAC's Board and top management sought better definition of objectives, priorities, schedules, and resource requirements, along with better control of staffing and periodic assessment of progress. Later on, as RAC's scope of work expanded to encompass types of technical work broader than those applicable to the Army's problems as they were seen in the early 1960's, RAC's organization needed to change so as to encompass a wider variety of disciplines and technical activities in an increasingly competitive environment demanding more vigorous efforts at sales and diversification.

During the eleven years of its history, RAC's top management, under its President, was concentrated first in two Vice Presidents, then in three, and finally in four: one each for Operational Systems; Technological Systems; Economic, Political and Social Sciences; and Vice President and Treasurer. Partly to facilitate diversification and partly to provide foresighted management and controls, RAC strengthened top management by providing special assistance for corporate planning and program development. RAC instituted planning and goal-setting procedures to ensure sound, long-range development. These procedures involved chiefly the offices of the three technical Vice Presidents and the Department Heads reporting to them. RAC adjusted its divisional or departmental organization in line with major changes in emphasis in its technical programs and projects.

Attention to the organization and purposes of top management and line organization was paralleled by pioneering done in fashioning support for managers and technical staff. Like its peers, ORO/RAC had to create units to handle novel support tasks. It was necessary to provide for the safe storage and handling of many thousands of secret or confidential papers – many coming from outside RAC, many generated within. It was necessary to participate in systems of personnel security and to do it in ways that would respect the personal integrity and functional requirements of all of RAC's varied staff. It was necessary to build an effective publications department, able not only to produce reports in a variety of forms, with speed if need be, but also able to do so within security regulations.

RAC's personnel department had to develop new procedures not only for recruitment and retention of varied and often highly specialized staff, but also for equitable salary administration and for hiring and promotion practices giving due consideration to the needs and rights of minorities and women. RAC inherited a well-stocked library from ORO, and RAC's librarian (the former ORO librarian) kept it abreast of requirements for support of many kinds. The RAC library had to have on hand or be able to borrow quickly many specialized documents. RAC established cooperative relations with other libraries, general and specialized, in government, public organizations, and industry.

As for staffing, the major concerns were to see that RAC's staff always had the appropriate resources in technical skills; that the staff balance between professional and support personnel was favorable; that compensation and benefits were equitable and attractive, competitive with those of comparable employers yet acceptable to clients and to Congress.

ORGANIZATION

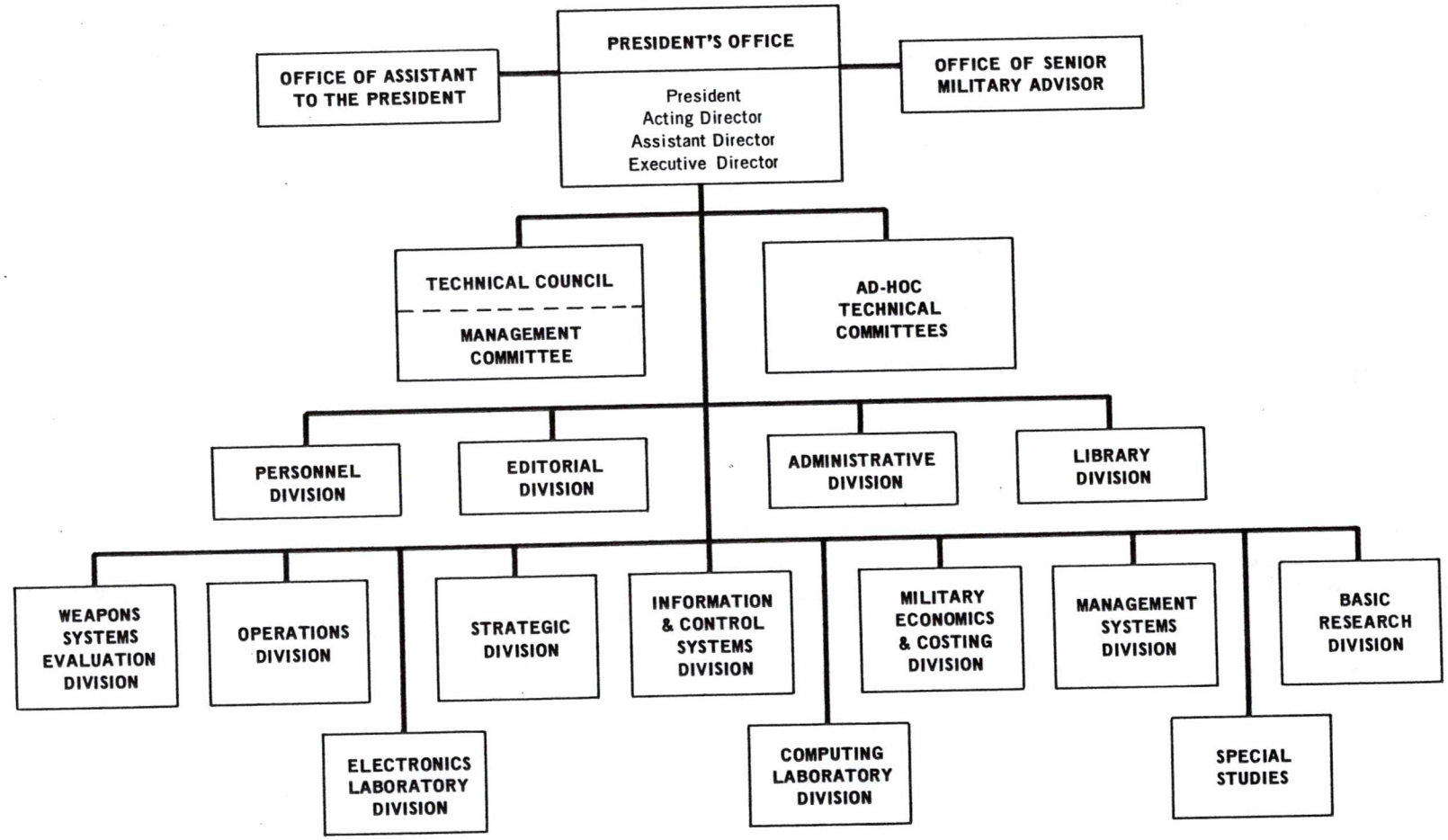
For more than six months after incorporation in September 1961, RAC retained the officers and organizational framework of ORO (see chart 1) except for the appointment as President of Mr. Frank A. Parker, former Assistant Director for Limited Warfare Systems, Defense Research and Engineering, Office of the Secretary of Defense. Division chiefs remained the same, as did the Associate Director, Dr. Lynn H. Rumbaugh, the Assistant Director, Dr. George S. Pettee, and the Executive Director, Brig. Gen. L. D. Flory, USA (Ret.)

Effective 26 March 1962, RAC's basic organization structure was radically changed. The professional staff was divided into two main branches (see chart 2). The Combat Systems Branch, directed by Dr. Rumbaugh, consisted of the Weapons Systems, Information and Control, Conflict Analysis, Combat Developments, and Methodological Research Divisions. The Computing and Electronics Laboratories were also included under Combat Systems. Dr. Hugh M. Cole, former Chief of the Operations Division, was appointed Director of the Logistics and Management Systems Branch. Operational Logistics, Support Systems, Logistic Simulation, and Economics and Costing Divisions fell in his purview, as well as the Library and Editorial functions. At this time, an Advanced Planning Group was set up with Dr. Pettee as Chairman. An Operating Committee was appointed, consisting of the President, heads of operating divisions, officers, and the Planning Group Chairman.

In April 1963, a third directorate was formed to undertake studies in systems engineering, the technical analysis of military equipment in use, and the potential application of advanced technology to new weapons concepts. Headed by Mr. Fred W. Wolcott, formerly Special Programs Manager of the Aeronutronic Division of Ford Motor Company, the Systems Engineering Directorate had four components – the Advanced Research, Electromagnetic, Mobility, and Tactical Systems Technology Divisions. It is noteworthy that this decision to improve and broaden RAC's capability to work in fields of science and technology (and thus

Chart 1

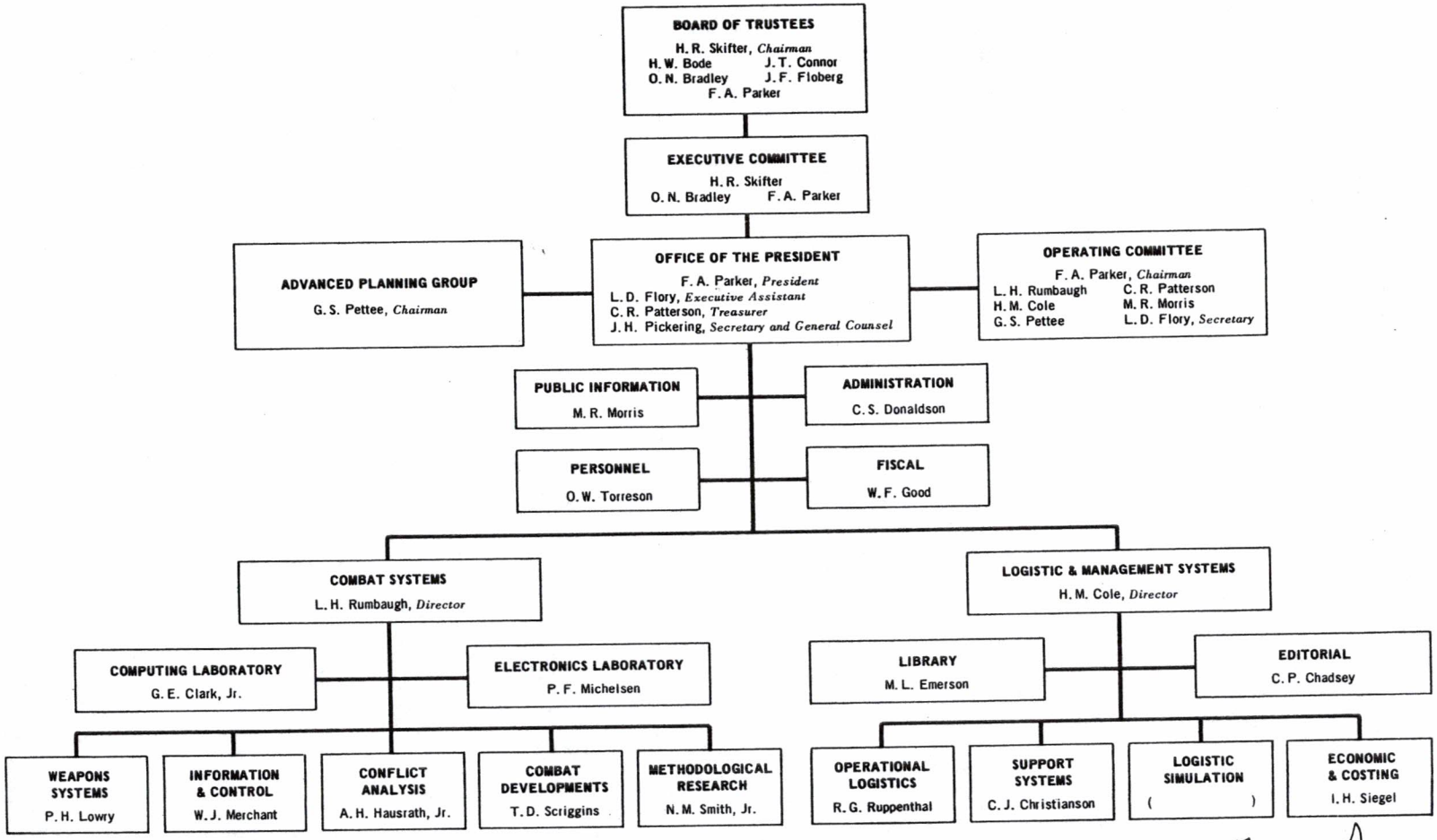
RESEARCH ANALYSIS CORPORATION



September 1, 1961

Chart 2

RESEARCH ANALYSIS CORPORATION



APPROVED

Effective 26 March 1962

reestablish a balance of emphasis between such concerns and those of operations research characteristic of ORO's early years) was made with the encouragement of the Army and with an Army commitment to support the work with additional funds.

In 1964, Dr. Cole became Vice President for Operations Analysis, a grouping composed of most of the divisions formerly under Combat Systems and Logistics and Management, redistributed to reflect new program emphases.

The functions of the Advanced Planning Group were divided between a Research Council and an Office of Planning. The Research Council was formed to ensure that high standards in research performance were achieved and maintained. As a means thereto, the Council was to perform two major tasks: to subject the products of RAC studies to thorough criticism and to provide to management and senior research personnel highly qualified professional advice on the design and conduct of major studies. Chaired by Dr. George S. Pettee, the Council included Dr. Rumbaugh, General T. T. Handy, who had been associated with ORO/RAC since his retirement from the Army in 1954, and Dr. Irving H. Siegel, former Chief of RAC's Economics and Costing Division.

The mission of the Office of Planning included determination of trends in client requirements and the capabilities of the RAC staff to meet these needs, and development and maintenance of a corporate plan of growth. Mr. Philip R. Compton, formerly with Lockheed Missiles and Space Company, was appointed Director of Planning in August of 1964.

In September 1965, fifteen RAC divisional units were reduced to eight autonomous departments (see chart 3). Logistics activities were combined in one department, the four Systems Engineering divisions were amalgamated and became the Unconventional Warfare and Science and Engineering Departments. Support Systems, Field Experiments, and the Electro-Mechanical Laboratory were disbanded and the personnel absorbed into other departments. Foreign Operations was split and each field office placed under the department chiefly responsible for the kind of work done in each. A Technical Committee was appointed for the purpose of bringing together corporate and departmental heads for discussion and resolution of problems affecting all of RAC. In the 19 months since the last previous organizational change, 28 professionals and 32 support personnel had been added to the RAC staff.

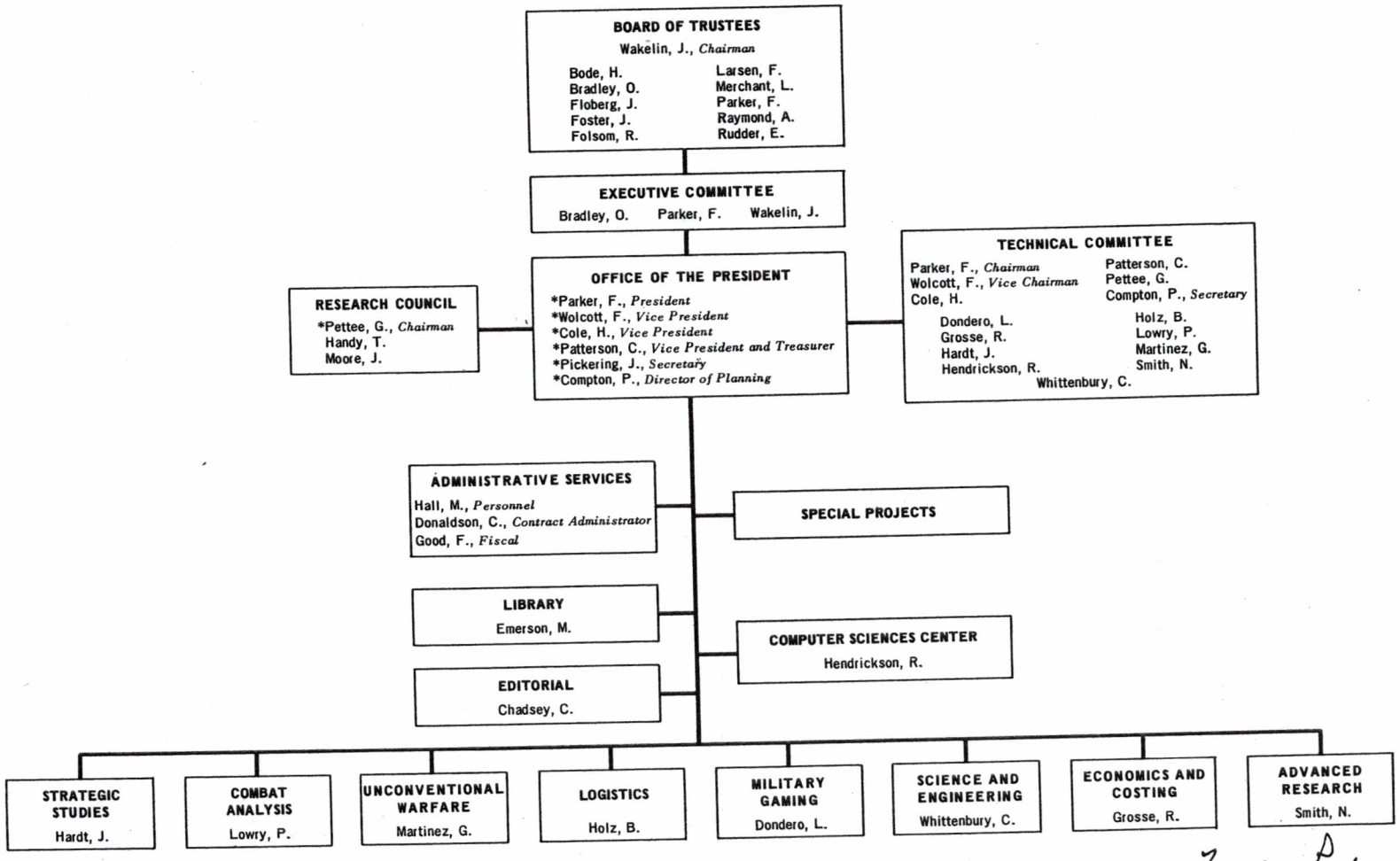
In 1966 and early 1967, the Army considered with RAC its probable needs for studies in the social sciences that were not being met by existing organizations to which the Army could turn. It was determined that the Army had some unmet requirements, but that it was not feasible or appropriate to redesign RAC radically so as to meet them. Instead—and particularly in view of the apparent prospects and needs for diversification of RAC's clients and skills—it was decided that RAC should try to develop capabilities to meet the needs of other agencies for social scientific studies, which capabilities would then be available to the Army. RAC responded in July 1967 by setting up an Exploratory Development Group to determine promising areas of work, supporting it with RAC funds. This group was led by Dr. Edmond C. Hutchinson, formerly Assistant Administrator for Africa of the Agency for International Development (AID), as Chairman.

An Office of Corporate Planning was also established in July, with Mr. R. Shale Paul, formerly Senior Analyst, Committee for Economic Development, as Director. The Office of Planning was retitled the Office of Program Development at this time.

