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Organizational strategies for protection against back contamination

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ORGANIZATIONAL STRATEGIES FOR PROTECTION AGAINST BACK CONTAMINATION

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FOREWARD

A review of titles of reports associated with project NGL 24-005-160 reveals an interesting evolution of thought and analysis. The original title of the project was "Safety of Containment Systems," and the intent was to design controls against back contamination from possible return of samples in space exploration. Analysis of experiences of the Lunar Receiving Laboratory and of available containment technology suggested that the primary risks of back contamination lay in the behavior of people applying the available technology, not in the shortcomings of technology. Subsequently the title of the project was revised to "Personnel Management Techniques Necessary to Maximize Bio-Barrier Integrity at a Martian Receiving Laboratory," reflecting the change in focus of the investigation. Continued investigation and analysis suggested that behavioral problems in the application of containment technology were more a function of organizational influences than a function of personal variables. Hence the title of this report, which focuses upon primary organizational issues in the development and application of programs for protection against back contamination.

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ORGANIZATIONAL STRATEGIES FOR PROTECTION AGAINST BACK CONTAMINATION

INTRODUCTION

The threat of extraterrestrial contamination has been a matter of concern to scientists and others since the early days of space exploration. The Outer Space Treaty of 1966 recognizes the possibility of harmful contamination of extraterrestrial bodies (outbound contamination)and of our planet (inbound contamination) and imposes responsibilities upon participating states for the prevention of contamination. Article V, for example, requires the sharing of outer space discoveries"...which could constitute a danger to the life or health of astronauts...," and Article IX requires that states conducting studies of outer space "...[shall] avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose...." Incorporation of these responsibilities into the U.S. space activities has proven difficult for a number of reasons. Prevention of extraterrestrial contamination is of special concern again with the planning of Viking missions to explore Mars and possibly to return samples to earth for analysis.

The issues of outbound and inbound contamination differ significantly in at least two respects. First, outbound contamination is concerned with the prevention of known organisms from being carried to extraterrestrial bodies, while inbound contamination is concerned with prevention of unknown organisms from being introduced to earth; it is far easier to plan for and cope with the known than with the unknown. Second, responsibility for the control of outbound contamination falls logically within the domain of a single agency, the National Aeronautics and Space Administration (NASA), while various agencies of the federal government are assigned differing responsibilities for the prevention of inbound contamination. Consequently, organization for the prevention of inbound contamination is far more complex and difficult than organizing for the prevention of outbound contamination.

This report is concerned with the organizational issues pertaining to the prevention of inbound contamination associated with possible Viking missions to Mars. The completed Apollo missions, which returned samples from the Moon, provide a convenient base for analysis of inbound contamination issues. Despite concern over the threat of inbound contamination from the moon and efforts to prevent back contamination, it is generally concluded that the back contamination efforts in the Apollo missions would have been ineffective had these missions encountered living organisms. Those planning for the prevention of back contamination from the Viking missions should analyze the reasons for failure of back contamination efforts in the Apollo missions and should design alternatives to remove or overcome the reasons for this failure.

The alleged failure of programs to prevent back contamination from the Apollo missions was not evident in the actual occurrence of back contamination. No evidence of living organisms was encountered. Rather, it has been argued that the programs implemented to prevent back contamination would not have been adequate to prevent back contamination had living organisms been discovered.

Undoubtedly one of the reasons for the inadequate performance of back contamination prevention programs was the widespread belief that no danger was present. The possibility of encountering life on future missions, although small, is much greater than it was in the Apollo missions and is a cause for concern. The inadequate performance in implementation of measures to prevent back contamination from the Apollo missions is surprising in view of the recognized successes of NASA in both technological and managerial aspects of space flights. NASA has pioneered many innovative managerial techniques for large scale organizations, but the program for prevention of back contamination apparently was not successful. Problems in the implementation of back contamination programs appear to have been organizational and managerial rather than technological.

The basic issue of concern is: "how should programs be designed for the prevention of back contamination from space missions such as the planned Viking missions?" As suggested earlier, this analysis focuses upon reasons for difficulties encountered in the programs for the prevention of back contamination in the Apollo flights. Based upon that analysis, several alternatives for consideration in the design of future programs dealing with back contamination are examined and proposed for special consideration.

The National Aeronautics and Space Administration was established in 1958 through Congressional legislation. NASA, as a civilian agency, was charged with overall aeronautical and space responsibilities except those concerned with military matters.[2] NASA's objectives include:

1) "expansion of human knowledge of phenomena in the atmosphere and space...

2) "[perfection] of aeronautical and space vehicles...

3) "long-range studies of the potential benefits...and problems...[of peaceful] space activities...

4) "preservation of the rule of the United States as a leader in aeronautical and space science

5) "making available to [defense] agencies...discoveries that have military value

6) "cooperation...with other nations...in peaceful [aeronautical and space] application

7) "close cooperation among all interested agencies of the United States in order to avoid unnecessary duplication of effort, facilities and equipment."[3]

Specific issues relating to extraterrestrial contamination were not mentioned in the enabling legislation. Responsibility for protection against extraterrestrial contamination was accepted by the U.S. as signatory to the Outer Space Treaty but there has been no statutory assignment of these responsibilities to NASA or other federal agencies.

Issues regarding the location of responsibility for prevention of back contamination and authority for implementing programs to prevent back contamination appear upon review to be critical in analysis of the back contamination programs of the Apollo flights. Every large organization must differentiate responsibilities assigned subordinate bodies (i.e. specialize) in struggling for efficiency of performance; this need for differentiation is particularly acute in circumstances involving rapidly changing technology such as space exploration. Differentiation of responsibilities makes more difficult the integration of activities of specialized organization sub-units. Differentiation of specialization without equivalent development of means for integration is of little value. NASA has, by most accounts, been highly successful in the development of means for integration of activities among highly diffenentiated organizational assignments; techniques of PERT (Program Evaluation and Review Technique) planning, matrix organization, and project management were developed and applied successfully within NASA for the integration of differentiated responsibilities.[4] Responsibility for the prevention of back contamination accepted in the space treaty does not, however, appear to have been clearly assigned to NASA. Rather, responsibility for the prevention of and authorities to prevent back contamination appears to have been diffused among various federal agencies; these are examined in later sections of this report. The basic issue to be addressed in the design of programs to prevent back contamination from the Viking flights is the most appropriate differentiation of responsibilities for prevention of the introduction of contaminants and vehicles for the adequate integration of activities to prevent such contamination. This is an organizational issue concerning various federal agencies (Agriculture, Interior, and Health, Education, and Welfare), not merely an organizational issue confined to NASA.

HISTORICAL BACKGROUND

NASA

The National Aeronautics and Space Administration (NASA) was established in 1958 in direct response to the Russian launching of Sputnik in October, 1957. NASA's purpose was to coordinate and mobilize U.S. space efforts to ensure U.S.

leadership in this area of activity. A predecessor agency, the National Advisory Committee for Aeronautics (NACA) had been established in 1915 to study and develop practical solutions to problems of flight. With the exception of the World War II period, most of the NACA efforts had been directed toward basic research in flight technology, not the application of technology. Directed research in flight technology was conducted largely by the military. Congressional intent in the establishment of NASA apparently was to mobilize U.S. space efforts through consolidation of all non-military space and aeronautics activities within a single agency to achieve and maintain world leadership in space science and technology, and to incorporate national objectives of space exploration and science with the NACA objectives relating to flight technology.[5]

Consolidation of aeronautic and space activities was sought through directing presidential review of activities and transfer of activities to NASA as appropriate. Authority was granted to the President to transfer to NASA "any functions (including powers, duties, activities, facilities or parts of functions) of any other department or agency..." for a period of four years, subject to review by Congress.[6] Among other such transfers, the NACA was abolished and its functions transferred to NASA.

