Organization and Research and Development Decision Making Within a Government Department

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THIS paper examines some organizational aspects of military R and D decision making. For the purposes of our discussion we visualize R and D as a continuous spectrum of activities that can for expository purposes be divided into discrete steps, as follows:

Step I. The formation and empirical verification of theories about parameters of the physical world.

Step II. The creation and testing of radically new physical components, devices, and techniques.

Step III. The identification, modification, and combination of existing components and devices to provide a distinctly new application practical in terms of performance, reliability, and cost.

Step IV. Relatively minor modification of existing components, devices, and systems to improve performance, increase reliability, reduce cost, and simplify application.[1]

For those who like a more conventional terminology step I can be equated with basic science, step II with applied research, step III with advanced engineering and development, and step IV with engineering. Since several of the papers presented in this volume are concerned with the nature of these steps and their interaction, we shall not discuss them in any detail here.

It is commonly said that the technical problems of weaponry are increasing. Certainly, two changes distinguish the post-Korean projects from those of 1946 to 1949. First, step I and II activities play a larger role in the missile and supersonic aircraft developments of the 1950's, although the bulk of the effort remains in stage III. Second, the effort at stage III has become more complex.

In this kind of technical environment, the crucial decision to initiate a weapons program, to provide for its funding, and to administer its execution can be formulated in terms of two kinds of considerations.

[1] This tabulation is adopted from David Novick, "What Do We Mean By Research and Development," *Illinois Business Review*, November 1959.

First, what is the relationship between cost in terms of both dollars and time and the performance of the weapon, that is, what might be called the development possibility function. Second, what is military utility or value of various combinations of cost, time, and performance. Conceptually, it is apparent that the decisions in weapons projects are identical to those in the theory of the firm. But in view of the great uncertainties involved a purely formalistic and static analysis would tell us very little about how weapons projects are administered.

The approach we have been assigned is to examine some of the aspects of the organizational framework for weapons projects. Each of the various groups involved can be viewed as one element or force in the decision process that we ordinarily visualize as taking place inside the skull of an idealized decision maker. In this way, we can distinguish some of the factors that underlie a complex development decision.

Patterns of Organization

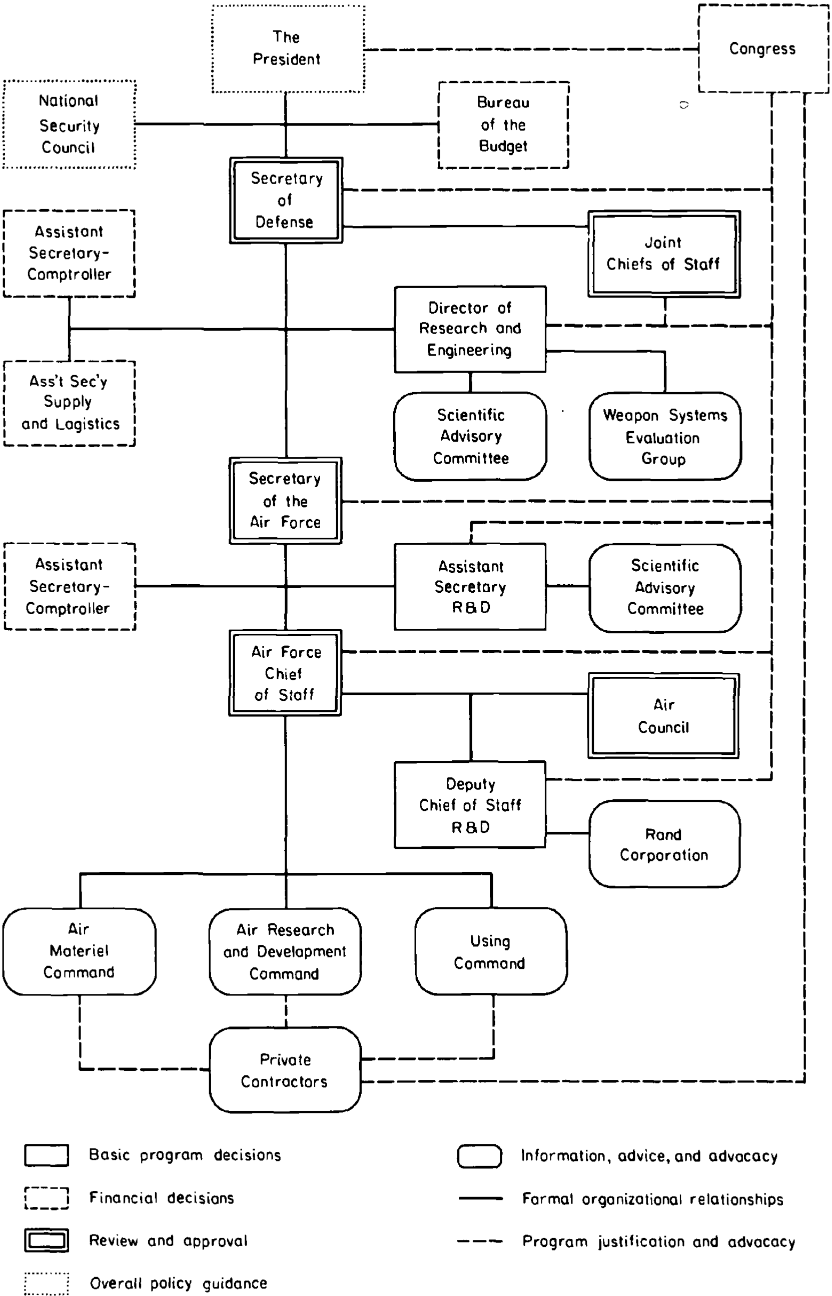
Having set forth the several levels of research and development, it is appropriate to examine the pattern of organization within which decisions concerning them are made. Figure 1 sets forth a highly simplified, over-all organizational chart, using the Air Force by way of illustration. This chart shows all of the major groups that are apt to become involved in a decision to go ahead with a step III development project for a major (and probably controversial) system. A decision involving a step I research project would probably involve many fewer groups and perhaps only some subunit of the Air Research and Development Command, which would enter into a contract for a few thousand dollars with a university, specifying that one or two individuals would work in a fairly broad area.