A recommendation made by the Secretary of Defense that Federal Contract Research Centers seek clients in other Federal departments and in state and local governments gave new

Chart 3

RESEARCH ANALYSIS CORPORATION



*Member of Operating Committee

APPROVED

1 September 1965

impetus to RAC's diversification efforts, already well launched in response to Congressional ceilings and changes in the demand both for operations analysis per se and for other kinds of service that RAC might provide in the future. RAC made organizational changes designed to facilitate diversification and adjust to new client demands and research emphases in June 1969 (see chart 4). Three major research areas were established, each under the supervision of a Vice President. Dr. Cole was given responsibility for Operational Systems, Mr. Wolcott for Technological Systems, and Dr. Hutchinson for Economic, Political and Social Sciences. The names of a number of departments were changed to fit their primary functions more closely. The Combat Analysis and Unconventional Warfare Departments were dissolved, and the two offices formerly composing the Exploratory Development Group–Public Communications and Safety, and Economic and Social Development–became full-fledged departments.

Mr. Wolcott resigned in September 1969 and was replaced as Vice President, Technological Systems, by Dr. Clive G. Whittenbury, former Chief of Science and Technology Department. On Dr. Pettee's retirement in November of that year, Dr. Charles A. H. Thomson, formerly of the RAND Corporation, became Chairman of the Research Council. The Strategic Studies Department was disbanded early in 1971. RAC's organizational structure at the end of ten years is shown in Chart 5.

PERSONNEL

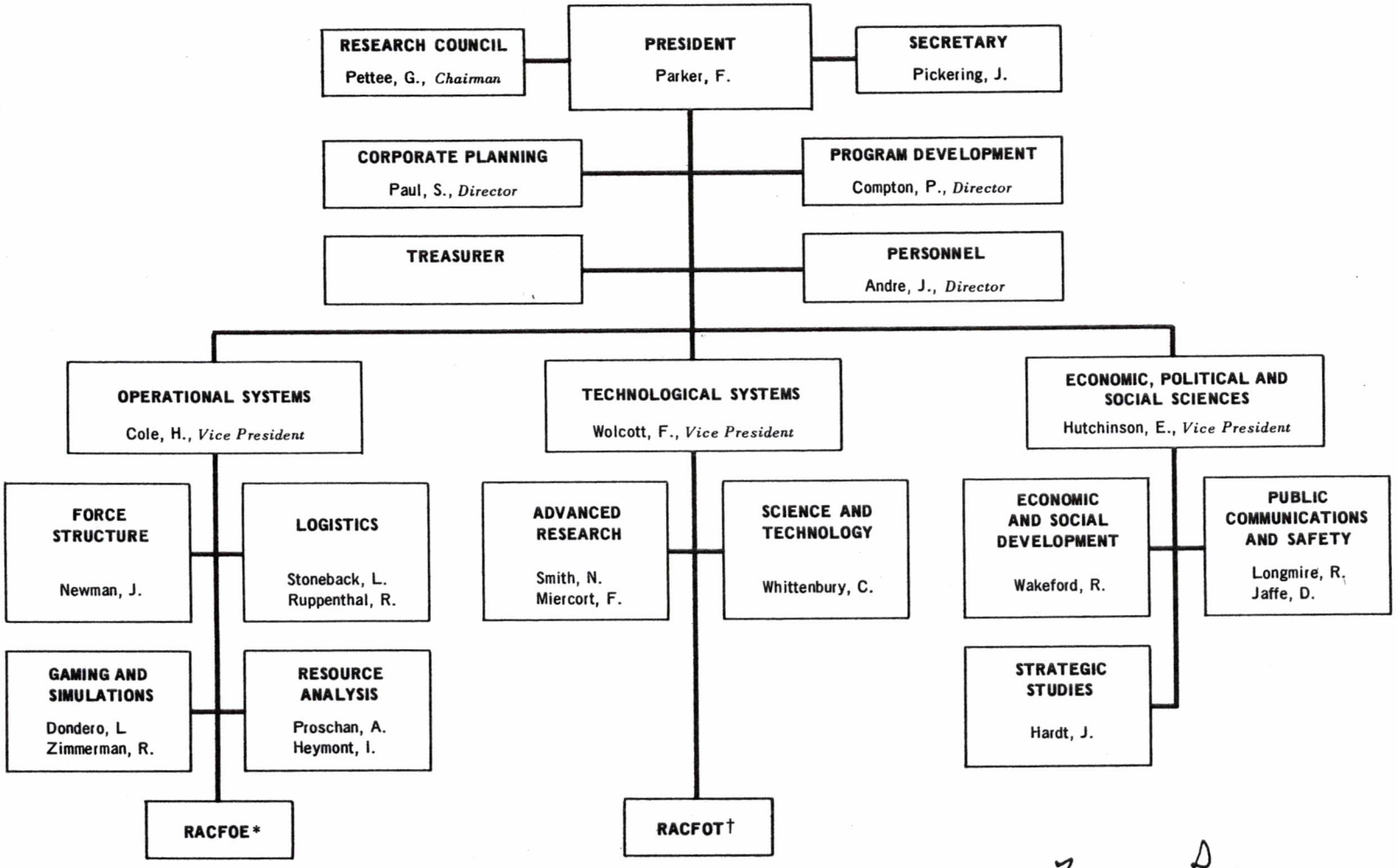
At the time of the changeover from ORO in September 1961, RAC had 430 full-time employees, classified either as management and technical staff (MTS), or support staff. Although a broad distinction was made between these two groups, the detailed basis for assigning personnel to one of the other changed throughout RAC's life, as RAC management sought to maintain a proper balance between them and to keep down the costs of a technical manyear (TMY) of effort. RAC sought to accomplish this by reducing support staff, either by attrition (especially in the early years) or by reductions in force (in later years). Of the initial 430 staff members, 146, or 34%, were classified as MTS. The remainder of 284, or 66%, were classified as support personnel. The technical staff steadily increased in numbers for the next five years and had almost doubled by 1966, when it constituted 46% of the total staff. During the peak year of 1967, RAC had 287 on the technical staff and 355 on the support staff, for a total of 642 full-time employees. At the close of the decade, professionals and support personnel were each just 50% of the total RAC staff of 401 (see Table 1).

In September 1961, 36% of the RAC professional staff were college graduates with bachelor's degrees, 38% had obtained their master's degrees, and 23% had their Ph.D's (see Fig. 1). At the mid-point, 1966, 39% of the professionals had bachelor's degrees, 41% had master's, and 16% were Ph.D's. Although there were some slight fluctuations in these percentages in the next five years, the proportions were the same in September 1971. There was a 5% increase in staff members holding both bachelor's and master's degrees over the decade and a decrease of 7% in professionals with Ph.D's.

Composition of the RAC professional staff by field of study or discipline showed a marked change over the 1961-1971 period. Forty-four percent of the staff held degrees in the social and life sciences in 1961, as compared to 56% in the engineering, physical and mathematical sciences. The social and life science group had declined to 35 percent by 1966 and to 33 percent by 1971, while those with engineering, physical and mathematical science degrees represented 65 percent of the total by 1966 and 67 percent by 1971 (see Table 2).

Chart 4

RESEARCH ANALYSIS CORPORATION



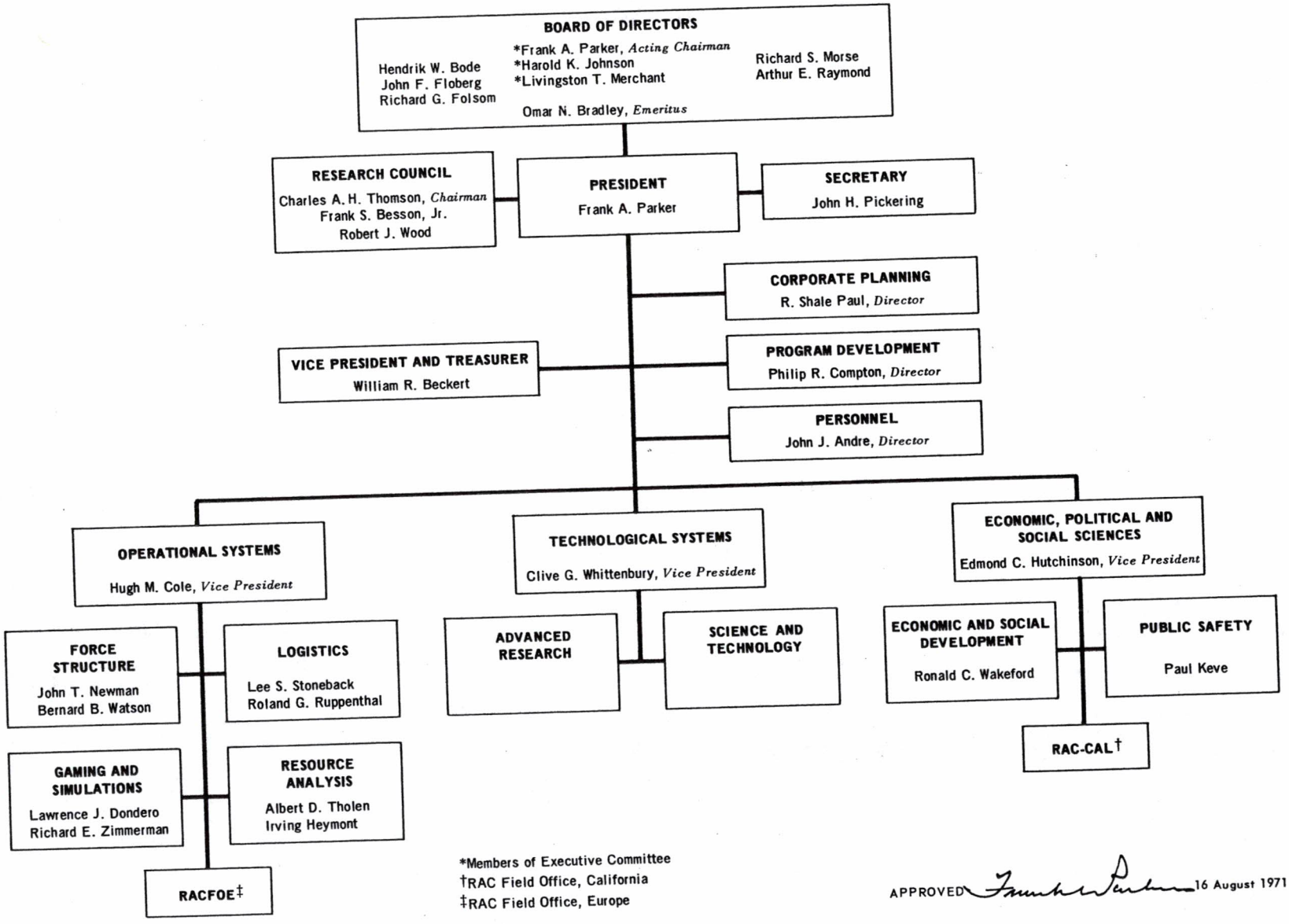
*RAC Field Office, Europe

†RAC Field Office, Thailand

APPROVED Frank Parker 16 June 1969

Chart 5

RESEARCH ANALYSIS CORPORATION



*Members of Executive Committee
†RAC Field Office, California
‡RAC Field Office, Europe

APPROVED Frank A. Parker 16 August 1971

RACFOE+

‡RAC Field Office, Europe

APPROVED 16 August 1971

Table 1

STAFFING[a]

(yearly, as of 1 September)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972[b]
MTS[c]	146(.34)	171(.39)	214(.43)	243(.45)	262(.44)	280(.46)	287(.45)	251(.44)	222(.42)	202(.45)	201(.50)	142(.48)
Support	284(.66)	264(.61)	278(.57)	304(.55)	333(.56)	331(.54)	355(.55)	321(.56)	301(.58)	244(.55)	200(.50)	151(.52)
Total	430	435	492	547	595	611	642	572	523	446	401	293

[a]Full time employees.

[b]As of 31 Aug 72.

[c]Management and Technical Staff.

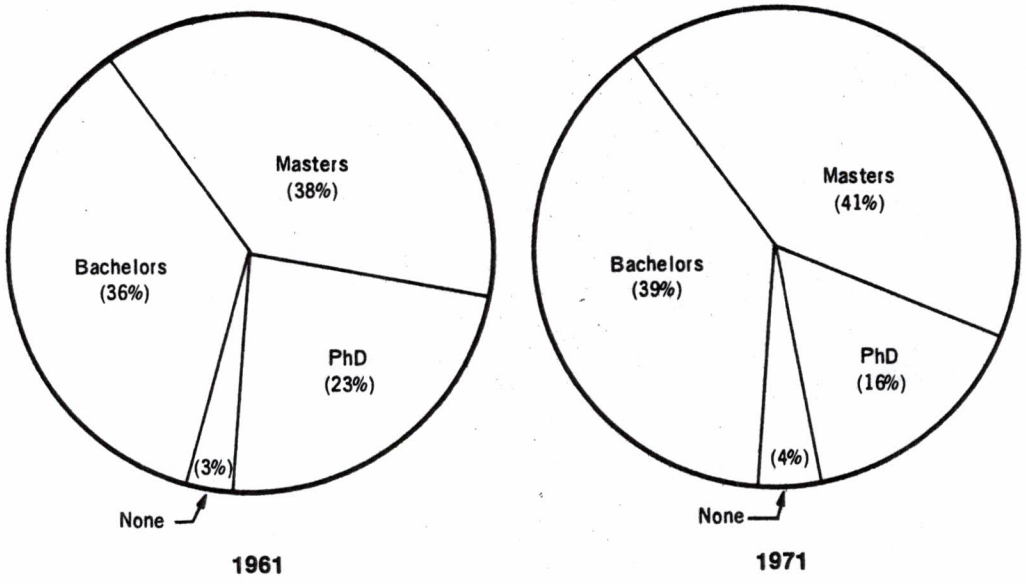


Fig. 1—Professional Staff—By Degree

Table 2

PROFESSIONAL STAFF[a]

By Degree/Discipline

(as of 1 September)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Social & Life Sciences	58(.44)	72(.45)	87(.44)	105(.42)	99(.38)	99(.35)	99(.36)	73(.30)	80(.35)	70(.34)	58(.33)
Engineering, Physical & Mathematical Sciences	74(.56)	88(.55)	110(.56)	147(.58)	164(.62)	181(.65)	180(.64)	167(.70)	146(.65)	137(.66)	121(.67)
Total	132	160	197	252	263	280	279	240	226	207	179
As % of total:											
Economics	16(.12)	20	29	39	35	28(.10)					21(.11)
History	8(.06)	10	11	11	7	7(.025)					2(.01)
Military Science	6(.04)					14(.05)					7(.04)
Political Science	7(.05)					17(.06)					5(.03)
Engineering	19(.14)	24	37	53	66	68(.24)					41(.23)
Math. & Statistics	23(.17)	31	34	50	49	44(.16)					37(.21)
Physics	22(.17)	21	20	19	17	18(.06)					13(.07)
Operations Research				4	10	27(.10)					17(.09)
By Education:											
No degree	5(.03)	5	5	12	13	10(.04)	6	6	6	8	7(.04)
Bachelors	47(.36)	61	77	111	107	110(.39)	103	88	80	78	70(.39)
Masters	50(.38)	63	74	87	97	115(.41)	117	100	96	80	74(.41)
PhDs	30(.23)	31	41	42	46	45(.16)	53	46	44	41	28(.16)
Total	132	160	197	252	263	280	279	240	226	207	179

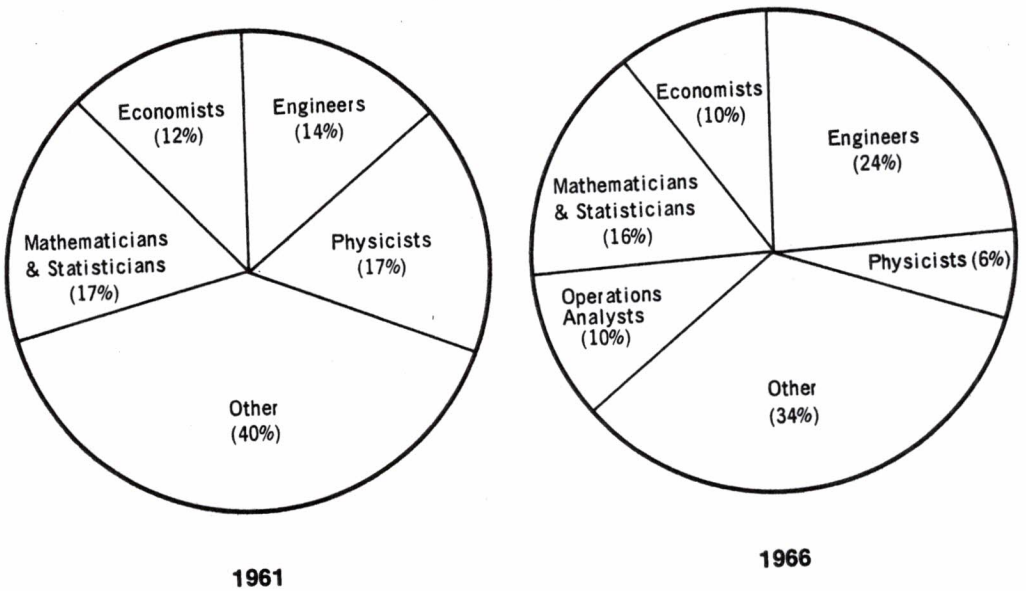
[a]Full time employees.

In 1961 more RAC staff members had degrees in physics than in any other discipline, and physicists represented 17 percent of the total professional staff. Ten years later only 7 percent of the total professionals were physicists (see Fig. 2). Mathematicians and statisticians combined also composed 17 percent of the staff in 1961 and showed a percentage increase of 4 percent over the ten-year period. The number of RAC engineers doubled in the first two years of the decade, and by 1966 was three and a half times that of 1961. Although considerably less in numbers by 1971, engineers formed the largest group and accounted for 23 percent of the professional staff. Economists, who rose from fourth to third ranking because of increased numbers, declined over the period as a percentage of total professionals. Operations analysis as such was not among the disciplines used by RAC to categorize its staff in 1961. This category was introduced soon thereafter. Operations analysis was in fourth position by 1966 and maintained that ranking through the remainder of the decade.