Issues relating to coordination of efforts among federal agencies also were recognized in the 1958 Space Act, which provided for the exchange of information and discoveries among agencies particularly as they relate to national defense, and for "close cooperation among all interested agencies of the United States in order to avoid unnecessary duplication of effort, facilities and equipment."[7] Title II of the National Aeronautics and Space Act explicitly referred to the coordination of activities and, among other provisions, established the National Aeronautical and Space (NAS) Council to advise the President about space activities and programs. The act also provided for co-operation between NASA and the Department of Defense and the resolution of differences arising among agencies of the U.S. with respect to aeronautical and space activities. Responsibility for coordination of activities was assigned to the President.

Much of the early effort of NASA was directed toward development of technological capabilities for the conduct of outer space exploration. Programs were developed relatively quickly in the areas of advanced research and technology, tracking and data acquisition, and applications of space technology. Centers (facilities) for the application of these programs also were identified or established as needed. The distinction between "program" and "center" in the NASA organization is apparent throughout the history of NASA operations, and concern over the relative roles of program offices and centers has provided the impetus for various experiments in the development of organizational frameworks.

Program management in NASA involves the planning and direction of an inter-related series of research and development projects designed to achieve one or more of NASA's major objectives.[8] Program offices in NASA have varied over time but have included programs directed toward development of aeronautics and space technology, manned space flight, and missile tracking and data systems. Program specializing in a single functional aspect of space activities.

NASA field centers are responsible for the execution of NASA programs, largely through contracts with research, development, and manufacturing enterprises. Each center maintains and operates specialized facilities for space activities.

Additionally each center is expected to have the capability for preliminary design, fabrication, assembly, and testing of at least one vehicle and spacecraft unique to each major program.[9] Field centers constitute the operations organization of NASA and are specialized in terms of skill, technology, and facilities.

Program offices have primary responsibility for the direction of overall NASA efforts and exercise functional supervision over projects; field centers are responsible for program execution and exercise operational supervision over projects. Problems involved in the coordination of program offices and field centers have occasioned various organizational experiments within NASA and the development of relatively advanced managerial practices.

NASA program offices prior to 1959 focused upon the development of technological capabilities for the conduct of space research; there was no program office or effort directed toward bioscience or life science in the space effort of NASA. An ad hoc Bioscience Advisory Committee appointed by NASA in 1959, recommended that NASA develop programs in the biosciences.[10] That committee recommended that an Office of Life Sciences be established with a director coordinate in rank with existing program directors, that is, that a program in Life Sciences be established with priorities equivalent to the priorities assigned existing NASA programs. This recommendation was based upon recognition that NASA had responsibility for manned space flights and upon recognition of the possible danger resulting from contact with extra-terrestrial life. An Office of Life Sciences Programs subsequently was established within NASA in March, 1960, although development of the office and related programs was implemented slowly.

The appointment of a new director of NASA in 1961 provided the occasion for examination of the NASA organization and subsequent reorganization in November, 1961. An internal examination of NASA during that time noted, among other things, that there was imbalance among the program offices; the Office of Life Sciences was too weak and the Office of Space Flight was too strong. Interestingly, the Office of Life Sciences was dropped in the November, 1961 reorganization of program offices after a life span of less than two years. A November, 1962 organization chart does, however, indicate responsibility for bioscience programs within the Office of Space Sciences; other responsibilities of that Office include geophysics and astronomy programs, launch vehicles and propulsion programs, and lunar and planetary programs. Responsibilities indicated for the Office of Advanced Research and Technology include biotechnology and human research as well as nuclear systems, space vehicles, aeronautical research, propulsion and power generation, and electronics and control. Clearly the concern for life sciences indicated in the 1960 creation of an Office of Life Sciences was not evidenced in the NASA reorganization in 1961.[11]

This brief review of the history of bioscience and life sciences efforts within NASA suggests that concern for the life science implications of space exploration were given relatively little priority in NASA efforts. This relative lack of concern can be explained in terms of the necessarily high priority for development of technology capabilities, the lack of clear authorization of NASA efforts in the life sciences given responsibilities of other federal agencies, and pressures upon NASA to avoid duplication of other federal efforts. The fact remains, however, that concern for life sciences in the NASA organization appears to have been minimal.

Relationships between NASA and other federal agencies were a matter of concern in the design of the Space Act of 1958 and continue to be of concern. The intent of that act apparently was to provide a means for focusing and integrating efforts toward space exoloration, efforts that might otherwise have been conducted independently by a variety of federal programs. Various other federal programs (notably Defense) had clear concerns for space technology and applications, and the creation of NASA was intended to expedite the development of technology for space exploration through integration of these varied interests and efforts. The National Aeronautics and Space Council created in the 1958 Space Act was one means of attempting to provide coordination among federal programs relating to the space effort. That council, composed of designated federal officials and appointed civilians, was charged with <u>advising</u> the President relative to aeronautics and space efforts. Interestingly, the role of the council was changed in amendments to the Space Act in 1961, the revised role to provide for expanded responsibilities.[12] The council was placed within the Executive Office of the President, the civilian members were dropped from the council, and the council was charged with <u>assisting</u> the President in the aeronautics and space field. Additionally, the duties of the council were expanded to include cooperation "among all departments and agencies of the United States engaged in aeronautical and space activities." By implication, the NAS Council was charged with providing cooperation among federal efforts in the life sciences and space activities. The NAS council was abolished in 1973.[13]

Concern for protection against back contamination from space flights was expressed during the planning of the Apollo missions to the moon and the return of astronauts and lunar samples. A conference dealing with back contamination issues was convened by the National Academy of Sciences in July, 1964.[14] (The NAS has had an advisory relationship with NASA since 1958.) The concern raised by the NAS and members of the scientific community made it imperative that NASA take account of these concerns in the planning and implementation of manned space flights to the moon. Lacking any clearly designated legislative responsibility for protection against back contamination or legislative authority to impose protective measures such as quarantine, NASA appears to have initiated informal contact and discussion with the Public Health Service and the Department of Agriculture regarding back contamination issues. This informal relationship continued until 1967, when the Interagency Committee on Back Contamination (ICBC) was formed.[15]

One reason for the formalization of relationships within the ICBC probably was the negotiation of an international Outer Space Treaty in 1966. That treaty provides that studies of outer space and exploration of the moon and other celestial bodies should be conducted in such a manner as "to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter."[16] The obligation to protect Earth's biosphere against harmful back contamination was accepted by the United States, and the ICBC developed as the vehicle for meeting this obligation with regard to back contamination from lunar sources.

A history of the ICBC in the development and implementation of back contamination programs associated with the Apollo flights is analyzed in a later section of this report. The discussion of the ICBC at this point is intended to demonstrate the general nature of NASA concerns with back contamination and means of acting on these concerns. It was noted earlier that programs concerned with the life sciences in NASA received relatively low priority compared with space technology and astronomical research. The Outer Space Treaty (1966) and pressures from the scientific community and the National Academy of Sciences imposed obligations upon NASA for protection against back contamination associated with the Apollo flights. Serious questions have been raised about the legal authority for quarantine regulations employed during the Apollo flights, and proposals have been made to rectify the currently confusing status. No such changes have been accomplished, however, and specific responsibilities for performance of the obligations of the Outer Space Treaty and authority to employ quarantine in protection against back contamination from space flights have not been established. The ICBC was abandoned following the Apollo flights, and the situation surrounding the planned Viking flights to Mars is essentially the same as that which existed prior to the Apollo flights.

ICBC

The Interagency Committee on Back Contamination has been viewed as a primary instrument in the back contamination efforts associated with the Apollo flights. The mixed reviews of the efficacy of those efforts suggest that a brief review of the experiences of the ICBC is in order.