For present purposes, we shall confine our attention to a decision to begin serious development of a major weapon system (step III).

There are a number of ways in which such a development may be initiated. A contractor may propose it. It may result from a special study by a group such as the RAND Corporation. It may be proposed by a subunit of either the ARDC or an operating command. But the first formal document proposing development of such a system probably originates in the headquarters development staff.

Various development possibilities and their military value are appraised and integrated into a program recommendation by the

FIGURE 1
Groups Involved in a Major Air Force Program Decision



headquarters research and development staff of the particular military service. Participating in these determinations are civilian counterparts in the offices of the service secretary and perhaps the Secretary of Defense. Information and often complete recommendations are obtained from the service's procurement and research agencies, from commands which will use the proposed weapon system, from industrial contractors, and from a variety of independent groups.

Several hundred persons are apt to have a hand in the process of coordinating and clearing the development proposal through the numerous offices in Washington and the field. These are not ultimate decision makers, but some of them may help to shape the ultimate decision.

The location of the crucial decision to proceed with a development program depends upon the quantity of resources required, the degree of certainty attached to cost and military value expectations, the relationship of the particular program to programs of other agencies, the extent to which overall national policy is affected, and many other elements. Most program decisions are formally made by the service secretary upon the recommendation of the military chief. However, if neither of the two revises the recommendations of his staff, who has made the decision? And decisions of the services can be altered or overruled by the Secretary of Defense and his staff. When top national policy is involved, weapons development decisions have been passed up to the President, e.g. it was President Roosevelt's decision to develop the atomic bomb and President Truman's decision to move forward into the hydrogen bomb.

What can be stated is that the program decision is a function of the United States executive branch. The Congress has on occasion attempted unsuccessfully to cancel programs (such as the Air Force's Mace guided missile) and to have programs initiated (such as its efforts to accelerate development of a nuclear propelled bomber). But its power over program decisions must be exercised mainly through persuasion (a not insignificant factor) and through broad budgetary controls.[2]

This suggests another aspect of the program decision—the determination of resource levels, usually in dollar terms, once the program has been approved. Again, the locus of program decisions is not

[2] For an excellent discussion of the U.S. organization for weapons program decision making, see *Hearings* on Organization and Management of Missile Programs, H.R. Committee on Government Operations, 11th Report, 1959, especially pp. 151–152.

easily described. Initial program budgets are usually prepared by military procurement agencies on the basis of information submitted by contractors. The budgets are then revised successively by the service headquarters staff, by the service secretary's comptroller and research and development staffs, by the Secretary of Defense's staff, by the Bureau of the Budget, and finally by Congress.[3] Even when Congress makes its annual appropriation, the level of spending on any one program is not absolutely determined, for the executive agencies can withhold money (as was done in the Polaris and Nike Zeus programs, to cite only two instances) and can divert money from other categories to conduct programs for which funds were not appropriated (as in the Mace case[4]).