In 1961, 20 percent of total support personnel were assigned directly to departments, six percent were assisting in the computer and electronics laboratories, and the remaining 74 percent were deployed as shown in Table 3. In 1967, the peak employment year, the Computer Laboratory (COMPLAB) support made up 10 percent of the total, and the number working in the departments had increased to 31 percent. At the close of the decade the percentages of the three groupings were substantially the same as they had been in 1961–19 percent in the departments, seven percent in the computer laboratory, and 74 percent in the other areas.

A special feature of RAC's organization was the Office of the Senior Military Adviser. The Adviser was furnished to RAC by the Army's Office of the Chief of Research and Development (OCRD). The Adviser and a small staff of officers provided day-to-day liaison with RAC, from the office of RAC's President on down, facilitating the flow of information, proposals, and approvals relating to the conduct of RAC's research for the Army. This office also provided contracting officer's technical representatives. The Senior Adviser or his representative was always present at each meeting of each Study Advisory Group set up by the Army to monitor, guide, and evaluate progress and results of each RAC project. The Senior Adviser was usually an experienced Army officer of the rank of Colonel. As such, he was able to give invaluable informal advice and counsel to RAC staff, as well as to perform his prescribed duties. His office handled administrative matters, arranging for notification and official permissions for RAC staff to visit field headquarters, channeling correspondence and communications between RAC and the various Army staffs and agencies involved in RAC's work. The Office was set up in July 1948–during the ORO days–and it maintained its status and functions until June 1, 1972. On that date it was closed out in view of the expected sale of RAC to The General Research Corporation (GRC). In many ways, this office played an invaluable role in easing the many relationships between RAC and the Army staffs, incident to the formulation and execution of RAC's annual work program.

The annual work program was arrived at by joint negotiations between RAC's senior managerial staff and key project leaders on the one hand, and the Army's Chief of Research and Development on the other. This office channeled contacts with the major interested Army agencies, although much of the substantive discussion and formulation of the Army's annual work program took place directly with key personnel, military and civilian, in the Army agencies for whom RAC studies were being authorized and funded. Final shaping of the



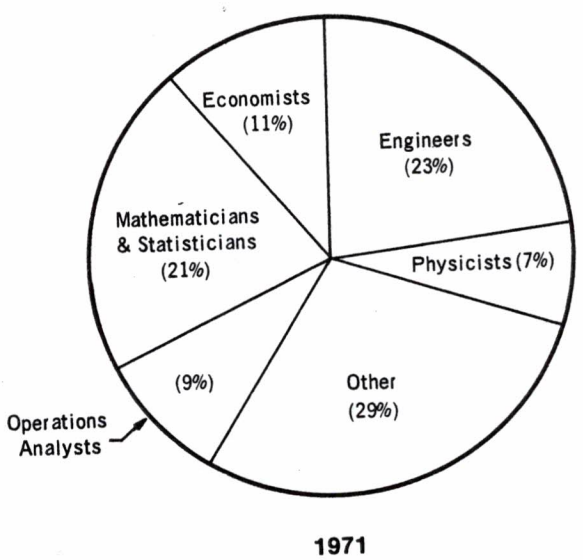


Fig. 2—Professional Staff—By Discipline

Table 3

SUPPORT STAFF[a]

(as of 1 September)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
President, RC, CP, PD, SMA	11	12	13	10	9	11	11	7	7	7	7
Vice Presidents		4	8	4	4	4	4	4	9	8	9
Treasurer/Controller/Fiscal	10	10	10	14	14	14	18	21	21	21	19
Adm. Mgr/Contracts	2	2	2	2	2	2	3	5	4	3	3
Procurement	2	2	3	3	3	3	3	3	3	1	1
Editorial/Production	38	36	37	40	45	41	46	49	45	30	22
Library	15	13	13	16	17	16	17	16	15	13	14
Personnel	14	13	12	13	20	20	15	14	12	9	10
Security	47	42	29	26	26	24	27	23	20	16	16
Document Control	27	23	22	21	19	17	19	15	14	13	12
Office Services	44	40	40	42	41	48	47	46	44	39	35
Computer Lab.	8	7	12	17	26	33	36	28	24	15	14
Electronics Lab.	8	10	15	17	12						
Operations/Logistics	5	6	7	6	10	25	28	26	30	29	8
Management Systems	9										
Support Systems		4	4	6	6						
Combat Developments		2	5								
Field Experiments				5	4						
Weapons Systems	11	9	8								
Combat Analysis				9	8	8	6	6			
Force Structure									2	4	3
Information & Control	6	3	2								
Systems Engineering				8	13						
Unconventional Warfare						10	15	6			
Science & Engineering						10	8	6			
Science & Technology									6	4	6
Economics & Costing	8	6	7	9	12	14	14	9			
Resource Analysis									9	5	4
Basic/Advanced Research	3	2	2	5	6	6	8	8	7	4	2
Special Studies		3					2	1			
Strategic Division	10	13	23								
Military Gaming				20	21	18	17	12	11	7	6
Strategic Studies				5	6	7	10	9	8	7	
Pol/Mil Studies											2
Soviet/Com Studies											1
Field	6	2	4	6	9				4	1	
Exploratory Development							1	7			
Econ. & Soc. Dev.									3	4	3
Pub. Com. & Safety									3	4	3
Totals	284	264	278	304	333	331	355	321	301	244	200

[a]Full time employees.

program, on the Army's side, was the responsibility of the office of the Assistant Vice Chief of Staff. Army-wide coordination was accomplished through an Army Study Advisory Committee. This Committee, and its staff supporting agencies, considered in detail every proposal for a study, its definition and its proposed funding. Its work in effect determined what RAC could do within the limits of overall funding and study definitions. Some flexibility remained, however. During a given work year (each work year ran from September 1 of one year to August 31 of the next), funding and study approvals could be reprogrammed to permit work on studies regarded as of higher priority or urgency. For contractual administration, the Army's contracting office grouped all the authorized studies into six task orders. This arrangement improved visibility and control of grouped studies, while retaining adequate flexibility and permitting easily feasible administration on RAC's part.

The Study Advisory Groups (previously called Project Advisory Groups, or PAGs) were set up by the Army under a general regulation (AR 1-110, of January 22, 1968) to monitor all Army-sponsored contractually supported studies and analyses. Although created by and responsible to the Army, the SAGs functioned virtually as a working element of RAC's project teams. They not only provided the overall guidance, problem definition, and flow of necessary facts and comments called for in their authorizing regulation, but many of their members worked closely and directly with the RAC staff. The SAGs met as often as needed to review work in progress to assess the achievement of milestones on the way, and to evaluate final RAC reports. They were set up for the life of a project. It was hoped that their membership would remain stable for the life of the project, to provide continuity of leadership and familiarity with the scope and details of research execution. This was not always the case, either with respect to the Chairman, who played a vital role, or with respect to membership from other participating Army agencies. (The Chairman came from the sponsoring agency—the one that initiated the project and expected to use its results. Other members came, on invitation, from other Army staffs or agencies with an interest in the research or its outcome. Representation of the Office of the Special Assistant to the Army's Undersecretary for Operations Research was mandatory.)

The work of the SAGs had a special dimension, not explicitly recognized in their authorizing regulation, that arose from the representation of all or most Army agencies interested in studies or analyses of a topic that was controversial within the Army. Since each SAG member was required to give his agency's official assessment of work in progress, SAGs served as indicators of the range of opinion, interest, and involvement of several Army agencies. Although SAG votes were always taken without RAC members present, the range of attitude and opinion was usually apparent. Hence RAC was able to get an overview of the impact of issues and differences of opinion that might not otherwise have been so clearly revealed. Moreover, since RAC staffs during most of the decade tended to be more stable, and work on particular topics with more continuity than did the Army representatives (whose changing career assignments made continuity more difficult and unlikely), RAC itself became a source of continuing understanding of problem and developments that was often invaluable to Army agencies and their representatives. SAGs sometimes served as informal but vital channels of communication among Army agencies.

SAG formal structure, duties, and functioning tended to emphasize the immediate, the realistic, and the clearly usable research and its results that reinforced trends toward short-run

studies narrowly conceived. This was not always so—in the FOREWON exercise, SAG work was sustained at a high level over a long period. But for such studies to be conceived and executed, there had to be a special awareness of need. Moreover, back of the SAGs stood general officers within the Army structure, charged by a Chief of Staff Memorandum[1] with supervision and monitorship of all important OR studies, whether done by RAC or not. These monitors were responsible for assuring sound conception at the outset, sound execution (with virtual power to terminate a study if they thought it necessary), and clearly usable results.

A final comment on the broad development of RAC's management, staffing, and relations with the Army is in order. As RAC grew, with a wider range of studies and functions, with larger staffs, and with changes in the Army environment, it was necessary for RAC to provide much stronger management, with more elaborate organization, than had sufficed for ORO. In particular, as the challenges and needs for diversification grew, management had to do much more than arrange for the orderly execution of business for the Army. New clients had to be sought, new tasks and new capabilities had to be fashioned. During RAC's life, RAC's personnel shifted. The Army's relation to RAC occasioned more specific procedure and control by regulation. RAC's management had to grow and change to cope with the new needs.

1. CSM 68-450, 26 November 1968, "Monitorship of the Army Contractual Operations Research (OR) Study Program."

Chapter X

RAC's GOVERNING BOARD AND TOP MANAGEMENT

Boards of directors of corporations generally share certain common concerns and responsibilities, such as the determination of broad goals and decisions on main fields of work; the selection and compensation of top management and key staff; the formulation of broad corporate policy and the making of key choices governing structure, function, and manner of operation; and concern with main relationships with key clients, the world of business and the professions, government, and the public. The Board of the Research Analysis Corporation bore all these responsibilities, and more. The nature of all these responsibilities and the way in which RAC's Board dealt with them are the subjects of this chapter.

From RAC's inception in 1961 until early 1969, the Board and top management dealt chiefly with the problems of fashioning and guiding RAC first to perform its major initial mission: to provide special services to one primary client, the Army; and then, to reshape the Corporation to meet stresses and challenges that appeared later on. Despite success in molding such an organization, it became clear from 1966 on that several main conditions under which RAC was attempting to carry out this major mission were changing. They were changing in ways that brought into increasing question the reasonableness and viability of RAC's special relation with the Army. Therefore the Board and management had to consider several courses of action. Could these changes be coped with, and RAC's essence preserved, so long as RAC maintained its special relation to the Army? Did preservation of RAC's capability for service to the Army, and to its other clients, call for a drastic change in that status? And finally, should RAC be dissolved or disposed of, on the grounds that it was no longer viable in the circumstances of present and foreseeable client and Congressional attitudes and actions?

By 1969 it seemed to RAC's Board and top management that a change of status was unavoidable. Together they examined alternatives and set out a course of action whereby RAC's essence, although not its status as a specialized agency, might best be preserved. This latter topic is the subject of a later chapter.

Throughout both phases, the Board worked out necessary and proper relationships with RAC's management for division of functions in establishing broad policy and guidelines for corporate development. The Board respected management's autonomy in operational matters, while management kept the Board fully informed. Responsibility for the fashioning of programs of work, jointly with the Army or with other clients, was the prerogative of management. Major responsibility for relations with the Army fell on management. The President staffed with the Army the Board's views and concerns about the nature and composition of RAC's work for the Army and kept the Board informed about the course of consensus or disagreement on matters of work programs. The Board, at the special invitation of the Director of Defense Research and Engineering, gave to the Department of Defense and

to the Army its independent views about the RAC work program, in three annual reports. In the later phases, as diversification developed, a similar pattern for handling responsibilities for relationships with other clients was followed.

The Board's overriding concern throughout RAC's existence was to be sure RAC was doing everything it should do to be of maximum usefulness to the Army. Issues of diversification of clients and work were considered and acted on so as to keep this goal dominant. When RAC's charter was changed to recognize diversification of clients, the Board reaffirmed the principle that diversification should not be at the expense of maximum service to the Army. Questions of fee to be paid by all clients were considered in the light of the objective that RAC should have enough fiscal stability and independence to permit sustained operations—and opportunity to explore new fields of service that would benefit the Army as well as the direct client paying the fee, wherever development of capability benefiting a number of clients was feasible and justifiable. The Army hoped that RAC could develop capabilities for social scientific research of benefit to the Army without direct Army support by doing work for other clients. Administration of RAC's contracts with the Army (including dealing with auditing and questions of proposed disallowances raised by the Defense and Army auditing agencies) was a management responsibility, although the Board gave advice and support in such matters. The Board also commissioned its own annual audit by a private firm.

To ensure continuity in Board supervision and relations with management, the Board set up an Executive Committee, with appropriate powers. Both the Executive Committee and the Board itself considered whether RAC's growth in personnel, funding and breadth of functions was appropriate in the light of client needs. They took care to see that RAC's growth and activities should not give justifiable grounds for Congressional concerns that government was relying excessively on contractors to perform tasks which the government should do for itself, or that RAC's activities constituted unfair competition with other suppliers of studies and advice. The Board took pains to see that RAC was so organized and managed that RAC's output would be of consistently high quality.

Recognizing Congressional interest in questions of proper compensation of management and staff, and in avoidance of problems of real or presumed conflict of interest, the Board from the outset paid close attention to such matters. It set up a Compensation Committee to consider them and give detailed study to management reports on the structure, policies, and details of RAC's personnel administration and staff. The Board reviewed and approved the employment and compensation of all key management and professional appointees nominated by management. At Congressional prompting, the Board set up policies not only to obviate conflicts of interest on the part of the management and staff, but also to ensure that Board members themselves would not be open to such charges.

The Board took its management and fiduciary responsibilities seriously, but it did not try to run the company. Responsibility and authority were effectively delegated, and the Board insisted on full reporting so it could be sure that they were properly exercised. The Board kept RAC's broad operations under sustained scrutiny, striving to ensure that RAC would always measure up to the Army's early intent in establishing it as a vigorous, independent source of high quality work bearing on important problems and needs of the Army. Once it appeared that conditions surrounding the Army's intent had irretrievably changed, the Board sought to preserve RAC's essence, quality, and capabilities, taking account of the new and future environment.

ARTICLES OF INCORPORATION AND BY-LAWS

RAC's formal legal structure was set up in Articles of Incorporation, and its major organization and modes of procedure set forth in By-Laws. The Articles of Incorporation provided for RAC's name, declared the Corporation to be perpetual, and set forth its purposes, initially to provide services for the Army and for the Federal Government. The Articles also provided for a Board of Trustees (later renamed Directors); while stipulating there would be no shareholders and no net earnings should inure to the benefit of any private individual. The Articles provided further that no substantial part of the Corporation's activities should attempt to influence legislation by propaganda or otherwise, and no part of its activities should consist of participating, directly or indirectly, in political campaigning. The articles provided, finally, that

> "Upon the dissolution or winding up of the Corporation, after adequately providing for its debts and obligations, the Directors or person or persons in charge of liquidation shall turn over any remaining assets to the United States of America as the Secretary of the Army may direct."

These Articles, first filed on June 6, 1961, remained virtually unchanged throughout RAC's independent existence, with one important amendment adopted by the Board at its meeting on October 10, 1967. This amendment broadened the language of the charter so as to enable RAC to serve clients other than the Federal Government, while preserving its tax-exempt status. This amendment was proposed after discussion with the Army, and in particular with the approval of the Assistant Secretary of the Army for Research and Development. At this time, the members of the Board were redesignated Directors, rather than Trustees.

RAC's By-Laws, consisting of ten short articles, covered the usual subjects of place of offices, corporate seal, Board of Directors, committees, officers, contracts and bank accounts, fiscal year, waiver of notice, indemnification, and amendment. The number of directors could vary between three and twelve, with a three-year term of office.

MEMBERSHIP

As noted in Chapter III, Dr. Hector A. Skifter, President of Airborne Instruments Laboratory, was elected Chairman at the first meeting of the Board of Trustees in June, 1961. Dr. Hendrik W. Bode, vice president of Bell Telephone Laboratories; John T. Connor, president of Merck & Co., Inc.; and General James McCormack, Jr., vice president, Massachusetts Institute of Technology, were present. General Omar N. Bradley, Chairman of the Board, Bulova Watch Company, was absent. John T. Pickering was elected Secretary of the Corporation. At the next meeting, on July 7, 1961, Frank A. Parker, Jr., was elected President of RAC and a member of the Board. It was announced that General McCormack had resigned.

Dr. Skifter continued as Chairman of the Board until his death on July 25, 1964. Dr. Bode succeeded him as temporary Chairman on September 18, 1964. At the meeting of August 16, 1961, the Board welcomed John F. Floberg, general counsel, Firestone Tire & Rubber Company, as a new member. Mr. Connor resigned in January 1963, on the occasion of his appointment as one of the incorporators of the Communications Satellite Corporation.

In Congressional hearings in August 1962[1], some concern was expressed that the Board membership came chiefly from industry. The Board in response sought additional members,

1. *Hearings* on System Development and Management (Part 4) before the Subcommittee on Military Operations of the House Committee on Government Operations, August 15, 1962, p. 1442.

partly to strengthen academic representation and also to attain wider geographic distribution. At its meeting on March 29, 1963, the Board elected Dr. James E. Rudder, President of Texas A&M University System, to fill out the term vacated by Mr. Connor. At its meeting on May 27, 1963, the Board elected Dr. Richard G. Folsom, President, Rensselaer Polytechnic Institute, to membership. At the meeting of January 8, 1965, the Board elected four additional trustees: Mr. Arthur E. Raymond, formerly vice president, Douglas Aircraft Corporation; Dr. Finn J. Larsen, vice president of Minneapolis-Honeywell Corporation; Dr. John S. Foster, Director, Lawrence Radiation Laboratory; and Dr. James H. Wakelin, Chief Scientist, Ryan Aeronautical Corporation. At its meeting of June 25, 1965, the Board elected Ambassador Livingston T. Merchant as a member, and elected Dr. Wakelin to be Chairman. In October, the Board accepted the resignation of Dr. Foster, who had been appointed Director of Defense Research and Engineering. Dr. Larsen resigned in November 1965, on his appointment as Deputy Director of Defense Research and Engineering.

On October 31, 1966, the Board elected Mr. Richard S. Morse, Sloan School of Management, MIT, to membership. At the meeting in May 1968, General Bradley resigned as a regular member, and he was named a Director Emeritus. On July 15, 1968, the Board elected General Harold K. Johnson (USA-Ret) to membership.