The ICBC, although formalized in an interagency agreement in August, 1967, had been developing less formally since 1964. Coordinating relationships appear to have been established earlier between NASA and the Public Health Service. A PHS employee, Dr. Briggs Phillips, was appointed to represent the PHS at the Manned Space Center before the formalization of the ICBC. His contact at the MSC was the director of medical research and operations, who was responsible for all back contamination efforts at the MSC or the chief of Biomedical Specialities Branch, who was responsible to the director for execution of back contamination procedures. Dr. Phillips's role was to keep both NASA and PHS informed of problems of mutual interest, to expedite coordination of efforts in these problem areas, and to aid in communications between programs of both agencies.[17]

The Public Health Service has the authority to make and enforce regulations to prevent the introduction and spread of communicable disease into the United States and thus, presumably, might regulate reentry of lunar astronauts into the U.S. It would appear that NASA was motivated to coordinate back contamination efforts with the PHS prior to reentry of astronauts to avoid a confrontation at that time. Similarly, the Department of Agriculture regulates the importation of organisms, vectors and soils, and the Department of Interior is responsible for protecting fish and wildlife resources, responsibilities that might also occasion confrontation with NASA regarding the importation of lunar samples. All three agencies were parties to the ICBC as it was developed.

The interagency agreement establishing the ICBC and applications of this agreement present a confusing picture of the responsibility and authority for protection against back contamination from the Apollo flights. The purpose stated in the agreement suggests that the ICBC is responsible for protection against back contamination.[18] Examination of the agreement, the operations of the ICBC, and relationships between the ICBC and NASA, however, suggests that the ICBC was created by NASA as a means of fending off pressures from the concerned agencies and preventing those agencies from taking actions that might have frustrated the primary mission of the Apollo flights. Evidence for this interpretation includes the following:

- Definition of the functions of the ICBC limits the Committee to "advising," "recommending," "considering," and "reviewing" actions.
- Eleven members of the ICBC were specified, two from the PHS, one each from Agriculture, Interior, and the National Academy of Sciences, and six from NASA. While the chairman and deputy chairman were designated as PHS members, the executive secretary was designated as a NASA member. Further, it was specified that no meeting could be held without the attendance of some NASA representatives.
- No voting procedures were specified.
- NASA clearly viewed the ICBC as advisory to NASA, and, to the frustration of ICBC members, the ICBC was designated as "advisory" on occasion.
- ICBC members from agencies other than NASA had other full-time responsibilities and were able to devote relatively little time and attention to ICBC matters.
- Funds for the conduct of investigations or the implementation of programs recommended by the ICBC were available only from NASA, and the Committee had no independent source of funds.
- An incident is widely cited of NASA's alleged inability to implement ICBC quarantine procedures because of technological incapabilities, incapabilities that were overcome when the quarantine restrictions on the Apollo flights were later lifted.

This alleged incapability is cited as evidence of NASA pressure to avoid constraints imposed to prevent back contamination when they came into conflict with other NASA objectices.

- The Public Health Service representative at the Manned Space Center, Dr. Briggs Phillips, had no line authority with respect to implementation of quarantine provisions. He could only exercise informal influence through individuals in the MSC or through communication to the PHS and thus to the ICBC.

NASA's goals and objectives were concerned with development and implementation of technolgical capabilities for space flight and exploration. The prevention of back contamination resulting from space exploration was not a central objective of NASA; it was a constraint whose achievement was a more central goal of the other agencies represented on the ICBC. The risk of back contamination from lunar exploration was generally considered minimal, and it is not surprising that prevention of back contamination held relatively low priority within the NASA objectives. In effect, NASA's objective regarding back contamination was to secure approval of operations from other involved agencies rather than to secure protection against back contamination; this latter goal was not fully incorporated into NASA operational objectives. The ICBC provided NASA with a mechanism for securing approval whether or not the ICBC provided an effective mechanism for protecting against the risk of back contamination.

REVIEW

The organization of federal programs concerned with back contamination from space exploration and the actual back contamination efforts during the Apollo flights illustrate several models in the organization theory literature. One of these, the "contingency model" of Lawrence and Lorsch, applies the concepts of differentiation (specialization) and integration (coordination) in the analysis of organization structure and identifies determinants of the appropriate degree of differentiation and means of integrating specialized functions.[19] The model addresses alternative means of integrating or coordinating differentiated functions required for organizational efficiency.

Functions are differentially assigned to specialized organizational units to provide efficiency of performance. According to Lawrence and Lorsch, the degree of differentiation required depends critically upon the nature of the environments affecting the organization. The more differentiated the environments (clients, suppliers, resources), the more specialized and differentiated the organization structure must be. Thus, for example, a specialized public relations function becomes necessary only as there develops a relevant public pressure requiring specialized attention. The degree of specialization or differentiation also varies with the uncertainty and rate of change in the environment; an environmental pressure that changes rapidly (e.g. advances in technology) requires more specialized attention than an environment that is relatively stable over time. Thus effective performance of the organization requires specialization and differentiation of responsibilities adequate to cope with and exploit opportunities provided by the environment.

Increasing differentiation of responsibilities through specialization creates barriers to coordination or integration. Persons working in specialized units develop common disciplinary bonds and orientations that differ from those found in other specialized units. Specialized units are assigned specific goals that often replace the goals of the total organization. Informal cooperation and coordination among members of specialized functional units declines as differentiated goals, values, and orientations develop, and specific means of providing coordination or integration must be sought to overcome the developing barriers to cooperation. Specialization or differentiation, then, is effective to the extent that it is balanced by integrative techniques.

A variety of approaches toward integration can be identified, each more or less applicable depending upon the specific circumstances. One approach to integration is through planning and scheduling; differentiated functions proceed independently toward specific goals and are integrated through schedules for completion of individual activities. Another approach to integration is through organizational structuring; differentiated units that must be coordinated report to a single position, which provides integration through coordinated directives (the "linking pin" concept of Rensis Likert).[20] Other approaches to integrate involve individuals who informally buffer relationships between potentially conflicting units and provide integration through personal efforts.

The organization of the federal government illustrates differentiation and specialization to cope with relatively specific environmental contingencies (e.g. Departments of Defense, State, Labor, Agriculture). Legislation establishing these specialized functions is designed, insofar as possible, to avoid integration by eliminating overlapping interests and concerns. If necessary, integrative efforts can be applied through the Cabinet, councils such as the

National Defense Council, or personal efforts of the Executive Office of the President. The establishment of NASA also can be viewed as an attempt toward integration, although it also led to new issues of differentiation. The development and application of technology for space exploration posed issues (weather forecasting, defense, communications, scientific exploration) of concern to a number of federal agencies and created the opportunity for potential conflict among agencies. Integration of previously independent space activities was provided in the creation of NASA which was established as a specialized organizational body to conduct aeronautical and space activities. Integration was attempted through creation of a specialized organizational body charged with the conduct of all aeronautical and space activities. In fact, the Space Act of 1958, which established NASA, recognized implicitly the nature of integration being attempted and certain of the potential problems in this attempt. NASA was created as a specialized organizational unit to provide integration of activities, but it was not expected to provide integration of the interests, goals, and priorities of existing federal agencies as they relate to space activities; the National Aeronautical and Space Council was formed to serve this function.

Once established, NASA developed into a specialized organizational unit with goals, responsibilities, orientations, and priorities differentiated from those of other federal units. The major goals and value orientations developed within NASA appear to be directed primarily to the development and application of technology for space exploration. These differentiated responsibilities, values, and orientations created the potential for conflict with other federal programs and the need for an integrative mechanism like the NAS Council.