In sum, very many hands and heads participate in any weapon system program decision, with the result being a lengthy and complex decision making chain. Almost inevitably the chain will include both advocates and skeptics, and an important dissent can seriously delay a program considered urgent by others. These characteristics of the U.S. program decision making process have been studied and criticized repeatedly in recent years. As retired Lt. General James M. Gavin, former chief of the Army Office of Research and Development, wrote,

> It has been the decisions that have been, at times, shockingly in error, not only the decisions themselves, but their tardiness. And the principal object of any reorganization now should be to accelerate and improve the quality of the decision-making processes.[5]

Nevertheless, as noted earlier, our immediate object is simply to point out the economic features and problems of the program decision making process, not to recommend specific corrections. To that end it is particularly useful to look for a moment at the terminal links in the decision chain: the information inputs at one end and the final decision making locus at the other end.

Let us begin by considering the final decision locus. Critics of the

[3] Cf. *Hearings* on Research and Development, H.R. Committee on Government Operations, 32nd report, 1958, especially pp. 100–102 and pp. 116–146.

[4] Cf. *Hearings* on Organization and Management of Missile Programs, *op. cit.*, p. 65.

[5] *War and Peace in the Space Age*, New York, Harper, 1958, p. 163 ff. Other examples include the Rockefeller Report, *International Security: The Military Aspect*, Garden City, Doubleday, 1958, pp. 27–35; and the Robertson Report.

weapons decision making process have often questioned the need for secretarial reviews and concurrences. However, analysis of commercially sponsored developments suggests that their wonderment may be misdirected—it is perhaps more amazing that so much authority is delegated to generals and assistant secretaries. Even in the largest U.S. corporations, projects involving more than roughly $100,000 are critically evaluated by at least a vice-president, and often by the company's president and board of directors. Yet, in contrast, Air Force weapon system project officers (usually lieutenant colonels) have authority to approve program changes involving up to $350,000, and the Air Research and Development Command can begin new programs costing up to $1 million and authorize program changes worth up to $5 million on its own initiative. Major weapons programs, however, involve tens to hundreds of millions of dollars. The interest of top Pentagon decision makers when these sums are at stake is not surprising.[6] The significant question is not whether these top officials should be interested; it is whether they are in a position to comprehend the full range of issues involved in a technically complex program decision. But this matter must be deferred until the issues themselves are better defined.

Turning to the inputs of information for such decisions, most of the various groups shown in Figure 1 add information about strategic worth and technical feasibility. Two outside groups, the weapons contractors and the scientific advisory committees, deserve some special attention at this point.

Role of Contractors

In recent years, private contractors have taken an active part both as sources of information and as advocates of the weapons development in which they participate. With respect to the former role, contractors are perhaps the most important source of new weapons ideas.[7] Besides ideas, they provide information on the technological feasibility of new concepts and data on estimated development costs

[6] In other nations weapons acquisition decisions are also matters of top-level interest, often at the expense of rapid decision making. For one account of delayed top-level decisions, see "Swiss Fighter Choice Referred to Council," *Aviation Week*, October 26, 1959, p. 103.

[7] Cf. the testimony of Air Force Association president Peter J. Schenk in *Hearings* on Employment of Retired Military and Civilian Personnel by Defense Industries, Subcommittee for Special Investigations of the H.R. Committee on Armed Services, 1959, p. 396; and the Robertson Report.

and schedules—the basic elements of what we have called the development possibility map. In addition, practically every major weapon system prime contractor has an operations analysis group which studies the military value of new weapons possibilities—the other half of our theoretical program decision model.

Such contractor furnished information could be a valuable input into the program decision making process. On occasion, however, advocacy becomes mixed with education in unwholesome proportions. Particularly troublesome are unrealistic cost and time estimates submitted to "sell" a company's proposals. Moreover, contractors are so prolific in generating new weapons proposals that frequently the ideas are not fully evaluated by military planners who lack the time or perseverance required to plow through the chaff for a few kernels of wheat. As a result, even though contractors are potentially the best source of information on weapons possibilities, the admixture of advocacy with information prevents realization of the source's full value.