The Board's membership remained unchanged until the death of Dr. James Rudder on March 23, 1970. On October 28, 1971, Dr. Bode resigned. Dr. Wakelin resigned in January 1971, on his appointment as Assistant Secretary of Commerce for Science and Technology. Mr. Parker replaced him as Acting Chairman. Mr. Raymond announced at the meeting of December 16, 1971, he would not seek re-election at the conclusion of his term in 1972. Dr. Wakelin rejoined the Board in August 1972.

INTERNAL STRUCTURE

At its third meeting, on August 16, 1961, RAC's Board set up an Executive Committee. Originally composed of Dr. Skifter, General Bradley, and Mr. Parker, this committee met, usually once a month, to discharge tasks within Board delegation of authority and to prepare subjects for Board consideration and action. The powers of the Executive Committee were broad from the outset.

Recognizing the importance of sustained attention to problems of salary structure and personnel administration, the Board set up a Compensation Committee on January 8, 1965. This action was prompted in part by Congressional interest in salaries paid by RAC and by similar organizations. Members of key Congressional committees, including those on Armed Services and Civil Service, wanted to be sure that salaries were reasonable in comparison with civil service pay ranges, and with salaries paid for similar positions by private industry. The Board also recognized that the comparative salaries paid by RAC had a great deal to do with RAC's ability to recruit, motivate, and retain first-rate personnel.

The Compensation Committee, appointed by the Chairman, was empowered to review periodically, and report and make recommendations to the Board concerning compensation policies, officers' salaries and salaries of employees in excess of $20,000, and the fringe benefit program of the Corporation. These tasks had previously been discharged by the Executive Committee or the Board itself. The Committee considered the adequacy of RAC's program of fringe benefits, its comparability to those offered by similar organizations, and its acceptability to the government. The Committee also dealt with the various details arising from the Board's policy that RAC salaries should be competitive with those of agencies doing similar work, and competing for staff from the same sources.

CLIENT RELATIONS

Central to the concerns of RAC's Board and top management for shaping and preserving RAC's essential nature, lay the continuing and changing problems of client relations. For client relations bore heavily on the conditions of independence, objectivity, financial stability, creativity, and relevance of work to the major interests and needs of clients, and to the public interest. These conditions virtually determined RAC's capacity to do worthwhile work on emerging and imprecisely definable problems, and to produce results of high credibility and value.

At the outset, these problems were addressed in a situation in which RAC had only one client—the Army. The Army's views on issues of independence and judgment of what problems would be of relevance to the Army's needs and long-term interests underlay its decision to change ORO into a new organization. RAC's Board and management had to take a stand on the proper scope of RAC's independence, and the proper role of RAC in selection of work projects and programs, and balance them with the Army's concepts of how RAC should respond to Army—perceived needs and interests. Both the appearance and reality of objectivity of research and its reporting had to be sought within a relationship sufficiently intimate with the Army to permit full awareness of the Army's position on such problems—including those not infrequent cases when the Army itself was divided. Financial stability—adequate long-term support promoting staff stability and security and the freedom to deal at length with important problems—was obviously related to the Army's perceptions of the value of RAC's work, as well as to the recurring question of the proper amount of RAC's fee. Concern with public service through broad dissemination of research results had to be balanced against the requirements of timely and occasionally confidential advice to the Army on subjects of public controversy in which the Army (or parts of it) was playing on adversary role.

At the beginning, the Board and top management approached these problems with the understanding that RAC would have only one chief client, the Army. They expected that the Army would take account of RAC's needs for funds and data, and respect RAC's independence. For it was clear that in a relationship in which RAC had only one client, one source of funds and of information bearing on the client's special problems, RAC would be virtually at the mercy of the client in any dispute over serious issues. RAC had little independent bargaining power in such matters and, except for the effort to achieve reasonable financial stability through possession of a small equity that RAC controlled itself, did not seek such independence. The Board realized that without other sources of support (from other clients or from foundations, for example) RAC would have to choose between acquiescence or dissolution if the lines were rigidly drawn on any vital issue so RAC could not perform its mission of providing independent, objective, and scientifically sound advice. Yet when other potential clients approached RAC to do work for them, the Board's policy called for that work to be done if possible through the Army contract.

Questions of bargaining effectiveness aside, important trends appeared early in RAC's history that pointed strongly to the advantages of diversifying clientele and sources of support. First came increasing awareness that RAC's work for the Army could be improved if RAC, in serving other clients, assembled staff, capabilities and experience that would serve the Army as well. Another was increasing assertions, in government and in the research community, that a public service corporation had some obligation to make its capabilities as well as its research results broadly available for public purposes. More weighty than either of these, however, were the uncertainties and anxieties occasioned by the probable effects on RAC of

congressional controls on study centers. Already in 1961, such measures were visible. As the decade wore on, they took new and more severe forms that increasingly threatened RAC's growth, viability, and capability.

In RAC's early years, Congressional restrictions took the form of sharp questioning in committee hearings, admonitory language in committee reports, and the like. But by mid-decade, Congress was taking direct steps to restrict availability of government funds for RAC on a non-competitive basis. Such restrictions, or ceilings, included limiting spending to previous-year levels or reducing amounts that the Army or the Department of Defense could allocate to RAC work on a non-competitive basis. Such restrictions threatened erosion of capabilities in a period of rising research costs. Moreover, it became more and more likely that much sharper restrictions might be imposed if the Congress—or key Congressmen who interested themselves in such matters—felt they were warranted. These uncertainties were compounded by recognition that the ceilings and other limitations were imposed without taking reasonable account of the special requirements of a study center.

Since Congress did not impose these restraints on non-competitive funding for work not done for the Department of Defense or of the Army, one clear course of action to offset them would be for RAC to seek clients elsewhere.

It was not long before opportunities arose for RAC to contribute to work elsewhere in Defense than the Army; and for other agencies of the government as well. The Board and top management had to consider the impact of such involvements on RAC's work, management structure, and staff, as well as on RAC's responsibilities to its major client and to public service. Throughout, the Board considered them in the light of its judgment that whatever was done to diversify should not prejudice RAC's relationships with its primary client.

The issue of the relationships between objectivity and quality of research on the one hand, and diversification of clients on the other was raised in a broad context by a Presidential Committee (the Bell Committee)[2] in 1961-62. The Bell Committee pondered the values of a close relation between a study center and single client—promoting close acquaintance with structure and problems, confidence, confidentiality, and flexibility while risking the appearance of *ex parte* advice primarily shaped by considerations of the client's interests in adversary matters. The Committee balanced these values against the appearance or reality of objectivity, the sharing of capabilities in the new fields of systems analysis and operations research and hence broader public service possible if the study center served a number of clients. The Committee came to a qualified conclusion that "organizations of this kind should not be discouraged from dealing with a variety of clients, both in and out of government."[3]

RAC's Board, however, considering the same range of values, concluded that objectivity depended more on the caliber of management and staff than on a single or multi-client relationship; and the Board emphasized its own determination to expect and receive objectivity from the RAC staff.

2. A government committee appointed by President Kennedy in 1961, under the chairmanship of David Bell, then Director of the Bureau of the Budget. This committee was established to look into all aspects of the issues raised by government contracting for scientific evaluations and advice, research engineering services, and technical and administrative management services. The Committee's report, made public on April 30, 1962, was the first comprehensive consideration of these issues. It did much to clarify the differences between services provided by agencies involved in basic research and the provision of scientific evaluations and operations research and policy advice on the one hand, and agencies providing research, development, technical and engineering work and management on the other.

3. Loc. cit., p. 31.

Throughout RAC's life, even after the Corporation came to have contractual and client relationships with many agencies other than the Army or the Department of Defense, the Board concerned itself with those relationships almost wholly as they affected RAC's dealings with the Army as a client. In RAC's early moves to work for other military agencies, the Board approved relationships whereby funds and supervision were channeled through the overall Army contract.

President Parker reported to the Board at its eighth meeting (April 18, 1962) the Defense Department's view that while research organizations should be oriented to the needs of a single service, they should not be "captives," nor discouraged from serving a variety of clients. The Board then adopted a policy approving work for non-Army agencies so long as it did not alienate the Army or interfere with RAC's primary mission to serve the Army.

FEE

Another issue examined by the Bell Committee was that of the propriety and amount of a fee to be included in contract arrangements between not-for-profit study centers and their clients. Such fees in ordinary government contracting practices constituted additions to income of a contractor over and above all reimbursable direct and indirect costs, and thus were similar to a profit. In the case of not-for-profit institutions (such as RAC or RAND), however, such income was to be used for the broad objectives sought by the corporation. It was used to support independent research, to provide working capital, to acquire facilities, and to cover certain legitimate and non-reimbursable costs. In no sense was it comparable to profit. It was not designed to reward entrepreneurial foresight or efficiency.

The fee issue proved highly controversial through RAC's life. At the beginning, however, the Bell Report concluded that

> ". . . there are two sound reasons to justify payment of a development or general support allowance to (not-for-profit) organizations. One is (to) provide some degree of operational stability and flexibility to organizations which otherwise would be very tightly bound to the precise limitations of cost financing of specific tasks; . . . (and) to even out variations in the income of the organization resulting from variations in the level of contract work. A second justification is that most not-for-profit organizations must conduct some independent self-initiated research if they are to obtain and hold highly competent scientists and engineers. (Loc. cit., p. 41)"

The Board accepted these conclusions and throughout abetted RAC management's efforts to maintain fee in the Army contract at a level between four and five per cent of the face value of the contract. The Board also concluded that fee was appropriate in all its other contracts as well and fostered efforts to negotiate them with all other clients, both in and out of the Department of Defense, at appropriate levels. These levels were determined with reference to the size and duration of contract, and the practices of various clients, especially those not in the fields of national defense or security.

The Board adopted a guideline that fee levels should be maintained until RAC's accumulated equity approximated working capital for six months—a standard never more than half met. The Board particularly favored the use of fee to provide financial stability, flexibility, and independence; and to pay for corporate-sponsored research, especially in RAC's latter years when RAC sought diversification by broadening its capabilities.

GROWTH AND CONTROL

A third area for Board and top management concern also appeared early. This arose out of Congressional concerns, expressed, for example, in a 1961 report of the House Committee on Appropriations (H. Report No. 574, 87th Cong., 1st Session, pp. 53-54), over the failure of the Department of Defense to take adequate steps to control what the Committee believed to be unwarranted growth and unjustified use of contract agencies. RAC's Board, along with members of boards responsible for the governance of other study centers, was called on to play a role in shaping the Department's policies and ideas for control of study centers, and in finding ways to deal with these consequences of resulting Congressional actions as reflected in Defense and Army policies and procedures.

MANAGEMENT–THE ARMY CONTEXT

In delineating the broad outlines of RAC's proposed contract relationships with the Army, the Board and top management emphasized from the outset the necessity for the Corporation to maintain its independence in management concerns while at the same time recognizing legitimate interests of the Army. They insisted that the contract should be written in broad terms and embody a system of budgetary control that would allow appropriate reporting to the Army, but not submit the new Corporation to excessive restraint and direction exercised through formal and detailed contract provisions.

Efforts by some in the Army to establish detailed contracting procedures and requirements for progress reporting, monitoring and checks on performance[4] revealed that the Army could not be considered an organizational entity from the standpoint of research management. Officials responsible for writing and letting contracts for the procurement of goods and services were rarely familiar with the nature of a product such as studies and advice of a long-run character, incapable of precise specification in advance, not responsive to costs or pricing as the major determinant of value received. Contract administrators and auditors naturally tended to apply the established criteria and procedures of their profession–in which the procurement and management of innovative studies and research did not bulk large. Officials responsible for formulating research tasks, located in other parts of the Army, did not bear responsibility for contract administration or auditing, although they were better qualified for judging the importance of a problem and the quality of studies and advice relevant to it. Even those personnel, however, exhibited difficulties and shortcomings in visualizing and monitoring future-oriented research tasks. There were dangers that they would overmanage research and would bring to bear too limited and short-sighted perspectives on the formulation of problems, the assembly and manipulation of relevant data, and the assessment of results.

A particularly revealing example of the problems posed by the application of inappropriate auditing standards to the work of a study center occurred late in 1963. The Army Audit Agency (AAA) had issued a report on the Army-RAC relationship that went beyond normal criteria applied in auditing procedures to question the validity and worth of some of

4. At its 15th meeting (January 19, 1964), the Board, in considering the Army contract for the period 1964-65, took a firm position against the proposal of the Army contracting officer that each project under the contract be treated as a separate task order or, in effect, a separate contractual agreement. Such a system promised to lead to great administrative difficulties and risk great loss of flexibility to respond to the Army's changing needs. It might lead to as many as 400 separate contractual amendments each year. The Board accepted the Army's later proposal to group RAC's work under six basic task orders, one each for a broad class of work.

RAC's reports. It was not clear from the Audit report whether the reports in question were adjudged unsatisfactory because they contravened accepted Army views or policies, or whether they failed to meet standards of quality (admittedly unspecified), and hence were unacceptable for contract fulfillment.

The Board in its meeting of January 19, 1964, considered the issues. It promptly decided that if the basis for disallowance or complaint was a difference of opinion with the Army, the Board would uphold the right of the RAC staff to dissent from Army opinions since objective and independent research would inevitably lead to such differences on occasion, and RAC was responsible for giving the Army an independent view well-grounded in fact and analysis. However, if the issue turned on quality, the Board would take such action as seemed appropriate to improve RAC performance.

To assure itself as to the merits of the issue raised by the audit, the President appointed a special committee under the chairmanship of General Thomas T. Handy to review all the reports and documents in question and to give the Board an independent assessment of them. General Handy was uniquely qualified to carry out this mission. He had had a long and distinguished career in the Army, holding high command and staff positions. He also had worked with ORO and RAC since his retirement in 1954, and was intimately familiar with RAC's work program, personnel, and management practices. He and his committee advised the Board that RAC's work was generally of high competence and that the documents and reports in question in general demonstrated that quality; some criticism of the work in question was indeed justified, and some corrective action would be helpful; but this should be taken by RAC.

Throughout, the Board, acting through its Executive Committee for the most part, concerned itself with the problem of proposed disallowances by Army or Defense contracting officers of RAC expenditures.

In each year of RAC's existence it was audited. In every case, the auditors recommended a number of disallowances be imposed by the Army contracting officer. This resulted each year in a series of management negotiations, first with the auditors before they submitted their report, then with the Army contracting officer until a settlement was reached. These negotiations were conducted by RAC management, and the Board was kept informed. In general, the final disallowances were modest—only about 1.75% of the estimated face value of all contracts—and reflected the competent fiscal management of RAC.

BOARD REPORTS

As a result of Congressional concerns with Federal Contract Research Centers (or FCRC's),[5] each Board was asked by Dr. John S. Foster, the Defense Director of Research and Engineering, to give him an independent appraisal of the performance of their FCRC. He asked for their conception of its necessary attributes and their judgment on the manner in which the Department of Defense sponsor was using and supporting the Corporation. Dr. Foster asked for

5. The term Federal Contract Research Center, or FCRC, was arrived at by the National Science Foundation to apply to a relatively small group of non-profit agencies, chiefly funded by the Department of Defense or one of the services and responsive to the individual needs of the funding agency. These Centers included companies engaged (1) in basic research, (2) in operations research and policy studies, (3) in the provision of research, development, testing and engineering services, and finally (4) in provision of technical or administrative management of certain activities. The FCRCs were renamed Federally Funded Research and Development Centers (FFRDCs) in 1967, but the acronym FCRC remains in general usage. Sixteen of them were provisionally identified as providing services of the second type, in 1968. In 1971, only twelve were so identified. Federal appropriations for them in FY 1971 totaled $239 million; RAC accounted for $8,400,000 of that total.

short, high-level statements and assessments of overall performance and accomplishments; objectives and longer-range plans for achieving them; adequacy of controls over costs and spending; and ability and capability to perform worthwhile tasks—including effects of external factors of these qualities.

In three reports, transmitted to the Department of Defense through the Army in late 1967, 1968, and 1969, the Board took the opportunity to do more than make the broad assessments asked for. It stated its philosophy of its stewardship, pointing out that responsibilities for the governance of an organization devoted to public service in the public interest, and spending public funds, lay on the Board a burden not commonly borne by trustees of private corporations operating for profit. It indicated the ranges of its concerns, encompassing judgments of the quality of research and reporting and the utilization and devising of appropriate scientific methodology. It took account of improvements in fiscal and personnel management, expressing special interest in staff development as well as the control of salaries and costs. It concerned itself with the development of goals, missions, and long-range plans for achieving them. It took special interest in the work of the Exploratory Development Group and in other measures to achieve diversification, while maintaining surveillance to ensure that such efforts would be compatible with continuing good relations with the Army, and would proceed rapidly enough to offer some assurance of continuing growth and financial stability.[6]

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6. The Board reported:

> . . . it has made certain that it is kept continually informed so that it is in a position to advise on the technical issues and problems under investigation by the corporation, and on the basic operating policies and systems of information designed to give visibility to all aspects of RAC's operations.