Organizational experimentation within NASA also reflects a continuing search for appropriate balance between differentiation and integration. Program offices within NASA reflect specialized functions and responsibilities (tracking, space technology, applications, space research) and the field centers reflect differentiated facilities and capabilities (manned space flight, launch operations, unmanned space flight). Reorganization efforts within NASA during the 1950's and 1960's appear to have been attempts to achieve integration among program offices in terms of center utilization. The configuration of program offices within NASA reflects specialized areas of knowledge or specialized pressures from the scientific and industrial environments. The short-lived Office of Life Sciences was a direct response to pressure from the scientific community, a pressure that was not interpreted as central to the mission of NASA.

Another relevant model from organization theory relates to methods of decision making and conflict resolution within organizations (See Figure 1).[21] Conflict situations are differentiated in terms of two relevant dimensions: (1) the amount of consensus or agreement over goals, and (2) the amount of certainty of knowledge of the involved parties concerning the decision situation. Four modes of decision making are identified for different configurations of goal consensus and certainty of knowledge.

- Goal consensus-knowledge certainty. There is no real basis for conflict in cases in which all parties agree upon the goals to be achieved and possess certain knowledge concerning elements of the situation. Decisions are reached through established programs or policies.

		KNOWLEDGE	
		CERTAIN	UNCERTAIN
GOALS	CONSENSUS	PROGRAMS, POLICIES	POOLED EXPERT JUDGMENTS
	DISAGREEMENT	COMPROMISE, BARGAINING, POLITICS →	

DECISION MAKING IN DIFFERENT CONFLICT SITUATIONS

FIGURE 1

- Goal consensus-knowledge uncertainty. Parties are agreed upon the goals to be sought, but uncertainties in knowledge concerning the situation lead to conflict in the choice of means. Decision making in this situation requires a sharing of knowledge and pooling of expert judgments, (a committee of technical experts, for example).
- Goal differences-knowledge certainty. This situation is one of conflict over the ends sought, not the effectiveness of specified means. Decision making requires negotiation or compromise.
- Goal differences-knowledge uncertainty. The primary basis for conflict is a difference in ends sought. The uncertainties of knowledge concerning the situation, however, provide an expanded arena for negotiation and political decision making. Negotiation over ends may be masked as disagreements over the effectiveness of alternative means, and the potential for conflict is significantly larger than in a situation in which knowledge certainty is present.

The admission and confrontation of goal differences in organizational decision making typically is resisted because of the implicit threat to organizational integrity, and attempts are made to reach decisions through administrative means rather than through avowedly political means.

Concerns for the risk of back contamination from the Apollo flights created a potential conflict situation within the federal government. NASA, the PHS, the Departments of Agriculture and Interior, and the National Academy of Sciences all had different concerns for prevention of back contamination, and no one agency possessed certain knowledge about the nature of the risk of alternative means of preventing back contamination. The conflict model outlined above suggests the opportunity for political bargaining in conflict resolution and decision making. Differentiated responsibilities within the federal government led to a situation of interagency conflict over the risk of back contamination, a situation requiring special means for integrating agency efforts and resolving the conflicts regarding back contamination.

The ICBC established as a formal integrative body for the resolution of conflict over back contamination issues in the Apollo flights. Minutes of ICBC meetings and briefing materials give the impression that the ICBC was a joint committee of experts with agreed-upon goals who hoped to pool expert knowledge on the contamination control methods to be employed. The earlier analysis of the structure, composition, and powers of the ICBC suggests that the committee was employed by NASA as a means of avoiding political bargaining over ends and was restricted to advising NASA concerning means of preventing back contamination. It does not appear, however, that all parties respresnted in the ICBC shared the same goal priorities and commitment to prevention of back contamination risks. The employment of committees of experts pooling judgments about means is only appropriate as a decision making approach in cases in which there is goal consensus. Many of the alleged failures of the Apollo back contamination programs can be traced to the lack of such consensus.

One significant factor affecting the Apollo back contamination efforts was the belief, which was confirmed, that no living organizms would be encountered in the Apollo flights. Judged in terms of overall probability of risk of back contamination, the Apollo back contamination efforts might be viewed as quite successful; judged in terms of conditional probability of risk given encounter with living organisms, this judgment of success might be questioned. Even this relatively simple difference in goals creates the potential for conflict among agencies concerned with back contamination, a conflict not resolvable through pooling of expert judgments.

Viewed retrospectively, the ICBS was less effective as an organizational mechanism for integrating efforts of NASA, the PHS, and the Departments of Agriculture and Interior and more effective as a differentiated effort of NASA for coping with the pressures exerted by the regulatory agencies.

REFORMULATION OF ISSUES

Earlier in this report is was suggested that three conditions were needed for success in any program to prevent back contamination, conditions not fully met in the Apollo flights:

1) Recognition of risk of back contamination and commitment to the prevention of such a risk.

The risk of back contamination from the Apollo missions was generally considered minimal. The consequences of possible back contamination also were unknown, making it difficult to obtain agreement on the degree of protection to be provided. Commitment to the prevention of back contamination was diffused. While the Space Treaty obliged all signatories to protect against back contamination, responsibility for that obligation was not specifically assigned to any organizational body in the U.S. The National Academy of Sciences, Public Health Service, and the Departments of Agriculture and Interior each had specific concerns relating to back contamination, but protection against back contamination was a relatively minor element in the task domain of each. The primary orientation of NASA appears to have been the development and application of space technology; the prevention of back contamination was a constraint imposed upon NASA rather than a primary goal integral to the entire program of NASA.

2) Possession of knowledge about risk of back contamination and means of eliminating or reducing that risk.

Knowledge about the threat of back contamination from space and means of alleviating that risk is diffused among the nations's scientists and scientific organizations. The PHS and Departments of Agriculture and Interior have knowledge about dangers of known communicable diseases and infestation but know relatively little about the possibility of unknown contaminants from outer space. NASA is in the prime position to develop knowledge about space, but the relative lack of concern for life sciences demonstrated in NASA programs suggests there has been little development of knowledge concerning possible contaminants from space.

3) Possession of resources (funds and personnel) for the development and statutory power for the implementation of programs to prevent back contamination.

Financial resources for the study of space exploration are centered in NASA, not in the PHS or Departments of Agriculture and Interior. Abandonment of the NAS Council makes difficult the coordination of research efforts of joint concern to all agencies unless such coordination is fostered by NASA. Abandonment of the life sciences program office in NASA further complicates the development of any coordinated program for development of knowledge of back contamination risks.

The existing statutory power to impose protective measures against back contamination is questionable. Consideration of this issue was apparent in the formulation of the ICBC and has been the subject of several legal analyses. The legal power and authority of the federal government to impose quarantine restrictions upon space missions, for example, is debatable. What statutory power exists appears to reside with the PHS and Departments of Agriculture and Interior, not with NASA.[22]

The diffusion of powers and responsibilities among federal agencies made difficult any integration of efforts for protection against back contamination from the Apollo missions. This diffusion stems in part from the separation of powers between the executive and legislative branches in the federal government. Agencies are created and assigned responsibilities through legislative action; the executive branch is charged with administration of the agencies within the framework of enabling legislation. Agencies tend to develop into relatively independent bodies responding to relatively specialized constituencies. The budgetary process, controlled by both the executive and the legislature, becomes the primary means of directing day-to-day activities and accomplishing integration of activities among different agencies. Much of the integration that occurs is a consequence of efforts of individuals serving in the Executive Office or individuals serving in one agency who seek integration with other agencies through informal influences.

The ICBC of the Apollo program illustrates one approach to integration among federal agencies. The committee appears to have had its origin in informal contacts among agencies concerned with the problems posed by back contamination. The group was later formalized in an interagency agreement. That agreement, as noted earlier, did not resolve the confusion regarding powers and responsibilities of the involved agencies, but it did provide a framework within which informal influences would be exercised. Much of the integration of efforts achieved through the ICBC was the consequence of informal influence exercised by individuals such as Dr. Briggs Phillips rather than of the more formal relationships specified in the interagency agreement.