Of considerably less significance to the program decision making process, but of apparently greater public concern, are the efforts of contractors to promote their programs through public communications media and personal selling. The full-page advertisements purchased by producers of the competing Bomarc and Nike Hercules antiaircraft guided missiles provoked President Eisenhower to utter his much-quoted comment in 1959 about the "munitions lobby."[8] A House of Representatives committee termed such advertising "dangerous and unhealthy."[9] The same committee conducted extensive investigations into the employment of retired military officers by defense contractors for the purpose of their sales contacts and into the entertainment of military decision makers by contractors.[10] A more subtle means for generating widespread interest in specific weapons programs are company press releases (approved, of course, by the military agencies) describing in detail technical features and accomplishments of their development efforts.[11] Such releases are published

[8] *New York Times*, June 4, 1959, p. 14. The advertisements appeared in leading Washington, D.C., and New York newspapers on April 8 and 21, and May 27, 1959.

[9] *Hearings* on Employment of Retired Commissioned Officers, p. 15.

[10] *Ibid.*; and also by the same Subcommittee, *Supplemental Hearings* Released from Executive Session Relating to Entertainment, Furnished by the Martin Company of Baltimore, Md., of U.S. Government Officers, 1959.

[11] See, for example, the rash of optimistic articles on the Titan ICBM development in the January 11 and 18, 1960, issues of *Aviation Week* and the January 25 issue of *Missiles and Rockets*, just when the Titan program entered a period of crisis, with cancellation

readily by trade magazines anxious to report the newest developments in their fields, and the result is a substantial literature on otherwise secret weapons programs.

It must be said in fairness that much of the advocacy surrounding U. S. weapons programs is not of a malicious or mercenary sort. Both contractors and sponsoring services usually have a genuine belief that their weapons programs are essential to the national defense. If this sincerity does not come from pride in invention, it soon develops just as a result of constantly living with the idea. However, selling a new program to all the skeptics in a decision making chain is not easy. Indeed, history shows that were it not for zealous advocacy, many new military developments would never have received approval until it was too late. Under these circumstances, personal contact with "the right people" is an effective means of getting ideas accepted. Similarly, creating public demand for a program through advertising and feature articles is a way of winning over or bypassing balky decision makers. Nevertheless, there is a deep-seated presumption in the United States that the government (perhaps unlike private consumers) should not be "sold" on new weapons; that it is intelligent enough to recognize its needs and make rational decisions without coaxing.

Use of Scientific Consultants

Given the tendency for advocacy to creep into the presentations of both contractors and sponsoring military agencies, and recognizing their own inability to deal with the vast array of technical questions in weapons program decisions, top military and civilian officials have felt the need for some objective source of creative ideas and technical evaluation. One solution has been the widespread employment of professional scientists as special consultants to the government. Beginning with the National Defense Research Committee formed in 1940 (the group that sponsored the Manhattan Project and the Radiation Laboratory), the scientific advisory committee has come to play a truly significant role in U. S. weapons decisions. After World War II, the counsel of leading scientists and engineers was instrumental in the decision not to promote the development of ballistic missiles and later (when a committee of scientists predicted the breakthrough in hydrogen warhead technology) in the decision to develop ballistic

under serious consideration, after several highly unsuccessful tests. On the program's uncertain position at the time, cf. "Martin Girds for Titan Crisis," *Business Week*, January 9, 1960, p. 69.

missiles with maximum urgency. Scientific advisory committees similarly influenced decisions to undertake the Polaris submarine launched ballistic missile development, not to cancel (in 1959) the Bomarc antiaircraft guided missile program, to proceed cautiously on the Nike Zeus anti-missile project, and to proceed with or abandon a variety of other weapons developments. By 1960, practically no high-level weapons decision maker was without a full complement of standing and *ad hoc* scientific advisory committees.[12]

The role of scientific consultants and advisory committees in program decisions can be stated in terms of a theoretical program decision model. First, they determine whether or not a weapon system of certain technical characteristics is feasible or not (whether or not a development possibility curve exists); second, they assess the development cost and time required to obtain weapons of those characteristics (estimating the position and shape of our development possibility curves); and third, they make independent technical evaluations of the strategic worth of proposed weapon systems (building up what we have called the military value function).