The Board added:

> As examples of the degree to which the Board actively exercises its responsibilities of stewardship, the following are descriptive: . . . the Board reviews and approves the basic mission and the basic objectives of the corporation and any changes thereto; all matters related to salary policy and fringe benefits require specific review and approval by the Board; the Board is apprised quarterly of the financial performance of the organization in relation to its operating budget; the Board retains a firm of public accountants . . . to examine and audit the financial records and submit an annual report . . .; the Board examines in detail and approves a capital equipment budget and it makes specific allocations wherever any corporate funds are to be spent . . .; the Board studies and reviews the results of the various audits performed by various Federal agencies . . .; the Board gives its approval with respect to the final settlements of audit findings; the Board is informed in detail of any relevant comment or Congressional action affecting not only the Research Analysis Corporation but also other FCRC's; the Board specifically approves all contracts with clients that are in excess of $100,000 and reviews the general terms and conditions of these contracts; the Board establishes policies concerning the matter of fees and is continuously advised of the financial position of the corporation and its stability resulting from the accumulation of earned surpluses; several years ago the Board appointed a Compensation Committee to review all of the aspects of the details of the compensation program and determine the policies governing such programs, to establish salary grades for each position in RAC . . . to examine . . . the general administration of the salary program. The Compensation Committee also reviews all individual salary increases for those earning over $20,000 per year and forwards these recommendations to the Board. . . . The Board specifically approves in advance the employment of all new staff members whose salary exceeds $20,000. . . . the Executive Committee of the Board of Trustees acts in behalf of the Board and meets monthly. . .
>
> In conclusion, the Board is satisfied that the controls which it has set governing the operations of the Research Analysis Corporation and the procedures it has established for the detailed information required for its action make it clear that each member of the Board is deeply conscious of his responsibilities for stewardship over the programs financed by public funds and conducted in the public interest. (Loc. cit. pp. 13-15)

A chief concern shown by the Board in these reports was to improve RAC's usefulness to the Army and to underscore its view that RAC was not being as effectively used by the Army as it could or should be. In brief, the Board asserted that the Army had an important and continuing need for services that RAC could provide; that too much of RAC's effort was being devoted to issues of current priority calling for immediate answers; that not enough of RAC's efforts were being devoted to self-initiated research of long-term interest to the Army; and that issues of vital concern to the Army of the future were not being covered in current Army work programs. Noting that 10% of the Army contract could be spent for institutional research, the Board emphasized that this was not enough, proposing that RAC's independent programs for the Army should reflect 20% of RAC's Army work, that 40% should be devoted to current problems, and 40% to problems of the Army of the future.[7]

The second major topic was the effect on RAC of Congressional constraints. While calling attention once again to the fact that RAC was being treated the same as other FCRC's to which it in fact bore little similarity, the Board also stated that Congress had to be

7. As stated in the 1st Report, transmitted on October 31, 1967, these views and recommendations ran as follows:

> The Army has a continuing requirement for the development of analytical processes and systems designed to make the Army a more effective organization, to increase the efficiency of its operations, and where appropriate, to minimize its costs. A comprehensive program must include a balance between studies on current problems, analyses of longer range problems concerned with the Army of the future, and investigations leading to new analytical methods for future application. To be useful and effective, RAC must also be able to provide quick response to Army requests on issues that require an immediate or early answer; such requests are not usually programmed in advance and RAC must be able to adjust its work load by diverting personnel and resources on short notice to provide this type of assistance to the Army.
>
> The RAC management has continuously striven to meet the overall objectives of the Army. On the other hand, the Board believes that too large a percentage of the RAC effort is directed to high priority programs for which results or even partial answers are needed now or in the near future.

The Board underlined a major finding:

> The Board finds that the research programs under investigation at RAC do not now include a number of vital issues relating to the Army of the future, particularly those where results are not required in the immediate future but involve issues that can be expected to develop in the years ahead and which will have a profound impact on the Army. The Board believes that there should be a better balance between the program which require an early answer and the studies of the Army of the future for which answers are not required on short notice.

The Board continued:

> About 10% of the RAC effort for the Army is devoted to Institutional Research. This is work which RAC considers important both to the quality of its capability and to future demands laid on it by the Army. Institutional Research includes preliminary investigations of new and important problems, the improvement of analytical techniques, and the development of broader capabilities and talents in order to insure that RAC is prepared to treat a greater diversity of current and longer range problems for the Army. As a specific case, the Board has been briefed on projects undertaken with Institutional Research funding, which have identified several of these important longer range problems. RAC has recommended a research program to investigate these problems for the Army.

The Board concluded:

> It is the strong feeling of the Board that the program of Institutional Research is most valuable in the development of a highly competent professional organization and in the investigation of improved methods for application to Army problems.
>
> The Board believes, therefore, that the program for the Army should evolve into a balanced effort allocated approximately as follows: 40% for investigations of current problems, 40% for the study of critical areas concerned with the Army of the future, and 20% for Institutional Research. . . .

convinced of the differences and given the information on which to make a good assessment of the nature, the performance, and the needs of all the FCRC's. In the Board's words,

> If, in fact, these organizations (the FCRC's) are performing a useful and important public service function, then Congress must be satisfied that this is so. Until it is convinced that such is the case, the FCRC's can continue to expect constraints in the form of ceilings, budget cuts, and financial and management controls. Therefore it is a matter of urgency to remove any source of justified concern on the part of Congress and to provide sufficient information about the work and management of these organizations so that Congress can make a clear appraisal of their value.
>
> If the Congress is not so informed and convinced . . . then RAC and the other FCRC's will no longer be able to perform the functions and to meet the professional standards expected of them. Professional and scientific organizations cannot operate effectively if they are subject to wide fluctuations in financial support or a continuing decrease in that support. The general demand for the highly qualified professional people in these organizations is great and the net result of continuing on the present course is that it will be difficult, if not impossible, to persuade these people to stay with these organizations; they will most certainly seek employment elsewhere. Thus, RAC and the other FCRC's will gradually be reduced to a level of mediocrity and will be able to provide little significant assistance to the Government or the public in the years ahead.

The Board concluded its review of constraints and supply of resources with a strong recommendation that the Army increase its funding, in particular for the development of solutions to problems it would face in the future, in ways that will ensure that attention to such problems will not be lost in funding of studies of problems calling for immediate answers.

THE LAST YEARS – 1969-1972

By 1969 RAC had completed the mission set on its inauguration. Building on the foundations laid by ORO, under the guidance of the Board and the direction of its management, RAC had become a strong, capable organization able to provide first-class services to the Army. But the continuation of the mission lay in grave doubt. The client's demand for services dealing with fundamental, broad-gauged issues, looking to the longer future, remained weak and looked weaker, despite the insistence of RAC's Board and management that the opportunity to deal with such questions was vital to the preservation of a high quality staff and to the continuation of the kind of organization that RAC was designed to be. The conditions of funding imposed by the Congress as well as by the administration further threatened the viability of the original concept.

By 1969, therefore, it was clear that the trends foreseen years earlier were so strong that the chief task of the Board and top management would be to decide how best to cope with them. What changes in status and organization, what changes in the number and diversity of clients, what changes in patterns of funding and other support would have to be made if RAC were to continue as a first-class provider of independent, objective and scientific services and advice?

Hence, starting in 1969, the Board and management devoted attention to removal of the FCRC label, to diversification, and to relations with the Army designed to improve Army funding and use of RAC's capabilities. The Board paid concentrated attention to the problems of recasting RAC's status as a means of preserving RAC's staff and its capabilities for public service. Failing Army initiatives or proposals—and the Army was taking a deliberately neutral stance in the proceedings—the Board examined possibilities of reorganization and sale, either to other companies doing similar work, able to continue RAC's service to the Army, or to RAC's employees. The Board kept abreast of Congressional developments, until the actions of the Appropriations Committees in November and December of 1971 precipitated the decision to seek a qualified buyer, acceptable to the Army.

The successful purchaser was the General Research Corporation of Santa Barbara, California. On September 1, 1972, General Research took over RAC's staff, equities, liabilities, and contracts. In the course of preparation of criteria for an appropriate purchaser and in the actual conduct of the sale, the Board through its oversight watched out for the interests of RAC's personnel and sought to ensure that RAC's capabilities as an organization would be conserved. The Board also concerned itself with the preservation of RAC's assets for ultimate turnover to the government through the Army, as required in RAC's charter.

IN SUMMARY

Even prior to its takeover of work and personnel from ORO, and throughout its existence, RAC has been served by a small, strong, distinguished and balanced Board of Trustees. The Board saw to the selection and appointment of RAC's President, approving also the selection and compensation of RAC's key officers and higher paid staff. The Board oversaw and approved the selection and compensation procedures and policies for all ranks, concerned that RAC should be a prudent as well as competitive employer. From the outset the Board looked to the level and value of RAC's research work, concerned that RAC should have a continuing and growing capability to serve its major client, the Army. As early as 1962 the Board foresaw the need to seek diversification of clients as well as of research programs but insisted that this be done in ways that would preserve RAC's main identification with the Army, while improving RAC's capabilities to meet the Army's broader needs for research, studies, and advice. The Board saw diversification as necessary for several objectives. Primary among them was the need to assure financial stability and independence—increasingly threatened in the middle and later 1960's by the imposition of ceilings on the amount of RAC's non-competitive contracts with the Army or with other Defense agencies. Also important was the concern for public service—that RAC's skills and capabilities should be available for the solution of problems, international or domestic, lying outside the military domain. A further concern was the challenge of fresh and pioneering work to the staff itself.

The Board kept under continual review the views of Congress about the specialized not-for-profit corporations and their relation to RAC's policies, structure, and operations. These legislative concerns ranged from problems of apparent or real conflict of interest, the fairness of competitive relations with government research organizations, the quality of management, the existence and use of fee and the related questions of the proper degree of independence and stability for a not-for-profit corporation and the level of salaries, to the division of responsibility between government agencies and officials on the one hand, and the advising organization on the other, for the determination and execution of decisions of public policy.

The Board, responding to requests from the Director of Defense Research and Engineering, gave its broad assessments of RAC's problems and accomplishments, independently of those furnished by RAC's management.

Noting the concerns of key Congressmen, along with questions raised by the General Accounting Office, the Bureau of the Budget and others in the Executive Branch, the Board took early cognizance of the question whether RAC's organization and status as a Federal Contract Research Center provided the best framework within which RAC's service to the Army and to other clients could function and prosper. And in its final phases, the Board oversaw negotiations leading to the sale of RAC's assets to the General Research Corporation, and the procedures for transferring personnel and assets, assuring the preservation of equity for turnover to the Army, consistent with its view of RAC's duty and capability to serve the Army and its other clients.

The Board played a strong role in the system involving the Army and other clients, the Department of Defense as sponsor and supervisor, the Congress, RAC's officers and staff, and the developing community providing professional service of operational research and scientific advice in the public interest.

Chapter XI

RAC'S SALE

Why did RAC's Board of Directors decide to abandon RAC's status as an FCRC and choose to sell RAC's assets and transfer its staff, contracts, and capabilities to the best and most appropriate buyer? What criteria did the Board set up for determining who would be an appropriate buyer, given RAC's responsibilities to the Army and to its other clients, to its staff, and to the preservation of its capabilities to serve the public interest? How did RAC's management and Board carry out the sale? This chapter answers these questions.

The quick answer to the question of why, is this: by 1971, in the judgment of the Board, RAC could no longer hope to discharge the mission explicit in its charter and its original conception, while retaining its status and special relation to the Army. It would not have the needed stability, continuity, and sustained funding. More important, it could not expect to have sufficiently challenging tasks. The Army was not giving RAC opportunities to tackle fundamental, long-range problems. RAC's efforts to use institutional research funds to identify and probe such problems had gone without response. Central and corporate research funds were being used chiefly to promote diversification. But prospects for diversification of work done for other government agencies or for industry, that appeared bright in the mid-sixties, dimmed as the decade wore on. The environment for winning contracts to provide such services was growing increasingly competitive. Buyers of RAC's diversified services were not funding broad, conceptual, forward looking studies. They were seeking narrowly defined efforts to deal with specific problems with proved methods.

For all these reasons, it looked to the Board as if RAC had dwindling chances of keeping together the specially qualified staff needed to cope with complex, long-range, fundamental questions facing the Army or other clients in the future. There was grave doubt, especially in view of Congressional expressions of distrust, misunderstanding, and consequent restrictions on scope and funding, that RAC could keep together the staff needed to shoulder tasks of systems research, however complex, that were in essence dischargeable by the Army's staff, commands, or laboratories, or that could be purchased from industry or from for-profit systems analysis firms. Even if RAC could maintain its high-quality staff, there was serious question whether RAC needed special status and special opportunities for independence, objectivity, and creative innovation to do work of this sort.

The Board did not arrive at its decision hastily. Not until 1968 did it instruct management to take steps to abandon FCRC status. Not until mid-1970 did the Board decide to seek for-profit status. Even then the final choice of a preferred future status was uncertain. The Board had instructed management to pursue other alternatives intensively—to diversify

clientele and to continue efforts to get the Army to assign more important tasks, and to convince Congress that RAC needed special status and continuing support in order to deal with them. Moreover, despite threats evident from RAC's beginnings, RAC had grown and proved its capabilities in many fields during the 1960's. Periodically there were signs of a more favorable climate. The Board had occasions for hope.

One of these hopeful signs came in June 1966. The Assistant Secretary of the Army for Research and Development, Willis M. Hawkins, issued a memorandum on RAC-Army Relations to the Army's Chief of Research and Development that embodied a clear and comprehensive statement of the essentials of that relationship. This memorandum recognized a continuing Army need for an organization independently managed and directed that could undertake research and analyses on pressing Army problems, that could assist with major Army studies, and that could conduct analytical studies on problems influencing the long-range future of the Army. It recognized RAC's need for continuity, suggesting the device of a five-year contract, with work programs annually decided to meet the Army's pressing needs. It recognized RAC's needs for stability, in which its staff would be subject neither to excessively rapid growth nor to precipitate reduction. And it recognized the relation between the quality and capabilities of RAC's staff and the kinds of problems the Army should assign to them. In the words of the memorandum:

> In order to accomplish its principal purposes it is essential that RAC maintain an elite staff of extraordinarily capable professional people broadly knowledgeable in Army problems.
>
> By the same token it is incumbent on the Army . . . to assign it principally problems of extraordinary challenge; it should not assign to RAC a significant amount of its work on projects that could as well be undertaken within the Army staff, commands, or laboratories, or by other contracting organizations . . .

Further, the Hawkins memorandum recognized RAC's needs for diversification and for fees. It welcomed diversification so long as the Army remained as RAC's principal client. It approved the fee device, provided that RAC did not accumulate assets in excess of its corporate needs; and it recognized RAC's needs for corporate stability

> . . . including the accumulation of sufficient assets to provide working capital, acquisition of capital equipment, termination reserves, funding for a limited amount of completely independent research work . . . and contingency reserves to permit operations to proceed for a reasonable period of time should contract support not be available, or to permit the orderly dissolution of the organization, or for such other purposes as the Board of Trustees in its judgment considers necessary.

The Hawkins memorandum also set forth a clear and comprehensive set of expectations about RAC's Board. The Army looked to the Board for judicious management in accordance with the aims of RAC's charter; the Board should have both the responsibility and the independence to discharge its functions in the manner its judgment determined to be necessary. The memorandum went on,

> In particular . . . the Board must actively review management; appraise accomplishments; and closely control corporate obligations, personnel policies, wages, and expenditures of corporate assets.

In effect, the Hawkins memorandum was a clear restatement of RAC's nature and mission, clear recognition of what RAC needed to accomplish it, and a clear statement of responsibilities to be met by RAC's Board. As the earlier chapters have shown, RAC's Board measured up fully to the criteria established. Had the Army done as well—in particular, had it given RAC long-range and challenging tasks, while preserving RAC's essential independence and flexibility, it is doubtful whether the Board would have decided that in order to serve the Army best RAC would have to abandon its special status and change its corporate nature.

As matters turned out, the annual work program for the Army increasingly stressed immediate problems that seemed to the Army staff to be relevant and pressing. Despite RAC's efforts, through CALCHAS and IMPACT, to focus attention on continuing longer range issues, this trend continued and was compounded by a disposition to use RAC as an adjunct with other agencies in study groups addressing technological issues and their impact on Army systems and policies. The efforts of RAC's Board to reverse these trends were ineffectual. The position of the Army staff, as summarized by a high officer with a key role in shaping the Army-RAC work program, ultimately came to this: RAC should undertake no task under the Army-RAC program unless it could be completed and applied within two years from its start.

Meanwhile, diversification was proving to be an insufficient counterweight to the trends in the Army program.

Finally, actions of the Congress in cutting funds and limiting the manner of their use posed a sustained and increasing threat. Efforts to convince key Congressmen of RAC's needs for special status were ineffectual. Neither RAC's Board nor management, nor Defense officials, were able to make clear what those special requirements were, and why they made an important difference to RAC's work and Defense decisions. Congressional restrictions had been triggered by responses to the behavior of other FCRC's that were not doing the same kind of work that RAC did and did not need the same kind of special status to do it. Cuts in funds for FCRC's imposed in the late 1960's in an effort to limit what some Congressmen thought was unwarranted growth, excessive salaries and fringe benefits, and too high corporate costs, caused severe disruption to RAC's staff. The cuts imposed in 1970 and 1971 did far worse. They struck at RAC's ability to keep and motivate its best staff—the kind of people who could carry out the work contemplated by RAC's charter.

Whereas the Hawkins memorandum of 1966 offered hope, a letter of October 1968 from the Army's Assistant Secretary for Research and Development asked RAC's Board and management to consider seriously

> whether the present organization as an FCRC is best calculated to retain the kind of staff which will offer a wide-ranging capability to meet Army requirements, or whether another type of organizational framework is desirable . . .

On hearing from RAC's President and its executive committee what their estimate of the gravity of the situation was, the Board in November 1968, in view of its determination to preserve RAC as an effective organization to serve the Army, directed that action be taken to

remove the FCRC label from the Corporation and to obtain the views of the Army on what was necessary to accomplish such effective removal.

With this decision, RAC management and the Board commenced identification and exploration of the best alternative courses. By mid-August 1970, the Board had concluded that RAC should either be reorganized as a for-profit corporation or sold to a for-profit corporation. Such a new for-profit corporation should be able to expand, and the present RAC staff and management should exercise quality control and have a substantial financial interest in it. To be an eligible buyer, a for-profit corporation should not be in the business of designing, making, and selling items of military hardware; and it should be conducting activities that complemented, rather than duplicated, those of RAC; and it should preserve RAC's identity insofar as possible.

The Board transmitted these conclusions to the Secretary of the Army, asking him whether the Army would find such arrangements acceptable and whether such action would guarantee removal of the FCRC label. The Secretary replied that such arrangements seemed acceptable in principle but reminded RAC that the FCRC label was applied by Congress and could only be removed by Congress.

With this guidance from the Army, the RAC Board and management decided to pursue the first of its two options. Plans were developed for organizing a new for-profit corporation, the McLean Research Corporation (MRC), to assume RAC's functions. In April 1971, the Army acceded to this course of action. Accordingly, the Board and management created MRC, developed a prospectus for the sale of MRC stock to RAC employees and to others, and sought a ruling from the Internal Revenue Service that the transactions contemplated by the RAC-MRC plan would not give rise to penalty taxes under the Tax Reform Act of 1969 that could fall on RAC, its officers and directors, or on the officers and directors of MRC.

However, subsequent developments caused the Board to abandon its pursuit of the sale to MRC in November of 1971. Significant delays occurred in obtaining a ruling from the IRS. When the ruling came, it raised a possible issue regarding going concern or intangible asset value that neither the Army nor RAC believed existed. The possibility that going concern value might be asserted and applied in future years reopened possibilities of conflict of interest for RAC directors and officers as well as MRC directors and officers, posing uncertainties making it impossible to proceed without resolving them. As a result, MRC could not assume responsibility for RAC's contracts on September 1, 1971, as planned. RAC pursued clarification of the ruling by the IRS.