In order to develop programs for protection against back contamination from space exploration, organizational relationships must be developed that will satisfy the conditions developed above and decrease reliance upon informal activities of individuals to achieve integration of efforts. Development of effective programs for the prevention of back contamination from future space missions requires reorganization of federal responsibilities and clarification of powers for prevention of back contamination. Alternative strategies for achieving this reorganization are detailed and examined below.

ORGANIZATIONAL STRATEGIES

A variety of organizational strategies for integrating responsibilities and efforts for prevention of back contamination can be identified, each with certain advantages and disadvantages. In general, these strategies seek integration through structural relationships (reporting relationships, task and role definition, delegations of responsibility and authority) or through interpersonal relationships (shared values, understanding, informal communications and decision making). The strategies reviewed here all focus predominantly on integration through structural change and alignment of goals and responsibilities, rather than upon less formal methods such as interpersonal intervention. All the proposed strategies require some degree of legislative action to restructure responsibilities among federal agencies and to clarify and ensure possession of requisite powers to impose prevention measures such as quarantine. Change in the structure of responsibilities and powers also appears to be a more powerful strategy than interpersonal intervention, given the existing rigidity of federal organization of agencies.

POOLED RELATIONSHIPS

One organizational strategy for the prevention of back contamination involves formalized, clear differentiation of responsibilities and authority to implement controls over back contamination. This stategy requires complete analysis of all issues involved in back contamination, separation of these issues and implied responsibilities, and assignment of segmented, specialized, and independent responsibilities to various federal agencies. Each agency would proceed independently to accomplish its assigned responsibilites and, presumably, the pooled effects of these efforts would constitute the overall program to prevent back contamination. Thus, for example, the PHS might be assigned responsibility to prevent back contamination through returning astronauts, and the Department of Agriculture might be assigned responsibility for prevention of back contamination through returned space samples. (See Figure 2)

An obvious advantage of this strategy is that it would build upon existing specialization of knowledge, tradition, and orientation of federal programs. Each agency would continue within its own differentiated traditions with a minimum of concern about and interaction with other agencies. There would be relatively little goal consensus among the involved agencies, but this would be of little concern since no joint decision making would be required. Results of the programs within the regulatory agencies would be imposed upon NASA, as constraints and decisions requiring joint consideration of various requirements would be centered within NASA. Conflict among agencies would be formalized in terms of goals and constraints imposed upon NASA; the degree of such conflict would depend upon the degree to which the overall issues involved in prevention of back contamination could be differentiated in truly independent responsibilites.

Other correlated organizational changes also would be necessary for this strategy to succeed. One such change relates to the power of the regulatory agencies to impose constraints upon NASA. The development of quarantine provisions by the PHS, for example, would have little impact upon NASA operations if the PHS lacked statutory power to impose these

Operational Space Missions

NASA

Responsible for design of technology and conduct of space mission.

Interior

Responsible for protection of wildlife and natural resources.

Agriculture

Responsible for prevention of infestation and control over introduction of soils into the U.S.

Public Health

Responsible for protection of public health and prevention of introduction of communicable disease.

Illustration of pooled relationships, each agency responsible for performance of specific responsibilities coordinated through planning.

Figure 2

provisions or lacked organizational capabilities (financial, personnel, and technological resources) to impose the provsions. Current statutory powers of the regulatory agencies are not clearly applicable to protection against unknown dangers or to protection in international territories such as oceans; legislation would be required to provide the necessary statutory powers. Similarly, the regulatory agencies would require additional funding to conduct investigations of contamination threats, devise protective programs, and police activities that might violate provisions of the protective programs.

There are certain disadvantages of this pooled responsibility strategy. First, it would be extremely difficult, if not impossible, to identify truly independent responsiblities for assignment to the various agencies. Clearly NASA's responsibilities for the conduct of space exploration are interrelated with responsibilities of the regulatory agencies; NASA is forced to integrate otherwise independent responsibilities and cannot operate independently from the regulatory agencies. One major issue in integration would arise from the time orientations of the various agencies. NASA operations require long lead time and intricate meshing of and adherence to schedules. Constraints imposed by regulatory agencies would have to be in effect at the start of NASA planning for any specific mission if such constraints were to be incorporated successfully into mission planning. The regulatory agencies, however, are not under this type of time pressure and, given their specific goal orientations, might be inclined to extend time deadlines in order to achieve greater certainty of knowledge for the formulation of constraints.

The pooled responsibility strategy also is relatively inflexible once installed and relatively cumbersome to adapt to new or emerging issues. Responsibilities are integrated through planning of the formal organization structure on the basis of known information about an issue. Changing information about an issue may require change in the assignment of responsibilites, change accomplished in this instance through legislation. Given the developing knowledge concerning possible back contamination from space exploration, a more flexible approach to organization would appear desirable.

Pooled responsibility also could involve considerable duplication of effort among the agencies, as each conducted independent investigations of the threats of back contamination and the effectiveness of alternative means of prevention. Independent investigations conducted by the agencies also could result in competition for personnel and facilities.

Confronted with the prospect of constraints developed independently by the various regulatory agencies, NASA would, in all likelihood, attempt to form a body analogous to the ICBC as a means of coordinating these influences. Major differences between this new body and the ICBC of the Apollo flights concern the relative powers of the agencies involved. Given the restructuring of responsibilities and powers outlined above, the regulatory agencies would have more power than they held in the ICBC. Conflict over goals or means would require resolution through bargaining and political activity as before, but actual power would be more equally distributed than was the case in the ICBC. The regulatory agencies would have more power to force NASA to conduct desired studies, share information, and conform to prescribed constraints than was the case in the Apollo program. As during the Apollo program, the final result would be one of compromise among the various agencies, but the resulting compromise would more closely reflect the concerns of the regulatory agencies than did compromises during the Apollo program.

MATRIX ORGANIZATION

Matrix organization is an approach to integration that has been applied within NASA and within large scale industrial organizations. The theory of matrix organization is based on recognition that segmentation of indepen-

Matrix of Responsibilities for Space Missions

	NASA	Public Health	Agriculture	Interior
Design and develop technology for space missions	X			
Conduct missions for space exploration	X			
Regulate re-entry of space craft into the atmosphere		X	X	X
Regulate re-entry of astronauts		X		
Regulate re-entry of space samples		X	X	X

Illustrative allocation of responsibilities for the conduct of space missions. Operating units (e.g. Space Receiving Laboratory) are responsible to various agencies for different activities.

Figure 3

dent responsibilities into pooled relationships often is impossible or dysfunctional. Research, development, and production specializations can be differentiated in terms of specialized knowledge, skills, orientations, and disciplines, for example, while responsibilities and activities must be closely integrated. The theory of matrix organization differentiates among types of responsibility such as functional and programmatic responsibility and proposes that integration among specialized organizational units can be achieved by clarifying the type of responsibility each unit holds for particular issues.[24] Thus, for example, in Figure 3, the PHS might be assigned functional responsibility for the establishment of criteria for prevention of back contamination through returning astronauts and programmatic responsibility for verification that these criteria are achieved in each space mission; NASA would be assigned programmatic responsibility for the design and implementation of programs to achieve criterion performance in space missions. Individual operating units within NASA (e.g. the Space Receiving Laboratory) would be subject to direct supervision from both the PHS and NASA. Integration would be sought by assigning specialized units (e.g. NASA and the PHS) joint goals (e.g. successful conduct of space missions avoiding back contamination), overriding their specialized objectives (e.g. developing space technology, protecting public health), identifying correlated responsibilities (e.g. functional and programmatic responsibilities), and assigning both supervisory responsibilities for operations.