Naturally, not all scientific advisory committees perform all of these functions, and when they do, they do not perform them equally well. Such committees appear to be most useful in appraising the technical feasibility of proposed weapon systems, that is, in judging whether given systems can be developed or not. In this role the scientist's familiarity with the fringes of the state of the art is a valuable asset. But in projecting development costs and schedules, either *ab initio* or through the evaluation of contractor submissions, the scientist often has less to offer. The reason why is summarized from testimony of guided missile and satellite expert Werner von Braun:

> It is helpful to have a scientific advisory committee at a time when you kick the question around whether a certain proposal is sound or desirable and in the country's interest and whether the performance promises made are sound, and so forth. . . . But the missile business, particularly once a missile project really gets going, involves many questions which are, I would say, non-

[12] For a chronological "who's who" of committees in the guided missile field from 1950 through 1959, see *Hearings* on Organization and Management of Missile Programs, *op. cit.*, 1959, pp. 712–777. A more compact 1957 list appears in *Hearings* on Inquiry into Satellite and Missile Programs, Senate Committee on Armed Services, Preparedness Investigating Subcommittee, 1958, pp. 352–355. The contributions of scientific advisory committees are described at length in *Hearings* on Organization and Management of Missile Programs, 1959, *op. cit.*, especially pp. 12–15 and 69–74.

> scientific in nature; they have something to do with project management or time schedules. For example, a physics professor may know a lot about the upper atmosphere, but when it comes to making a sound appraisal of what missile schedule is sound and how you can phase a research and development program into industrial production, he is pretty much at a loss. . . . I believe an established missile program, like the Jupiter, has much more similarity with an industrial planning job than with a scientific project. . . . I would say [Jupiter] was 90 per cent engineering and 10 per cent scientific, and in these scientific areas we love scientific advice.[13]

Recognizing the value of scientific advice both in broad feasibility evaluations and detailed problem areas, von Braun nonetheless suggested a more fundamental reason for the proliferation of scientific advisory committees:

> Sir, there are many areas where we even go to them and ask for their advice, but I think to expect a scientist to have all the answers to everything—my personal feeling, to be frank about this, is as follows: I believe that the prestige factor plays a very important part in these things. When confronted with a difficult decision involving several hundred million dollars, and of vital importance to the national defense, many Pentagon executives like to protect themselves. It helps if a man can say, "I have on my advisory committee some Nobel prizewinners, or some very famous people that everybody knows." And if these famous people then sign a final recommendation, the executive feels, "Now, if something goes wrong, nobody can blame me for not having asked the smartest men in the country what they think about this."[14]

Even in the assessment of technological feasibility, the task of a scientific advisor is not as narrow as one might imagine. There is a tendency to think of the state of the art as something very objective—either an accomplishment is technologically possible or it is not, and that is all there is to it. But, more frequently, this is not so. There are

[13] *Hearings* on Inquiry into Satellite and Missile Programs, *op. cit.*, pp. 591, 592, 589, and 590. The order of the comments has been rearranged.

[14] *Ibid.*, p. 591.

two major factors: whether a given accomplishment is possible for the best group of scientists and engineers available; and whether a given group can accomplish the task. What is quite possible for one development group to accomplish may be extremely difficult for another development group, merely because the former group is more competent or has specialized experience. There are wide variations in competence between development groups both within individual companies and between firms. Consequently, a good technical feasibility evaluation must consider not only the state of the art in a very objective sense, but also the competence, insight, motivation, and other characteristics of those who propose to develop the weapon. By failing to include these latter subjective elements, some scientific advisory committees have missed the mark badly in their evaluations.

Organizational Influences

The foregoing discussion is perhaps sufficient to illustrate the enormous complexity of the structure through which R and D decisions must pass when major step III projects are involved. But there are a number of additional influences that are brought to bear on the final decision that have their antecedents in the organizational structure. They may not be immediately apparent from an examination of the formal organizational chart. These may be briefly summarized as (1) objectivity versus confidence, (2) the influence of the operators, (3) the level of priority, (4) the fit with roles and missions and, (5) the influence of external forces.

OBJECTIVITY VERSUS CONFIDENCE

When the state of the art is uncertain, weapons decisions must often be based on interpersonal confidence rather than objective analysis.[15] The history of technology is replete with situations where innovations were supported not because the underlying logic was overwhelming but because someone with funds believed in someone with an idea.[16]

One illustration of the influence of "confidence" will suffice. A situation involving hundreds of millions of dollars is to be found in

[15] Along the same line but in a more traditional vein, see F. H. Knight, who observes that the basic problem of organizational responsibility and control is judging men's powers of judgment, not the facts of the situation (*Risk, Uncertainty, and Profit*, Boston, Houghton Mifflin, 1921, p. 292).