In December of 1971, RAC's Board Chairman and President met with the Under Secretary of the Army to discuss the Board's position and reassess the whole situation. Late that month, Under Secretary BeLieu informed RAC provisionally that the Army's preferred position was now

> to transfer the most critical of those functions now performed by RAC to in-house agencies and to transfer a substantial fraction of the RAC staff into these agencies . . .

He foresaw difficulties, and the Army wanted to take time to pursue the issues (of civil service policy and current excess space in the RAC facility) before making a final reply.

The Board was not at all favorable to this course of action, believing that the uncertainties and limitations of the Army's proposal and its unsettling effect on RAC's staff

would seriously impair RAC's ability to complete its current contractual obligations to the Army and to other clients. Noting the Army's desire to pursue in detail the various problems of the Army approach, the Board felt that

> other alternatives would be preferable from the standpoint of protecting our capability to continue to perform work for the Army and other RAC clients and providing continued employment opportunities for the RAC staff.

By March of 1972, the Army's position stiffened. Under Secretary BeLieu wrote Mr. Parker reminding him of the Army's willingness to accept the MRC solution and of the perils of attempting to continue in a FCRC status. Moreover, he went on, the Army would now prefer to assume a substantial portion of the functions currently performed by RAC with an accompanying transfer of RAC personnel. Furthermore, said the Under Secretary,

> we plan to build up our in-house research capabilities to handle up to, say, approximately 50% of the work currently performed by RAC for the Army, and potential purchasers should be so informed.

The Board was even less favorably impressed with these latest statements of the Army's intentions. The Board considered that to transfer a significant fraction of RAC personnel to the Army Civil Service rolls was inconsistent with the objectives of retaining intact the group technical capability so vital to continuing high quality work for the Army. The Board also felt that the group not transferred would be so critically impaired in size and technical strength as to force the closing down of the organizational structure in which they worked.

The Board then pursued its second option—to sell RAC to a for-profit corporation in order to preserve intact the technical capability built up over the preceding 23 years to serve the Army, to provide continuing employment to as many of the RAC staff as possible, and to return to the Secretary of the Army the maximum equity through liquidation, following such a reorganization or sale, as provided in the Corporate charter.

In seeking an appropriate buyer, the Board instructed RAC's President to make contacts with organizations with whom an association with RAC would fulfill the following criteria:

1. Maximum financial return to RAC.
2. Assumption of liabilities relating to physical facilities and financial obligations to employees.
3. Assumption of contractual obligations for work.
4. Provision of reasonable continuing employment opportunity on a non-discriminatory basis for RAC professionals, technical, administrative, and support staff.
5. Maintenance of capability to serve Army needs for analytical research.
6. Absence of conflicting interests between analytical research and military hardware production.

The Board indicated that a prospective purchaser had to be acceptable to the Department of the Army, since the largest part of RAC's business was under contract with the Army and a transfer of the contract could not be made to a purchaser without the Army's consent.

The Board and its Executive Committee further decided that because of the special and sensitive nature of the work for the Army, requests for bid should be restricted to

organizations undertaking similar contract assignments and of a size compatible with RAC so that RAC personnel could have an influence in the affairs of the purchasing organization and enjoy identity within it.

The Executive Committee amplified these criteria to provide detailed guidance on specific items to be considered in evaluating proposals to purchase RAC. These items included the extent of the purchaser's commitment to providing an independent analytical capability to deal with issues of national interest, with emphasis on land warfare issues; the purchaser's existing research and analytic interests, and its growth potential. Further terms were maximum employment opportunities for RAC staff; indications that team efforts would be preserved; and the protection from any pressures of hardware orientation and sales that might exist in the purchasing organization. With respect to fulfillment of contractual obligations, the Executive Committee called attention to the degree of understanding of Army problems possessed by the management of the purchaser, as well as the agreement of the Army to novate, i.e., the transfer, RAC's existing contract to the proposed purchaser. RAC staff should accompany the contract.

Finally, with respect to the Board's responsibilities to protect the equity due the government on the dissolution of RAC, the Executive Committee instructed management to take into account maximum financial return to protect eventual government equity, clear acceptance of liability for RAC's lease of property, and least risk of residual liability for the lease, computer, accrued leave and retirement benefits.

During December 1971 and January 1972, Mr. Parker made contact with some 13 organizations to determine their interest. These organizations were carefully selected on the basis of type, size, and professional accomplishments, as well as complementarity to work underway at RAC. In addition, 13 other organizations approached RAC. They had learned through trade channels of the possibility of the transaction.

Most of these 26 companies were either visited by RAC management, or visited RAC, where they were given an opportunity to meet with the corporate officers and key staff members. During these visits each organization was given extensive financial and professional information on RAC. The general criteria for purchase were discussed with those companies visited and with those others who were sufficiently interested to visit RAC in search of more detailed information. All 26 companies were told they could make a bid. Nineteen of them requested formally an opportunity to do so. Identical requests for proposals were dispatched by RAC to each of the nineteen, between February 1 and 16, 1972. By March 1, ten bids had been received.

Copies of each of the proposals were sent to each member of the Board of Directors on March 6. On the same date, RAC senior management conducted a preliminary review of the proposals. The Army was asked to appoint a review committee to go over the proposals and appointed three members who spent two days at RAC examining the proposals in detail. The Army instructed its committee to consider legal matters only; the final selection of a legally acceptable choice was up to the RAC Board. On March 24, the Army informed RAC that nine of the ten bidders appeared eligible to receive the novated contract. The tenth had made a proposal that involved the transfer of RAC personnel in-house that did not appear to the Army to be necessary; the Army made no objection to further negotiations between RAC and that bidder. The Army decided to postpone its final review and decision about legal

acceptability until after RAC's Board had made a recommendation of a preferred buyer. Then the Army would decide on acceptability, taking into account evidence of the successor's capability to perform the novated contract, including its financial capability and the personnel available to assist in performing the novated contract.

On March 23, the Executive Committee decided to invite all bidders who had made responsive proposals to meet with the Executive Committee on April 5 and 6 for detailed discussions. One bidder's proposal was adjudged non-responsive to the request for proposals. Another bidder withdrew its proposal on April 1.

Among those asked to meet with the Executive Committee was the Operations and Systems Analysis Corporation (OSAC), a group of RAC employees. The Board carefully considered the OSAC proposal. It was fully responsive to the requirements for taking over RAC's contracts, assets, and personnel. But its financial resources were limited; and in view of its lack of proved experience as an independent organization, the Executive Committee found that other bids offered more security to RAC employees, greater return to the government in the form of equity on the sale and dissolution of RAC, and more assurance that fiscal matters would not interfere with contract completion.

The General Research Corporation (GRC), an established company with eleven years of proven administrative and technical performance and sales in excess of $20 million, submitted a proposal which included:

a. payment of a substantial premium to RAC over book value;
b. acquisition at fair market value of building, equipment, and leasehold improvements;
c. responsibility for completion of RAC contracts;
d. assumption of present lease if indemnified against excess facilities;
e. consolidation of computer installations with other GRC offices and laboratories;
f. assumption of accrued leave of RAC personnel transferring to GRC;
g. maintenance or combination of RAC's retirement fund with that of GRC; and
h. availability of stock option opportunities to transferring personnel.

After full review of this offer, and comparing it with others, the Executive Committee judged that this proposal would provide:

a. maximum return of RAC assets to the government;
b. best opportunity for continued employment of RAC personnel;
c. technical and professional background assuring completion of RAC contracts;
d. most satisfactory arrangements for assuming the building lease; and
e. organizational framework to keep intact the technical team of RAC and thus its capability to fulfill Army requirements for tactical and strategic studies and analysis.

On September 1, 1972, the General Research Corporation took over RAC's personnel, assets, capital equipment and leases, and contractual responsibilities. The bulk of RAC's staff became GRC's Operations Analysis Division. Most of the rest either joined GRC's Washington Operations Office or the American Technical Assistance Corporation, a GRC affiliate. RAC's senior management personnel moved into senior positions within GRC. RAC's Board commenced its duties to execute RAC's dissolution.

Chapter XII

AN ASSESSMENT

Three years after the sale of RAC to the General Research Corporation, some tentative answers to some broad questions are in order. Was RAC worthwhile? Did RAC reach its full potential? Was the choice of means to preserve RAC's essence the best of available alternatives? Was its capability to serve the public interest preserved? Could a new capability representing RAC's essential concept and best aspiration be reestablished? Should it be?

Was RAC worthwhile? Material for an answer is to be found in the preceding chapters setting forth RAC's chief activities. The reader can judge the benefits for himself. As for cost, RAC's sales aggregated a little over $100 million. Some $90 million of that went for defense work. Such outlays represented about a fourth of the total outlays for studies and analyses agencies in the ranks of the FCRC's throughout the decade. As a percentage of all defense outlays for all FCRC's, RAC costs were far less. And when compared to total government expenditures for military research, development, test and engineering services produced by all agencies outside the government, RAC costs were infinitesimal.

Did RAC achieve its full potential? The answer would have to be a heavily qualified yes. If full potential were to be measured by the probable achievements of an organization devoted to independent, objective analysis of important problems affecting the Army and national security, operating in an environment where there was full understanding and support on the part of the major client, the Department of Defense, and the Congress, the answer would have to be that RAC fell far short of its potential. The high quality of its personnel and its governance and management gave promise that much more could have been done. If account is taken, however, of the realistic constraints under which RAC functioned, in particular the threats of an uncertain and sharply competitive future in an environment increasingly less favorable to wide-ranging fundamental conceptual studies, the answer would have to be that RAC achieved most or all of what could be expected.

First, consider constraints imposed by the client. Some stemmed from the position of the Army itself within the Department of Defense, and as an institution playing a limited role in the total national efforts devoted to national security. Because of that limitation—which increased during RAC's lifetime—policy advice to the Army was bound to be limited in scope and potential effect. Moreover, the life style of the Army as an institution, both in its military professionals and in its civilian superiors and professional staffs, never favored going outside the Army itself for deep-reaching studies that would help the Army conceive its problems as an institution, arrive at fundamental alternatives in dealing with them, and then consider their relative merits and feasibility. During RAC's lifetime the Army faced severe problems of

conceiving its role and missions, its identity, and its place in national life. At times these larger issues seemed to overshadow the relatively technical and tractable questions of how to improve the design, enhance the capabilities, and fashion doctrine for the strategic and tactical uses of forces and weapons. Many of the problems that emerged during the trauma of Vietnam and in the period of adjustment afterwards were foreseeable clearly enough so that fundamental questions could have been posed for RAC to study. But this was not the Army's way.

RAC achieved most not as a leader in devising concepts and exploring their implications but as a collaborator in studies, adding strength to the execution of studies led by the Army. RAC devised important new methodologies for approaching logistics, manpower, and strategic studies. But the important uses of those methods and of the data amassed and processed by them were determined by others. In a very real sense RAC was the Army's creature.

RAC suffered throughout its life, especially in the last half of it, from constraints imposed by a Congress dealing in broad brush with real or imagined difficulties and shortcomings found in the world of the FCRC's in general or in the larger world of RDT&E. Limitations imposed on funding permitted without competition were chiefly designed to punish alleged shortcomings or to check apparently uncontrolled growth and to force Defense or the Army to build in-house capabilities or to buy studies and analyses elsewhere. RAC committed none of the alleged sins of bloated salaries, high costs, and uncontrolled growth. RAC salaries were kept in line both with comparable governmental salaries and with salaries paid for equivalent talent by other specialized groups providing studies and analyses, or by industry. RAC's costs, on examination, turned out to be as low or lower than comparable costs for comparable services in government or industry. RAC's professional staff never approached the ceiling of 500 suggested by the Department of Defense. RAC's growth was a constant object of concern for RAC's Board and Management. They believed in orderly growth as a condition of corporate health and effectiveness—a belief widely shared in American economic life. But they also ensured that it would be modest and in keeping with the kinds of tasks that RAC sought to perform.

Ceilings on funds, salaries and staffs imposed by Congress had effects going well beyond those traceable to the formal boundaries thus established. They were part of a larger, interacting system. Their effects were magnified by the way in which defense officials, RAC management and staff responded to them. They fueled efforts at diversification—and in retrospect it appears that the realistic opportunities for diversifying the clients and services of an organization schooled and skilled in defense and security problems, were not great. By motivating corporate efforts to escape limitations on sole-source procurement, they drove RAC into efforts to increase competitive sales in a period when the market for such sales was becoming more fragmented and frenetic, and less hospitable to the kind of innovative, conceptual work for which many of RAC's best people had been trained. Finally, Congressional limitations caused turbulence and uncertainty among the professional staff. Worse, by threatening prospects for long-term stable support—threats made more credible by RAC's responses to them—ceilings and other limitations offered strong reasons to the best staff to seek employment elsewhere.

Even more serious in their impact on RAC's effectiveness and capabilities were the changes in the competitive environment for studies and analyses funded by government and, in particular, in the ways in which government sought to procure such studies, especially outside the military. In its search to diversify its skills and services, RAC encountered an increasing proclivity on the part of government agencies to fund only those studies that could be clearly defined in advance and then to insist on tight control over their conception, execution, management, and determination and use of results. This condition worsened during the 1970's. It stood poles apart from the position that the kinds of problems RAC should be studying could not be defined precisely nor the research needed to illuminate them programmed tightly. It contravened the central tenet of earlier research policy that RAC's real role should be to find out, in conjunction with far-seeing and well-placed officials in client agencies, what the boundaries and nature of the problems really were, and then to decide how best they could be studied. This trend in buying studies and analyses persisted despite the judgement made explicit in the mid-1960's by such practitioners of thoroughgoing systems analysis as Henry Rowen and Alain Enthoven[1], that an agency such as RAC needed one or two years of intimate association with a new client, working in a new field, before its analytic work or its systems analysis and data handling could be expected to be realistic or effective. Under the conditions that became ever more prominent in the funding of research by governments at all levels, the opportunity to develop an effective special relationship with a major client, in or out of the Federal government, was fast disappearing. RAC, at its inception, took for granted its special relation with the Army and counted as one of its greatest assets the familiarity with Army ways and Army problems that had been gained by the Operations Research Office. By the end of the decade the value of such a special relation had greatly depreciated.

Through its life RAC brought to bear as best it could its familiarity with the Army's organization and needs. In working out ways and means to serve other clients, RAC observed as a primary condition preservation of its ability to serve the Army. But as the Army's importance as a special client declined and as the Army continued to reserve its major problems for its own treatment, RAC's value to the Army, and hence the value of its familiarity, declined.

One of the major concerns that gave rise to ORO and to similar institutions in the 1940's was that science and sophisticated methodology should be brought to bear on major

1. On this and related points, see the testimony of Enthoven on May 17, 1966, before the Senate Subcommittee on the Utilization of Scientific Manpower (*Hearings* on S. 2662, A Bill to Mobilize and Utilize the Scientific and Engineering Manpower of the Nation to Employ Systems Analysis and Systems Engineering . . .), pp. 146-162, esp. pp. 147 and 157. See also the testimony of Rowen the same hearings, at pp. 162-176. At p. 173, Rowen commented: "Good analysis of hard problems takes time–the persistent application of intellectual effort to a limited range of related issues over a period of years. These conditions are met in a number of defense-oriented organizations–RAND, RAC, IDA, CNA among them, and the contribution of these organizations to our understanding of the problems of defense has been very great indeed."

questions of governmental policy. With the increasing politicization of science and the formation of organizational devices to bring scientific advice to bear at the level of the White House, the value of RAC and similar agencies as a channel for such scientific problem-consideration and advice declined. It did not disappear, as some of RAC's best people participated in such agencies as the President's Scientific Advisory Committee (PSAC), and staff members gave them support and advice in areas where they had special knowledge and insight. But the pressures to maintain specialized FCRC organizations for specialized studies for particular clients were diffused by the proliferation of other means and other channels whereby scientific advice (not always of the highest or most objective quality) could be brought to bear in hammering out government solutions for key issues of high policy.

One Congressional charge was that the FCRC's were carrying out policymaking for their clients that the clients should have been doing for themselves. In RAC's case this came with particular irony in view of the limited extent to which the Army involved RAC in fundamental, comprehensive consideration of serious and controversial questions of public policy.

Another charge was that the FCRC's were providing their clients with highly competent defenses of policy positions rather than providing them with balanced and objective advice about policy choices. Since RAC was usually involved in large Army studies only as a collaborator, and since those studies themselves did not involve controversial courses so much as they sought more efficient ways of doing accepted tasks, this charge too was misplaced when leveled against RAC. Moreover, RAC's staff members carefully eschewed taking prominent positions on public issues. They did not write letters to newspapers taking sides either for or against their client's interest and positions, as was sometimes done by staff members of other FCRC's. And finally, RAC's record in guarding the secrecy of government documents and privileged communications from other sources was impeccable. There were no leakages, systematic or inadvertent, that were laid to RAC's charge after the intensive investigations following disclosure of the Pentagon Papers.

Was the choice of means to preserve RAC's essential capability to serve the public interest the best among alternatives open? RAC could have continued as an FCRC or transformed itself into a publicly owned, for-profit organization with special capabilities to provide studies and analyses. It was not forced to take the course of sale to an existing for-profit firm, of similar capabilities and experience, as it did.

As for continuation as an FCRC, little has transpired in the three years after the sale suggesting that if RAC had continued as an FCRC it would have done better than it did as a component of a for-profit organization. The Congressional pressures to reduce the level of Army or Defense support for non-competitive tasks remained powerful. No developments in the competitive environment for funding studies and analyses occurred that would have improved RAC's chances to survive in substantially its old form. The other similar FCRC's enjoyed a year of respite as the Department of Defense and the Congress made some small provision to cover inflationary increases in costs, but at lower levels of staffing. RAC as an entity would in all probability have fared no better, for there is no evidence that any new major client in or out of Defense would have come along to support the agency at a level, and

with the continuity, needed for RAC to maintain its integrity or to recapture its old capabilities.