Review of NASA's history suggests that varieties of matrix organization have been employed in the management of program offices and field center.[25] Program offices are responsible for the development and supervision of specific programmatic efforts (e.g. space technology) and field centers are responsible for the application of these programs (e.g. design of specific missiles). An analogous form of matrix organization might be developed for relationships among NASA and other federal agencies regarding back contamination programs.

As evidenced in the numerous reorganizations of relationships between program offices and field centers of NASA, matrix organization, although conceptually simple, is sometimes difficult to apply. Successful application of the concept of matrix organization requires the sharing of common goals by the units involved and an integrating level of management superior to the involved units. The Executive Office of the President might, theoretically, serve as this superior level of management in a matrix organization of responsibilities of NASA, the PHS, and other agencies. The analogy fails, however, because the agencies are responsible to Congress rather than to the President. Given current federal organization, Congress provides basic direction and funding for agency efforts; certain basic responsibilities of each agency are specified in legislative statutes. The Executive Office of the President might seek to provide the direction necessary in matrix organization but, given Congressional powers, might often lack the authority to resolve conflicts arising in the matrix form of organization.

Matrix organization has most application for continued interaction and integration of specialized units over time, such as the integration of defense and foreign affairs. Interactions between NASA, the PHS, and the Departments of Agriculture and Interior tend to focus upon the single issue of back contamination, an issue that varies with the type of space activity being conducted. Full scale development of a matrix organization for such an issue appears relatively expensive in terms of time and effort given the specificity of the issue.

PROJECT ORGANIZATION

Project organization is another strategy for integrating otherwise differentiated specializations.[26] Project organization also is an organization strategy that has been used to considerable advantage in internal management of NASA operations. Briefly, project organization involves the formation of teams of specialists formed to accomplish relatively specific objectives, usually of a relatively short run assignment. Thus, for example, NASA might form a project team of physicians, physical scientists, engineers, bioscientists, and social scientists to design a space receiving laboratory to accomplish specified objectives within set constraints. Each of the team members would bring to the project specialized knowledge, skills, and orientations; integration would be sought through the provision of common goals and mission assigned the project team. Team members would be responsible to the project leader for programmatic activities and to the manager of the specialized unit from which they were assigned for functional performance criteria. Specialization would be maintained through functional responsibility, and integration would be sought through project or programmatic responsibility.

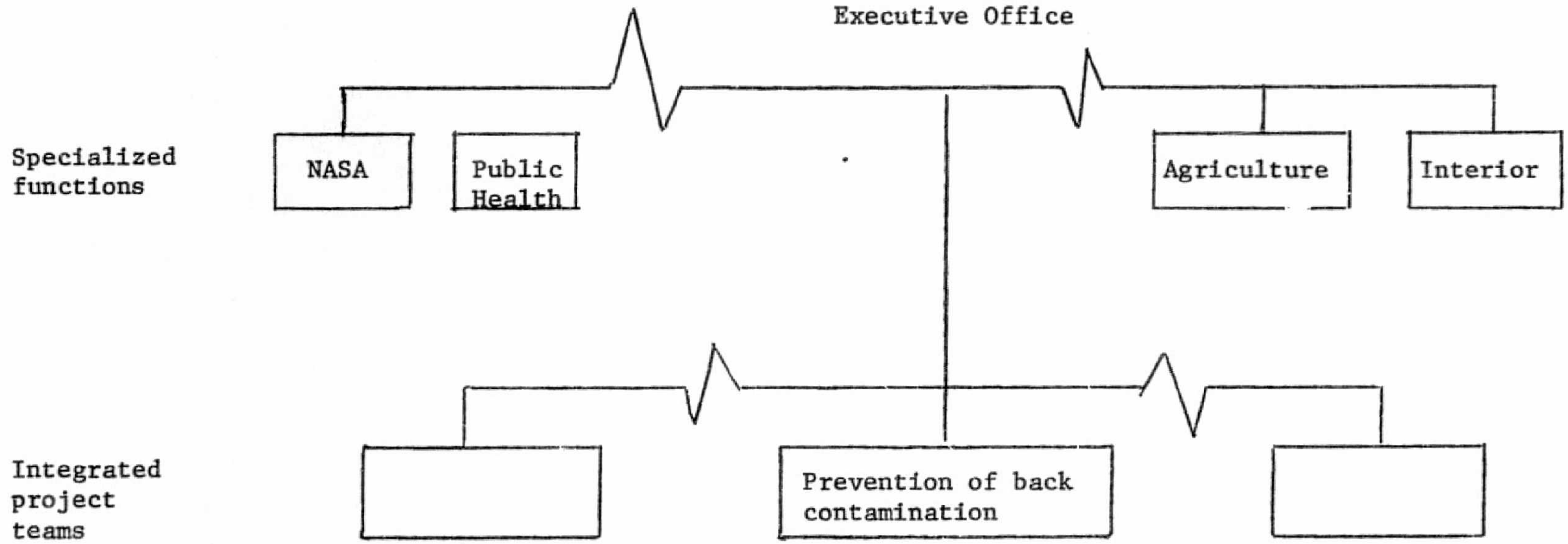
Project organization is somewhat analogous to matrix organization in that it attempts to maintain differentiation or specialization while providing for integration within the framework of common goals and objectives; however, project organization differs from matrix organization in several aspects. Project organization is focused upon relatively specific programmatic objectives normally with a termination point; matrix organization is concerned with relatively more general goals and relationships, which are anticipated to be continuing over time. The integration of specialized efforts would appear to be more easily accomplished within the framework of a project than within the framework of matrix organization.

Like matrix organization, project organization is possible only given a superior level of management to formulate objectives and assign responsibilities. Similarly, effective project organization requires that the functional units from which project members are drawn have the opportunity to appeal or contest decisions made within the project; team members must be able to appeal to their functional bases of support, which in turn must be able to appeal to an authority superior to the project administrator. Thus project organization is more easily applied within a single federal agency than among federal agencies that do not share a common superior managerial level.

Project organization for the control of back contamination might be conceptualized in terms of the illustration in Figure 4. Members of agencies with specialized capabilities relating to space flight and back contamination would be assigned to a project team responsible for the design of back contamination protective systems; the project team, not the related agencies, would be responsible for design of protective systems. Responsibilities for implementation of these systems might later be assigned to whatever established agencies are most appropriate.

The project organization depicted in Figure 4 resembles in certain respects the ICBS established for the Apollo flights. Comparison of the ICBC with an ideal project organization, however, points up certain prerequisites of project organization and difficulties of applying project organization among federal agencies. The ICBC was composed of representatives of different specialized agencies (NASA, PHS, Agriculture, Interior), not project or team members assigned temporarily to the project; representatives met occasionally as team members but carried fulltime responsibilities in their permanent assignments. The ICBC had no clearly assigned programmatic objectives for which it was responsible; rather the committee operated under an umbrella type of goal, which could encompass the different goals of the participating agencies. The ICBC was not responsible to any superior

Project Organization



Illustrative project organization, functional specialists from concerned agencies being assigned to work in project teams on special issues requiring integration.

Figure 4

authority for accomplishing objectives, whereas the member agencies were individually responsible to superior authorities for accomplishing specialized objectives. Decisions reached in the ICBC were not clearly binding upon member agencies, and, given joint responsibilities of agencies to the President and the Congress, member agencies had alternative routes for appeal of any ICBC decision.

In theory, project organization appears uniquely suited to the development and application of systems for protection against back contamination. A relatively specific objective could be formulated and project teams could be established to integrate the various specialized skills and disciplines necessary to accomplish that objective. In practice, however, effective project management involving otherwise independent agencies within the federal government appears difficult to achieve given dual responsibilities to the President and the Congress and the relative inflexibility of authorities and responsibilities established in statutes.