[16] There are also sufficient examples of failure under these conditions to provide one explanation of the tendency of program decision makers to gain assurance from several sources.

the conflict over whether the Nike Zeus antimissile missile system should be produced. Critics of the program in top decision making positions feared that, because of technological uncertainties, the system would not meet its performance promises or that the development would not be completed on schedule. Nevertheless, the Army had "tremendous confidence" in the system, largely because of the Army's successful experience with the same development team in the Nike Ajax and Nike Hercules programs.[17] To resolve this conflict, an independent committee of top scientists was appointed. Published information indicates that the committee accepted as given the development group's performance and schedule promises, confining its inquiry mainly to the question whether a weapon system of the proposed performance would provide military value commensurate with its cost.[18]

INFLUENCE OF THE OPERATORS

It is no secret that most military organizations are heavily oriented toward immediate operational capability—how can we fight right now. This is reflected in the fact that a chief of staff is typically an operating or combat man and that the headquarters operations staff is typically the most influential of the several functional staff groups. In the process of developing a proposal for a major advanced weapons system and pushing it through the decision making machinery, the influence of the operators bulks large. This has the tendency—but it is no more than that—to place emphasis on nearer-in projects and to mean that more speculative and farther-out projects are rejected, or are carried out as Step II component developments.

LEVEL OF PRIORITY

A major factor affecting both the level at which key decisions are made and the speed with which they are made is the level of priority of the project. The priority may be determined by an enemy threat, by a technological breakthrough or possibly by a competing project of a rival service. In the case of decisions affecting high priority pro-

[17] Cf. the testimony of Maj. Gen. Robert J. Wood, U.S. Army Deputy Chief of Research and Development, *Hearings* on Department of Defense Appropriations for 1960, H.R. Committee on Appropriations, Part 6, page 422. The fiscal year 1959, 1960, and 1961 Congressional appropriations documents abound with comments on the Nike Zeus controversy.

[18] Cf. "Defense Group Evaluates Zeus Potential," *Aviation Week*, November 2, 1959, p. 30; and "Zeus Delayed by Technical Doubt, Budget," *Aviation Week*, February 8, 1960, p. 32.

jects, the organizational machinery can be, and often is, made to work with considerable rapidity. Some of the steps normally undertaken are eliminated, some of the organizational units are short-circuited, and the ones retained are made to take coordinating action more rapidly. It is perhaps significant that in both the Navy and the Air Force, special organizations have been established to handle and make key R and D decisions on high priority missile projects.

FIT WITH ROLES AND MISSIONS

Some special decisions have to be made (usually at the top level of the service) when a project decision brings into issue the role or mission of the service. For example, in the air defense field, antiaircraft batteries had been assigned to the Army, air defense aircraft to the Air Force. With the advent of air defense missiles, the respective roles and missions of the services in the air defense field became a matter of controversy. Each service had a weapon presumably capable of destroying enemy bombers, and the only distinguishing feature was that the Army weapon (Nike) was a so-called point-defense weapon while the Air Force, in the Bomarc, had an "area-defense" weapon. This distinction was not sufficient to keep the weapons from being sharply competitive. This competition, and its potential threat to the services' role in the air defense mission, had a considerable influence not only on the initial R and D program decision but on a variety of subsidiary decisions as the respective programs proceeded.

What is usually referred to as interservice rivalry often has its origin in this type of roles and missions ambiguity. It thereupon may become an influential factor in various R and D decisions.

INFLUENCE OF EXTERNAL FORCES

There are, of course, a host of external forces which tend to influence R and D program decisions and which are the product both of the internal organizational complex of the Department of Defense and the services and of the relationship of the DOD to other parts of the government. The most familiar are the budgetary influences on program decisions as exercised by the Treasury, the Budget Bureau, the President and, ultimately, by the Congress. But there are many others.

The decision makers may be urged to delay the announcement of the cancellation of a major R and D program until after an election on the grounds of political expediency. They may be urged to give a contract for a new program to contractor A rather than contractor B on the grounds of a high level of unemployment in contractor A's territory and in view of the fact that contractor A's capability is almost on a par with B's.

The fact that such courses are urged, perhaps by powerful external organizations, does not mean that they are automatically followed. On the other hand, depending on the power of the external organization, they undoubtedly receive consideration unless deemed wholly unreasonable. The DOD and each service must, after all, live in an environment of accommodation with other branches and agencies of government.

It is sometimes claimed that political factors play a large role in R and D decisions, especially in the matter of source selection. It is our impression that political influence on R and D decisions is greatly overrated. But it would be absurd to deny that it is not attempted and that it tends to complicate R and D decisions.