Moreover, life as a publicly-owned company (owned for the most part, at the outset, by its employees) would have been equally difficult, or more so, than continuation as an FCRC or as a component of an established company. Problems of financing and of liquidity would have persisted and worsened as the level of sole-source support from the Army went down. Uncertainty that the work to be done would be challenging, would have altered or eroded the staff capabilities as rapidly and surely as would have been probable in either of the alternative organizational forms. To say that problems would have persisted and perhaps worsened is not, however, to say that RAC as an independent, employee-owned for-profit agency would not have been able to cope with them effectively. And in the event, the record of RAC's residuum, the Operations Analysis Division and the Support Center East of GRC, suggests that an independent OAD might have fared better if it had not become part of GRC. OAD contributed more in the way of earnings and other support to GRC, than it received in return. Yet the Board's choice of a purchaser must be assessed in terms of the situation as known, and as reasonably forecastable, at the time of sale.

If the test of the value of RAC after its sale, as it was during its life, was to be the perpetuation and enhancement of its staff and assurance of conditions under which it could continue to provide high-quality studies and services, experience after the sale yields a spectrum of results. In doing the kind of work for which the Army continued to provide solid financial support and effective collaboration and utilization of results—namely in the field of manpower studies and projections—the former RAC staff has maintained and increased its integrity and capabilities in the new framework. New clients, moreover, have appeared from elsewhere in the Defense community. In logistics, RAC has maintained its capability to deal with certain problems in the field of transportation, materiel management and logistics policy, although the staff has been thinned out. In resource analysis, staff reductions have diminished the scope of capabilities in being. But in the case of RAC's distinguished capabilities in war gaming and simulation, the function was abandoned and the staff dispersed to other tasks within the corporation, or elsewhere via resignation or dismissal. This is a clear case where the change in the demand for a service altered the capabilities of an organization to supply it. Despite their power and sophistication, the various RAC-designed war games, especially those involving large military formations, became very expensive to operate at frequencies and level of detail sufficient to assure statistical validity. Users could not afford to pay the added costs for such superior service, when modifications of existing forms of static analyses would provide results adequate for their purposes. The market dried up. However, the best personnel in gaming and simulations were shifted to empirical work in the analysis of tactical warfare, where the market has increased considerably.

Strategic studies remain, but are concentrated almost exclusively on problems of method. Politico-military studies had disappeared, in effect, prior to RAC's sale. Economic studies were drastically reduced, and key staff departed for employment in the government, in universities, or elsewhere. Similarly, the staffs working in science, technology, and engineering assessments were largely gone before RAC was sold. Those working in advanced studies in basic methodology had also departed, with the best specialists going to universities.

Finally, some of the best talent working in the field of force structure, went to new Army in-house capabilities; others were dispersed. In this field the demand for studies changed with the shift of emphasis within the Army general staff away from the earlier comprehensive force structure studies to studies and actions aimed at reducing the Army's headquarters and logistical tail, while wringing more combat organizations out of the same manpower. At this writing it is not yet clear whether this demonstration that more combat capability is available from a given manpower figure will result in more combat units overseas or at home, or will only result in reducing the overall size of the Army. Just such a problem would be appropriate for a RAC-type organization. There is little public indication that it is being so addressed within the Army, although it is being prominently featured in Congressional debates. Former RAC specialists in force structure analysis, now working in the Army, are having to wrestle with all the problems of life in an in-house staff. In particular they face those arising from having to postpone or stretch out long-term analytical work to cope with day-to-day problems and the immediate concerns of the agency's commanders.

As for present and future prospects, it seems clear that the continuation of competition for funds to perform studies, and trends in the way government agencies try to fund basic conceptual approaches to their galling but Protean problems offer little hope that the present arrangements could lead back to the recreation of the earlier type of FCRC for studies and analyses. Government buyers of advice are seeking for clearly definable research products, to be procured under conditions where the client decides how to formulate a problem, how to study it, how to schedule its milestones and phases, and then monitors closely the pace and details of the study. This method of funding conceptual research is well designed to assure that conceptions will be conventional and that results will lead at best to marginal improvements. Despite these severe limitations, these funding and monitoring practices are likely to persist, because the buyer can explain and justify the details of his programs to officials at all levels in the Executive and in Congress who review such operations and are increasingly likely to insist on apparently prudent standards and practices.

Could RAC be recreated under somewhat different circumstances? This is conjectural in the extreme, but a consideration of what RAC was and was supposed to be (let alone a consideration of how Rand came to be) reveals that there must be a very special set of circumstances involving the support of prestigious public officials such as Vannevar Bush, Henry Stimson, General George C. Marshall and General H. H. Arnold. There must be a widely shared sense of urgency about attacking the problems posed, and a belief that they demand the integrated yet free application of the best minds in many disciplines for solution. Further, there must be recognition that the organizational framework should facilitate attacks on such problems. It must have great flexibility. It must possess outstanding leadership able to achieve the interweaving of disciplines and research talents. Support must be ample; but so long as the research is not heavily dependent on laboratories, prototypes, and tests, it need not be expensive. The new organization should be able to tap the talents of the best in government and industry, in universities and elsewhere, and bring them together in unique ways.

Curiously, the very existence and early success of Federal Contract Research Centers engaged in studies and analysis may hinder or foster the search for a new organizational form

possessing the funding and freedom they possessed at the outset. Hindrances might arise from recognition that they did make great and innovative contributions, so why search for something different? But the fact that they had done well, but are now constrained in many unforeseen ways, might fuel the drive for finding a new equivalent. The earlier device seems to have lost its efficacy with the passage of time, the growth of administrative encrustations, and changes in the demand for studies and procurement practices to meet it. Some new untried initiative may look better.

Should something like an ideal RAC be recreated? The answer to this question depends on the answer to a prior and much more complicated question: what major problems of military organization and weaponry face the nation that cannot be addressed at least with marginal expectations of success by talented men and women in the military services, in industry, and in the universities? And what sort of interdisciplinary attack on them is needed? Is not operations research enough?

Problems of the arms race in a time of unfolding science and technology are far from solution. But what do specially integrated, conceptually oriented science and technology have to do with adding to the available methods of analysis and providing the knowledge needed for formulating and attacking such issues afresh? The arms race—if indeed it be the all-out race so often pictured—stands as but one example of an area crying for better and more innovative approaches, despite the attention devoted to it for decades by intellectuals, government servants, and politicians.

In the modest field of operations research there does not seem to be any role for a recreated RAC to play that could not be played adequately by the professionals and their institutions available throughout the country. Insofar as systems analysis is concerned—a somewhat better understood and less mystical term today because of extensive experience with it outside the field of security matters—there might be a stronger case for a recreated RAC, provided RAC could find more powerful ways to deal with the non-quantifiable elements of systems analysis. Political judgments form only one example of such elements. Real gains in meshing political judgments with other system components may have to wait for major developments in the field of political science itself and acceptance of them by the currently influential makers of political judgments. Such foreseeable conditions are unlikely in the extreme. Meanwhile, however, a recreated RAC might form a framework within which the quantifiable and the judgmental might be brought together in a less politicized fashion, at least during the processes of analysis, than happens today.

In considering the desirability of recreating something like RAC, the dimension of independence, and the delicate balancing needed between independence from a client and thorough and sustained knowledge of his problems, seems to be increasingly devalued if not ignored. A key element in the concept of a proper RAC or Rand is that it should be genuinely independent of its sponsor, so that its advice and studies would have not only the quality but also the appearance of objectivity and integrity. Such independence is hard to achieve if the supplier of studies and advice is dependent on a sole client for support and continuation. Yet attempts to solve this dilemma by seeking diversification offer only partial answers, especially if diversification is sought by doing work for more than one military sponsor in a world of

continuing interservice rivalry and dominance of a central organization (the Department of Defense) over its service components. The agency providing studies and analyses may occasionally be able to play a useful part if it can study problems involving other services than that to which it is normally attached. But in a world of interservice competition, it is not always possible for the neutral service to gain full information about the proposals or systems in conflict. If diversification seeks to do work for clients both in and out of the field of national security, strong tensions and conflicts may arise in the professional staffs dealing with one or the other class of problems. There are other difficulties as well.

The alternative to an independent agency for studies and analyses chiefly put forward by Congress, has been to strengthen in-house agencies for studies. Earlier objections of low salaries have been overcome as civil service salaries at most levels are more nearly competitive than before with those in industry for similar services. Other objections that the services have not given their laboratories or other in-house study agencies first-class, challenging problems have also been overcome at least in part. (Gains in this direction are likely to be unstable; the fashion of turning within for help in studies and analysis may weaken.) The central issue has not been addressed: can an in-house agency ever give genuinely independent advice? Or is the fact controlling that the director of the in-house agency and members of his staff are responsible to superiors who may neither desire nor reward genuinely creative and innovative, comprehensive, but embarrassing or disturbing, results and recommendations on issues touching on an institution's most private and vital concerns?

Another difficulty besetting the performance of in-house agencies is that their superiors and users of research are strongly motivated to succeed on every project. The concept of judging the success of an agency by considering the ratio of successes to failures, and the significance of each, is difficult for bureaucrats to justify—or for proponents of particular parts of a service to live with. Yet the expectations of success in scientific endeavors—even in the context of a company laboratory, do not set so rigid a standard. Conceptual and exploratory research is bound to have some failures. The motivation of the bureaucrat is to avoid them if at all possible—even at the price of failing to achieve an important breakthrough.

The particular pattern of motivations and interests, and the particular styles of leadership (especially as they are reinforced by higher organizations or by Congress) will make the difference in determining whether in-house agencies, however well staffed and funded, are used to the full. It is likely that in-house agencies as they exist today, and as they may be improved, will be able to cope effectively with a broad range of problems. But it is not certain that in-house agencies will be able to provide the quality of interdisciplinary staff and to assure them the opportunity to address a continuing series of intriguing and challenging problems, so such agencies can fashion for their clients the kind of assessment of the potentials of science and technology for the future, and preferred ways of applying them, that government needs.

What is missing from the current environment is the pervading sense of threat in the face of uncertainty that made the wartime OSRD possible and that fueled the movement toward ORO, RAC, and their parallel organizations. Given a motivation of similar power—and it need not stem from military or political challenge—the conditions might arise again in

which a new organization, similar in capability to those now being eroded, may be sought and supported.

Under current conditions it does not appear that the universities can support genuine, sustained interdisciplinary research on national security problems. They have been too politicized and traumatized by the events of the past ten years; and the inner organization and motivation of universities is not calculated to support continuing attention to as controversial an area as national security.

Industry is no better suited to provide broad-gauged conceptual studies of science and technology in their application to national defense issues. Those industries engaged in the design, production and sale of military systems and hardware will be hard put to it to free their studies from the taint of self-interest in profits, despite resort to "hardware exclusion" clauses. Their studies are almost bound to appear self-serving, whether they are in reality or not. Other industries may well find the prospects of profitability of providing studies and analyses too small to warrant sustained efforts to assemble, train, and keep in being high-quality interdisciplinary staffs to work in this special field alone.

Foundations can help by funding work at institutes and centers, but foundations may lack the free resources or the motivation to provide continuing support for the kinds of study centers that may be needed. Many foundations seek to pioneer research in unexplored fields; national security issues have had intensive study for decades past. Specialized providers of analytic and operations research services will continue to do good work in some fields. These range from organization and management study agencies to adjuncts of universities. But given government proclivities for buying and supporting tightly designed and monitored studies and analyses, it is not likely that such firms, that must seek profit to survive, will do much if any more than to respond to the conditions laid down by government as a buyer. And the current practices whereby government tries to buy specialized studies and advice give little reason for confidence that sustained and deep-reaching studies will be done by specialized providers.

All of these sources of studies will be able to cope with a wide range of problems. Standards of professional competence, determined and reinforced by professional associations and by the demands of buyers, will do much to assure dependability and response to particular needs. But it is by no means certain that the system as it is now developing will be able to fill the needs met by the specialized FCRC's in their best years.

There may be a possibility yet to recreate a RAC in its early image; and the conditions for its recreation and continuing support may recur. Whatever the future prospects, those involved in RAC's inception and performance, both within and without that particular corporation, can take pride in its accomplishments. Efforts to recreate it before the conditions are again propitious, however, may be unfortunate. A powerful felt need and acceptance and understanding in the government, in Congress, in academia, and in public life are needed if such agencies are to be recreated and to work to their full potential in the public interest.

Appendix A

THE BOARD OF DIRECTORS AND KEY OFFICERS

This appendix lists the members of RAC's Board of Directors, its corporate officers, the senior military advisers, and key personnel. The Board of Directors was titled the Board of Trustees prior to October 1967. Key personnel, other than corporate officers and the senior military advisers detailed to RAC by the Department of the Army, include heads of all major corporate organizational units. Since these units changed during RAC's life, personnel are listed in alphabetical order. Their organizational designations and dates of service follow.

BOARD OF TRUSTEES/DIRECTORS

HENDRIK W. BODE, 1961-71,
Acting Chairman, 1964-65.
Vice President, Bell Telephone Laboratories

OMAR N. BRADLEY, 1961-68
Emeritus, 1968-72
General of the Army

JOHN T. CONNOR, 1961-63.
Secretary of Commerce, 1965-67
Chairman of the Board, Allied Chemical Corp.

JOHN F. FLOBERG, 1961-72
Vice President, Secretary and General Counsel,
Firestone Tire and Rubber Company

RICHARD G. FOLSOM, 1963-72
President, Rensselaer Polytechnic Institute

JOHN S. FOSTER, 1965
Director, Lawrence Radiation Laboratories

HAROLD K. JOHNSON, 1968-
General, US Army, Ret.
Chief of Staff, US Army, 1964-68
Vice Chairman of the Board, Financial General Bankshares, Inc.

FINN J. LARSEN*, 1965
Corporate Vice President, Honeywell, Inc.

JAMES McCORMACK, JR., 1961
General, US Air Force, Ret.

LIVINGSTON T. MERCHANT, 1965-
Consultant
Career Ambassador (Retired, 1962)

RICHARD S. MORSE, 1966-72
Sloan School of Management, MIT

FRANK A. PARKER, 1961-72,
Acting Chairman, 1971-72
President, Research Analysis Corporation

ARTHUR E. RAYMOND, 1965-71
Consultant
Senior Vice President, Douglas Aircraft Company

JAMES EARL RUDDER,* 1963-70
President, Texas A&M University System

HECTOR R. SKIFTER,* Chairman, 1961-64
President, Airborne Instruments Laboratory

JAMES H. WAKELIN, 1965-71,
Chairman, June 1965 - Feb 1971, 1972-

*Deceased

JOHN H. PICKERING,
Secretary and General Counsel, 1962 - 18 October 1972
Assistant Secretary, 18 October - 31 December 1972

DOROTHY HOOVER WHITMARSH,
Treasurer and Assistant Secretary, 1 September - 18 October 1972;
Treasurer and Secretary, October 1972-

CORPORATE OFFICERS

FRANK A. PARKER
President, July 1961 - September 1972

JAMES H. WAKELIN
President, September 1, 1972-

WILLIAM R. BECKERT
Vice President and Treasurer, 1969 - 1 September 1972

HUGH M. COLE
Vice President, Operational Systems, June 1969 - September 1972
Vice President, Operations Analysis, 1964-1969
Director, Logistics and Management Branch, 1962-1964
Chief, Operations Division, 1961-1962

EDMOND C. HUTCHINSON
Vice President, Economic, Political and Social Sciences, 1968-1972
Chairman, Exploratory Development Group, 1967
Member, Research Council, 1967

JAMES A. McFADDEN, JR.
Vice President and Treasurer, 1967-1969

CHARLES R. PATTERSON
Treasurer, 1961-1967

CLIVE G. WHITTENBURY
Vice President, Technological Systems, 1969-1972
Head, Science and Engineering/Technology Department, 1965-1969

FRED W. WOLCOTT
Vice President, Technological Operations, 1964-1969
Director, Systems Engineering Directorate, 1963-1964

SENIOR MILITARY ADVISORS

1961-63	Col. Jack M. Duncan
1963-65	Col. LeRoy D. Brummit
1965-67	Col. Robert W. Garrett
1967-70	Col. Charles E. Preble, Jr.
1970-71	Col. William S. Howe, Jr.
1971-72	LtCol. Anthony Simkus

*Deceased

DEPARTMENT/DIVISION HEADS & OTHER KEY PERSONNEL

JOHN J. ANDRE
Director of Personnel, 1967-72

JOHN M. BREIT (Maj. Gen., USAF, Ret.)
Acting Chief, Unconventional Warfare Department, 1968-69

MARTIN W. BROSSMAN
Chief, Logistic Simulation Division, 1962-65

CHARLES P. CHADSEY
Senior Editorial Advisor, 1968-71
Editor, 1961-67

C. J. CHRISTIANSON
Chief, Support Systems Division, 1962-65

GEORGE E. CLARK, JR.
Head, Computing Laboratory, 1962

PHILIP R. COMPTON
Director of Program Development, 1967-72
Director of Development Planning, 1966-67

DANIEL E. COWGILL
Chief, Computer Sciences Center, 1966-72

HARRY L. CROW, Jr.*
Security Supervisor, 1962-66

RODERICK C. DENNEHY
Director, RAC Field Office, Europe, 1968-69
Chief, Tactical Systems Technology Division, 1963-65

CARL S. DONALDSON
Assistant Corporate Secretary, 1970-72
Manager, Contracts and Facilities, 1970-72
Contract Administrator, 1965-70
Administration Manager, 1962-65

LAWRENCE J. DONDERO
Chief, Gaming and Simulations Department, 1969-72
Chief, Military Gaming Department, 1965-69

MARGARET L. EMERSON
Librarian, 1961-72

LESTER D. FLORY (Brig. Gen., US Army, Ret.)
Executive Assistant, 1962-63
Executive Director, 1961-62

WALTER F. GOOD, JR.
Fiscal Manager, 1962-68

ROBERT N. GROSSE
Chief, Economics and Costing Division, 1963-66

MERRILL HALL
Director of Personnel, 1962-66

*Deceased

JOSEPH O. HARRISON, JR.
Chief, Computer Sciences Division, 1962-64

JOHN P. HARDT
Head, Strategic Studies Department, 1964-71

ALFRED H. HAUSRATH, JR.
Member, Research Council, 1965-67
Chief, Military Gaming Department, 1964-65
Chief, Conflict Analysis Division, 1962-64

ROBERT G. HENDRICKSON
Chief, Computer Sciences Center, 1964-66

BETTY W. HOLZ
Head, Logistics Department, 1965

HARRISON N. HOPPES
Chief, RACFOE, 1969-72
Chief, Combat Developments Division, 1963