CENTRALIZATION

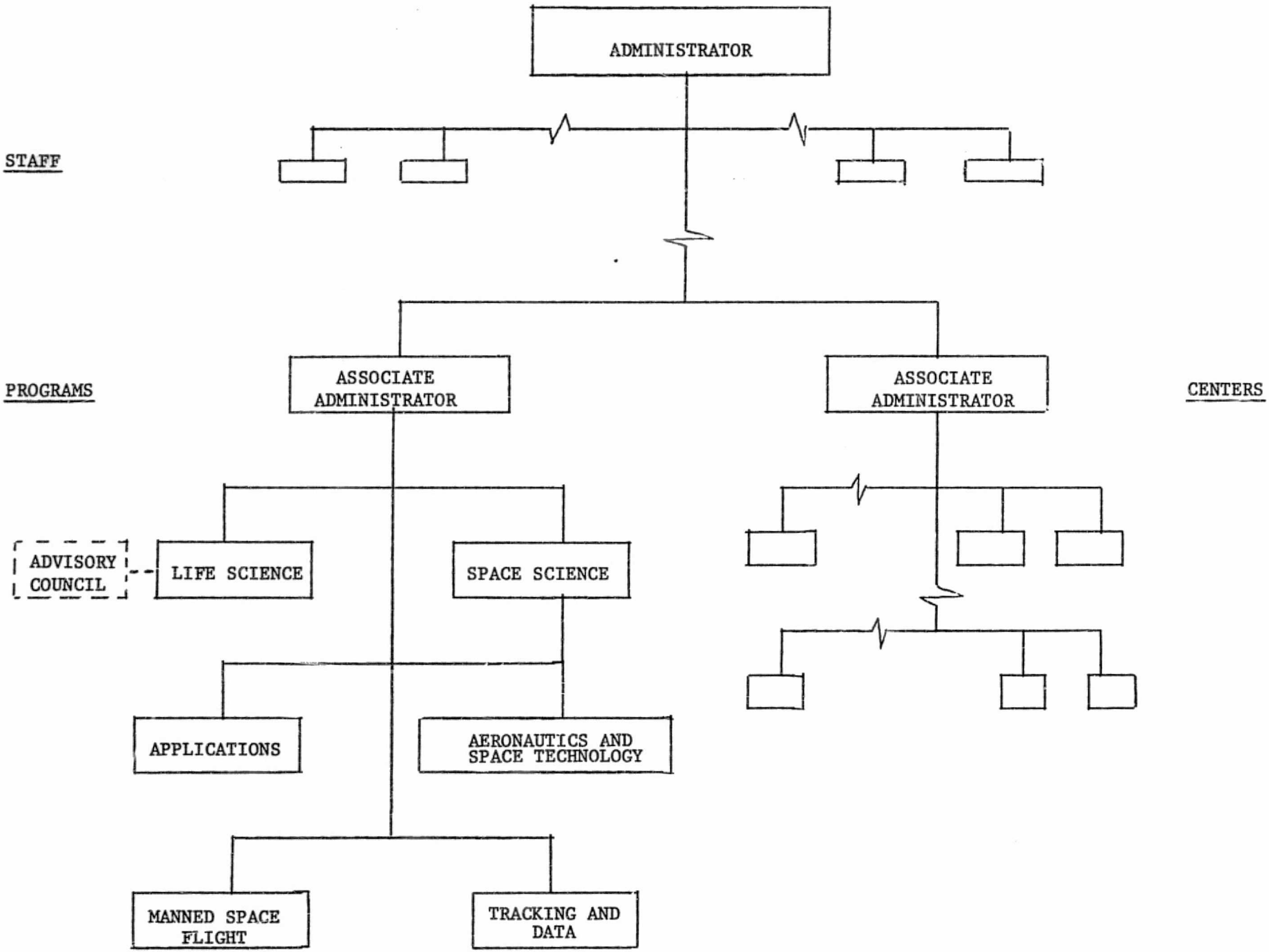
Another strategy for the design of organizational responsibilities for prevention of back contamination might involve the centralization of responsibilities within a single body, presumably NASA. Just as responsibility for conducting space activities has been assigned to NASA, so might responsibility for implementation of the back contamination provisions of the Space Treaty and protection of the U.S. against the introduction of contaminants from outer space. Responsibilities that currently are differentiated among NASA and the three regulatory agencies might be centralized within a single agency. This strategy has been proposed by Robinson as a means of clarifying legal responsibilities and statutory authority for the imposition of controls necessary to prevent back contamination.[27]

Centralization of responsibility in a single agency would overcome the difficulties of coordinating responsibilities now diffused among federal agencies. Coordination through line authority presumably would be easier within a single agency than currently is the case. Although all the agencies report through the Executive Office of the President, no clear line authority for integration of activities now exists. The agencies have statutory responsibilities established through Congressional action, and the President is not empowered to alter these responsibilities. Integration of activities imposed through line authority and administration is a viable alternative within a single agency, but it is not viable as a strategy of the Executive Office in the integration of responsibilities of various agencies. Integration of responsibilities would require legislative action assigning overall responsibilities to NASA and clarifying the related responsibilities of federal regulatory agencies.

Centralization of back contamination responsibilities within NASA could overcome problems of coordination and integration, conceivably at the expense of the advantages provided through specialization and differentiation of responsibilities. The regulatory agencies (PHS, Agriculture, Interior) have personnel familiar with problems of health, infestation, and contamination, resources not now available within NASA. The regulatory agencies also have many years of experience, which NASA lacks, in the design, implementation, and administration of programs such as quarantine. Finally, the goals of protection of health and natural resources have been internalized by the staff of the regulatory agencies and constitute a tradition equivalent to a disciplinary orientation; these goals appear to be peripheral in the NASA tradition, and even if imposed by statute, would become internalized only through time and considerable effort. The advantages of expertise, history, tradition, and goal orientation now present within the regulatory agencies would be lost through centralization of responsibilities with NASA.

Centralization of back contamination responsibilities within NASA shifts the issues of balancing differentiation and integration from the level of the Executive Office of the President and federal agencies to a subordinate level of the NASA administrator and NASA programs and operations. The provision of effective protection against back contamination requires that the NASA ortanization be developed to provide that protection. The organization sketched in Figure 5 suggests one way this might be accomplished.

> A life science program office would be established within NASA with responsibilities for life sciences research and for protecting against extraterrestrial contamination, both outbound and inbound. As recommended in the 1960 NASA report, this program would carry status equivalent to that of other program offices within NASA. Creation of such a program office would appear necessary to signal acceptance of life science goals as equivalent to technology development goals within NASA and to develop the expertise necessary in the design and implementation of life science and back contamination programs. The life sciences program within NASA would function as other programs in the design of programs of research, development of technology, and implementation through the field centers.



Illustrative Organization of Responsibilities Centralized in NASA
Figure 5

An advisory council analogous to the ICBS would be established to relate to the life sciences program. Representatives to this council would be assigned from the PHS, the Departments of Agriculture and Interior, and the National Academy of Sciences. During early years of the development of the NASA life sciences program, the council would provide a means of coordinating existing expertise; the council might later be abandoned as such expertise was developed within NASA. Given the changes in legislation proposed earlier, the council would necessarily be advisory to NASA without any formal authority over back contamination issues.

As the current practice is within NASA, programs for conducting life sciences and back contamination research, technology development, and administration of back contamination protection might be contracted through the field centers to federal agencies such as PHS and Agriculture. The existing expertise of the specialized resources now in these agencies might be tapped in this manner, leaving responsibility for the direction of back contamination programs within NASA.

The organizational strategy proposed here offers a number of advantages in clarification of existing confusion regarding back contamination responsibilities and in integration of responsibilities, while exploiting current specialized expertise. Implementation of this strategy would require legislative action, funding, and continued effort to develop the life sciences orientation within NASA. Given the lead time required in mission planning, it is questionable whether this strategy could be fully implemented in time to be operational for future Viking missions.