VAUGHN L. JACKSON
Technical Publications Director, 1972

PAUL W. KEVE
Head, Public Safety Department, 1971-72

SAMUEL A. LaMAR
Chief, Transportation Engineering Division, 1963

RICHARD M. LONGMIRE
Head, Public Communications and Safety Department, 1969-70
Head, Office of Public Safety, 1968-69

PHILIP H. LOWRY
Chief, Combat Analysis Department, 1964-69
Chief, Weapons Systems Evaluation Division, 1962-64

GEORGE A. MARTINEZ
Chief, Unconventional Warfare Department, 1965-68
Chief, Communications and Electronics Division, 1963-65

W. J. MERCHANT
Chief, Information and Control Division, 1962-64

PAUL F. MICHELSEN
Manager, Electronics Laboratory and Electro-Mechanical Laboratory, 1962-66

M. RANDOLPH MORRIS
Assistant to the President and Public Information Manager, 1962-65

JOHN T. NEWMAN (Colonel, US Army, Ret.)
Head, Force Structure Department, 1969-72

R. SHALE PAUL
Director, Corporate Planning Office, 1967-72
Acting Controller, 1966-67

GEORGE S. PETTEE
Chairman, Research Council, 1964-69
Head, Advanced Planning Group, 1962-64
Associate Director, 1961-62

THE BOARD OF DIRECTORS AND KEY OFFICERS

PAUL D. PHILLIPS (Brig. Gen., US Army, Ret.)
Chief, Resource Analysis Department, 1971

ARNOLD PROSCHAN*
Deputy Head and Head, Economics and Costing Department, 1965-71 (Department renamed Resource Analysis Department, 1966)

R. WILLIAM RAE
Acting Head, Public Communications and Safety Department, 1970-71

LYNN H. RUMBAUGH*
Member, Research Council, 1964
Director, Combat Systems Branch, 1962-63
Associate Director, 1961-62

ROLAND G. RUPPENTHAL
Chief, Operational Logistics Division, 1962-64
Deputy Chief, Logistics Department, 1964-72

THOMAS D. SCRIGGINS
Chief, Combat Developments Division, 1962-63

IRVING H. SIEGEL
Member, Research Council, 1964-65
Chief, Economics and Costing Division, 1961-63

NICHOLAS M. SMITH, JR.
Head, Advanced Research Division/Department, 1962-71

LEE S. STONEBACK (Colonel, US Army, Ret.)
Head, Logistics Department, 1965-72

EUGENE J. SUTO
Manager, Security and Documents, 1966-72

ALBERT D. THOLEN
Chief, Resource Analysis Department, 1971-72

CHARLES A. H. THOMSON
Chairman, Research Council, 1969-72

RICHARD E. TILLER
Chief, Combat Developments Division, 1964-65

O. W. TORRESON
Director of Personnel, 1961-62

RONALD C. WAKEFORD
Head, Economic and Social Development Department, 1969-72

DOROTHY HOOVER WHITMARSH
Administrative Assistant to the President, 1961-71

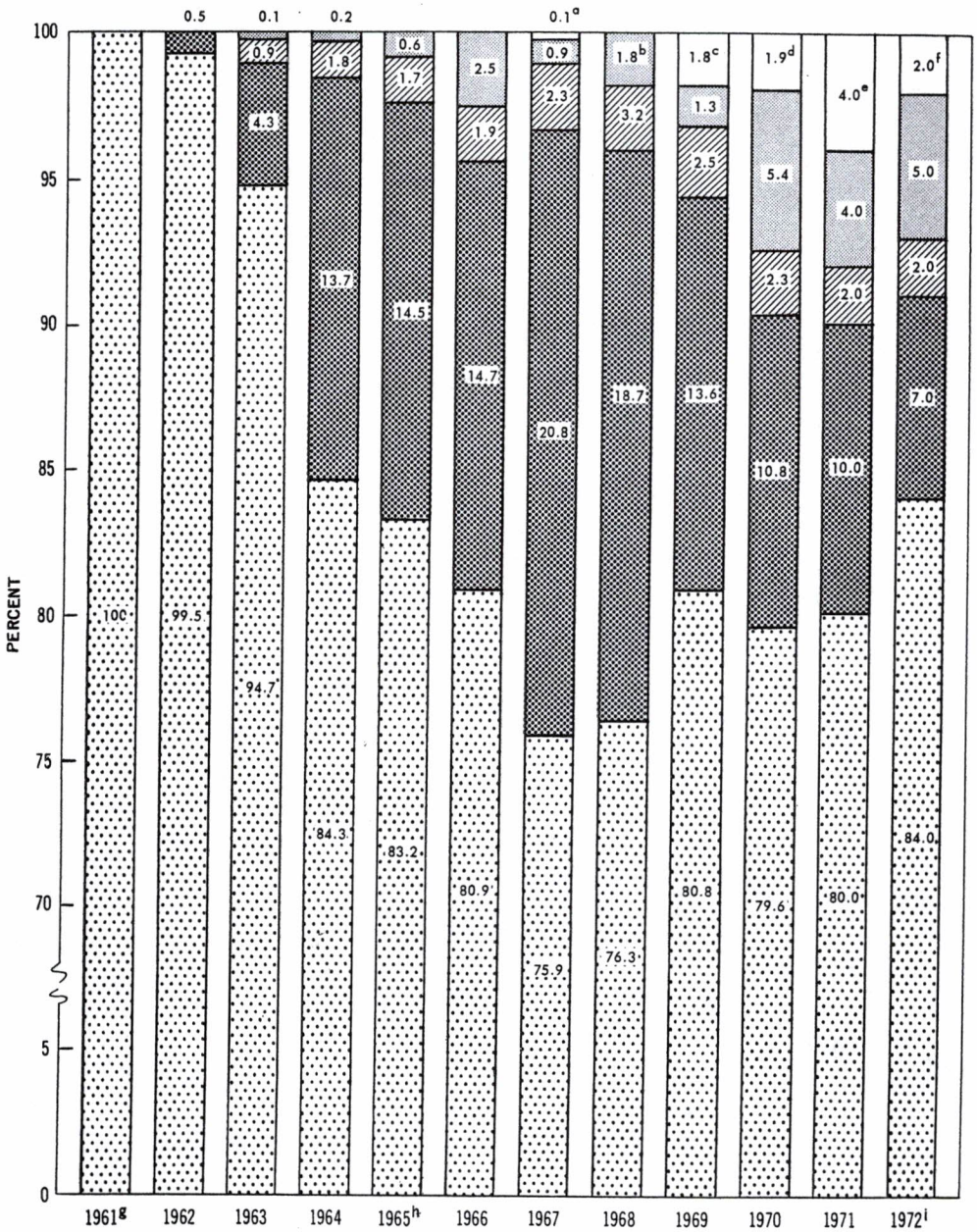
ROSWELL B. WING
Chief, RACTHAI, 1966-69

WILLIAM J. WOOD*
Technical Publications Director, 1968-72

KENNETH L. YUDOWITCH
Chief, Combat Developments Division, 1963-64

*Deceased

Appendix B



Sources of Support

[a] 0.1% includes 0.03% nondefense, state and local government (NDS/L).
[b] 1.8% includes 1.1% nondefense, federal (NDF); 0.4% NDS/L; 0.3% private nonprofit (PNP).
[c] 1.8% includes 0.2% NDS/L; 1.6% PNP.
[d] 1.9% includes 0.8% NDS/L; 0.6% PNP; 0.5% private sector, industry (P/I).
[e] 4.0% includes NDS/L and P/I—breakdown not available.
[f] 2.0% includes NDS/L and P/I—breakdown not available.
[g] 1 Sep –31 Dec 61.
[h] 0.1% includes 0.03% PNP.
[i] 1 Jan–31 Aug 72.

Department of the Army
Other Departments of Defense (DOD)
Defense related, non DOD
Nondefense, federal
Other

Appendix C

PUBLICATIONS

The Research Analysis Corporation (and the Operations Research Office before it) published its output in several major forms: reports, technical memoranda, staff papers, technical papers, client reports, and papers. Of these, reports (R) were the most comprehensive and formal. A Report treated one or more phases of a study, survey, or analysis, and presented findings of fact, conclusions, and, where appropriate, alternative courses of action. Of these, about two-fifths (77 out of 200) were given a security classification and hence not available in that form to the general public. The remainder were not classified and were deposited and distributed as agreed to by the client.

Technical Memoranda (TMs) were formal publications prepared for distribution to the sponsor and with the sponsor's approval were disseminated to individuals and organization. They treated one or more major phases or aspects of a research study and provided results in definitive terms. Sixty five of the 101 items in this category were classified. The series was merged with Reports in 1967.

Staff Papers (SPs) were formal publications, usually reporting in definitive terms on detailed phases of a research study. They were used to give timely distribution and thus to permit early use by a sponsor of special or urgent segments of a larger research project. The series was discontinued in 1963.

Technical Papers (TPs) dealt with problems of interest to a sponsor but not requiring his evaluation or action. TPs presented new methods, reference data, historical summaries, or conceptual essays. TPs dealt more with aids to the conduct of research than with research results.

The Client Report (CR) series was short (less than 50 items) and designed to categorize research not appropriately published as a Report or a Technical Paper. Almost all were unclassified. Eight were treated as proprietary and distributed to the client only. Some were of special interest, such as CR-19, "The Police Function in a Negro Community," and CR-25, "Perceptions of the Police in a Black Community" (funded by the Ford Foundation). Others (CR-7 and CR-31) dealt with the problem of allocation of resources to research and development tasks.

Papers (Ps) were scientific and technical papers, articles for professional journals, lectures, and speeches printed as a courtesy to the authors, or, on occasion, to meet certain RAC needs. Some 60 of these were produced between 1965 and 1971. Also during this period there appeared some 40 unnumbered papers. All of the Ps and most of the unnumbered papers were unclassified and available for general distribution. Among notable unnumbered papers were the "Guide for Reviewers of Studies Containing Cost-Effectiveness Analysis," by

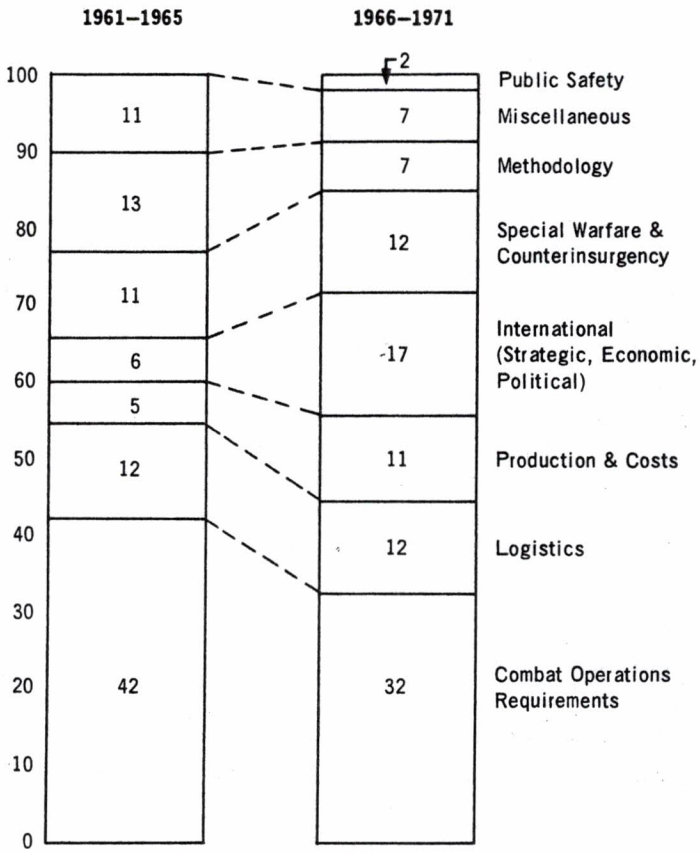


Fig. 3—RAC Publications by Research Areas
(in percent)

Irving Heymont and others; a "Report of the Working Conference to Develop an Integrated Approach to the Prevention and Control of Juvenile Delinquency," "Utilization of Negro Manpower in the Army: A 1951 Study," "Optimal Allocation of Missiles Against Area and Point Defenses," and "Production Applications of Large-Scale Linear Programming Models for Optimized Resource Allocation Within the US Department of Defense" (by Justin C. Whiton).

Among notable Ps were P-27, "Four Papers on Problems of Strategy," by George S. Pettee; "Simulation and Gaming Methods for Analysis of Logistics," by Albert D. Tholen; P-48, "Future Land-Mobile Communications," by Frank R. Eldridge; P-51, "Post Attack Recovery," by Bernard Sobin; and P-54, "East European Economic Development: Two Decades of Interrelationships and Interactions with the Soviet Union, " by John P. Hardt.

Some of RAC's work, done in field headquarters, appeared as field papers. Most of these were classified and done for the specific needs of US headquarters in Europe or in Vietnam or Thailand. Among these were studies of the highway, railway, and inland waterway transport systems of Thailand and a study of indicators of incipient insurgency. Field papers were sometimes incorporated in more comprehensive technical papers.

A few RAC studies were brought out by commercial publishers as books. These included:

Jerome Bracken and Garth P. McCormick, *Selected Applications of Non-linear Programming,* John Wiley & Sons, 1968. (Also published as RAC-R-68.)

Anthony Fiacco and Garth McCormick, *Nonlinear Programming: Sequential Unconstrained Minimization Techniques,* John Wiley & Sons, 1968. (Also published as RAC-R-67) Awarded the 1968 Lanchester Prize in operations research.

Peter C. Fishburn, *Utility Theory for Decision Making,* John Wiley & Sons, 1970.

Alfred H. Hausrath, *Simulation and Security in War and Peace: The Role of War Gaming,* McGraw-Hill, 1971.

Many RAC papers were published in professional journals and the various symposia of the Military Operations Research Society.

RAC staff contributed articles to the *Encyclopedia Britannica* and to other encyclopedias. Several produced important volumes, not results of RAC work. Notable examples were Hugh M. Cole's volume on *The Ardennes: Battle of the Bulge* (in the US Army History of World War II, Washington, 1962); Martin W. Brossman's *A Japanese Paper-folding Classic,* Washington, 1961; and Theodore E. Sterne, *Introduction to Celestial Mechanics,* Interscience, 1960.

Reports

Among the most noteworthy unclassified Reports, listed in the order of publication, are the following:

R-20 *Cost Analysis of Supersonic Transport in Airline Operations,* 2 vols, 1966. Robert A. Booth, Ansel V. Gould, Samuel A. Lamar, Lawrence G. Regan of RAC, and James L. Johnson and James C. Willyard of Resource Management Consultants, Inc. Sponsored by FAA. OLC 28 Jul 67 Distr. Unlimited.

R-24 *An Evaluation of the Army Aircraft Logistical Evaluation Tests,* 1967. Ray M. Clarke, Walter P. Maiersperger, Wilbur O. Miller, Jr., Leonard B. Weingarten.

R-26 *Engine-Transmission Power Plants for Tactical Vehicles,* 1967. Emil M. Szten, Harold G. Seeger, Kenneth R. Simmons, William O. Sprang, Richard A. Tarkir.

R-27 *An Analysis of User Unit-Direct Support Unit Supply Operations in Seventh Army,* 1968. Robert W. Bluehdorn, John R. Bossenga, Jerry L. Buffay, Conway J. Christianson, T. Donald Dixon, Reginald F. Doran, Thomas F. Ferrara, Sean P. Foohey, Harrison N. Hoppes, Richard G. Huver, Howard A. Markham, Douglas E. Smith.

R-30 *Selected Studies in Soviet Economic Trends, Structure and Institutions,* 1968. John P. Hardt, Stanley H. Cohn, Dimitri M. Gallik, Vladimir G. Treml. OLC Distr. Unlimited, 4 Jun 68.

R-31 *An Analysis of Alternative Procedures for Developing Prescribed Load Lists (PLLS),* 2 vols, 1968. John R. Bossenga, Reginald F. Doran, Thomas M. Fabian, Thomas F. Ferrara, Harrison N. Hoppes, Jane M. Meyer, Elizabeth C. Moore, Douglas E. Smith.

R-48 *An Evaluation of a Heavy-Lift Helicopter in the Logistical Role,* 1968. Ray M. Clarke, Walter P. Maiersperger, Wilbur O. Miller.

R-64 *Economic Use of Military Aircraft and Sealift for Overseas Shipment in Peacetime,* 2 vols, 1969. Lawrence G. Regan, Richard D. Goodfriend, William E. Billion, Richard E. Melby, Beatrice R. Dane, Leonard A. Poth.

R-72 *Major Issues in Japan Security Policy Debate,* 1969. Young C. Kim.

R-76 *Tactical Frequency Management for FM and HF Radios,* 5 vols, 1970. Roger A. Burt, Samuel Cohen, R. F. Hildreth, John Kenworthy, J. H. Marshall, James E. Russell, Byron Webb.

R-78 *A Comprehensive Research Program in Crime Prevention,* 1969. Ronald E. Kirkpatrick, Richard C. Stevens.

R-86 *The FOREWON Force-Planning System,* Basic Report, Appendixes, and Annexes, 1969-71. J. T. Newman, W. B. Blakemore, J. A. Bruner, R. H. Cole, G. E. Cooper, G. R. Doenges, Jr., R. F. Doran, N. H. Fletcher, R. E. Forrester, J. T. Goodley, J. W. Johnson, W. I. Keller, E. P. Kerlin, P. S. Levy, P. E. Louer, C. J. Lynch, D. W. Mader, D. Parker, J. A. Scanga, E. P. Schneider, J. T. Small, W. H. Sutherland, W. B. Taylor, C. A. Warner, B. B. Watson, L. G. Wentling, R. G. Williams, P. R. Wolkenberg, R. E. Zimmerman.

R-92 *Economic Insights on Current Soviet Policy and Strategy,* 1969. John P. Hardt.

R-97 *Japan's Security Policy Toward Communist China: A Case Study of Strategic Factors,* 1970. Young C. Kim.

R-100 *Information Flow and Combat Effectiveness,* 1970, R. V. Tiede, L. A. Leake, S. Whipple, Jr., and others.

R-116 *Selection of Items for Air Shipment on an Economic Basis,* 1971. Ray M. Clarke, Armand A. Bilodeau, Donald M. Boyd, Martha E. Breon, Walter P. Maiersperger.

R-123 *Chinese Views of Sino-Soviet Relations: An Analysis of Operative Factors,* 1971. Harold C. Hinton.

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