It does appear to be a viable alternative for the provision of back contamination protections for later missions, which undoubetdly will follow the Viking series.

COORDINATING BODY

An alternative organizational strategy for coordinating responsibilities for protecting against back contamination would involve a special coordinating body like the ICBC of the Apollo programs. Two types of coordinating bodies, council and committee, are considered. Both types have been employed in the coordination of federal departments and agencies, and this analysis draws upon experiences with both approaches.

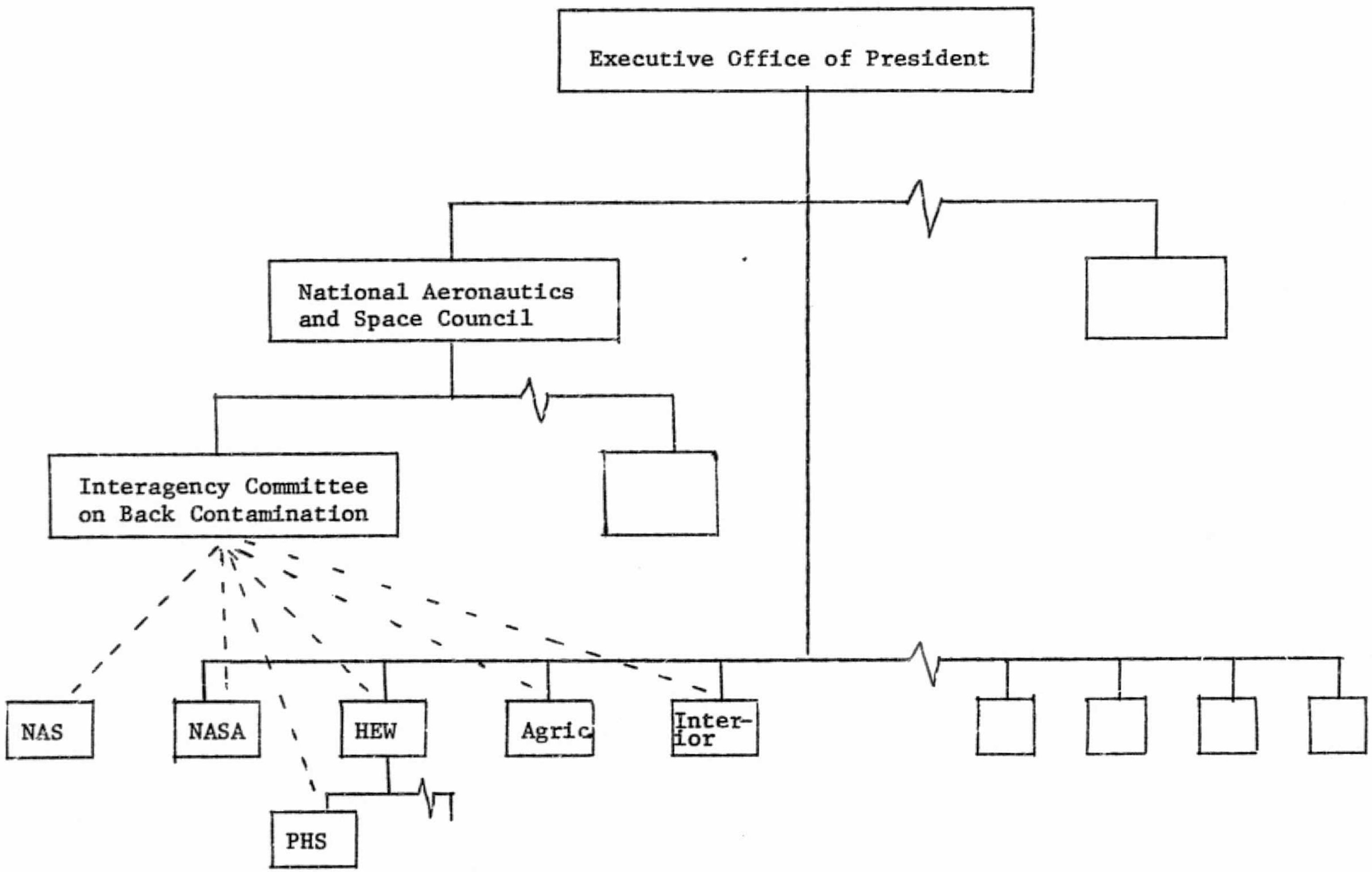
One approach is the establishment of a council, such as the National Security Council. The National Security Council, established in 1947 in a reorganization of the federal government, focuses on integration of domestic, foreign, and military policies relating to national security. Departments and agencies such as State, Defense, Central Intelligence, and Civilian Defense Mobilization are all assigned specific statutory responsibilities that affect national security, differentiated responsibilities that require integration for maximum effectiveness. All these departments and agencies report to both the President and Congress for direction, funding, and supervision, and conflicts among the departments can be resolved formally only through appeal to both or either the President and/or Congress. The NSC was established as a unit within the Executive Office of the President, with statutory responsibilities to advise the President and with funding through the Congress. Analyses of the operations of the NSC indicate that the role of the council varies somewhat with the administrative style of the President but that, in general, the council serves as a forum for airing issues before the President as input for decisions by the President. One analysis of the NSC suggests that member departments and agencies should attempt to keep particularly critical issues out of the NSC forum and should, whenever possible, negotiate resolution of these issues informally.[28] Whether the NSC provides the forum for discussion and coordination of efforts or the existence of the forum provides the impetus for informal negotiation and resolution of conflict, the net result would appear to be positive. The NSC, established in the Executive Office of the President, provides a formal vehicle for the resolution of interdepartmental conflict and coordination of efforts related to national security programs.

The approach of interagency committees is less formal than the coordinating council and is illustrated by the ICBC of the Apollo program. The interagency committee can be established through joint negotiation of the involved agencies with approval and/or direction from the Office of the President; statutory assignment of responsibilities and Congressional funding apparently are not required. Such a committee need not be limited to advising and might include decision making, although member agencies still bear any individual responsibilities assigned by statute. Interagency committees are considerably more flexible than are councils and would appear to be more appropriate for relatively specialized and short-term issues such as back contamination prevention. One shortcoming of the interagency committee approach, which has been noted in our analysis of the ICBC, concerns goal commitments. A council such as the NSC is assigned statutory responsibilities and hence goals, but goals of an interagency committee emerge from agency negotiations and, reflecting independent agency goals, are less likely to be shared goals. For maximum effectiveness of the interagency committee, influence of the Executive Office of the

President ought to be exerted in the specification of goals for the committee. Another potential shortcoming of the interagency committee approach relates to funding of committee efforts and the relative power of committee members in the control of these funding resources. Committee efforts, if dependent upon resources provided by member agencies, will likely be dominated by the agency providing most of the resources and be less responsive to concerns of other agencies. The interagency committee might also be improved as a means of resolving interagency conflict if provided with a forum for appeal to the Executive Office of the President such as exists with the NSC. The National Aeronautics and Space Council (NASC), now defunct, might have provided such a channel for an interagency committee for back contamination. Recreation of the NASC or identification of some alternative council with an interagency committee on back contamination would provide a means for appeal to the President by individual agencies involved in the committee and an impetus for conflict resolution within the committee.

Application of the coordinating body strategy in development of protections against back contamination from space might be accomplished through the following:

- Re-establishment of a National Aeronautics and Space Council within the Executive Office of the President with specifically assigned responsibilities to advise the President on obligations of the Space Treaty and funding of the Council operations.
- Statutory change to assign responsibilities and delegate authorities for protection against back contamination as suggested in the pooled relationships approach.
- Establishment of an interagency committee on back contamination within the NASC with membership from NASA, PHs, Agriculture, Interior, and the National Academy of Sciences and provision for funding of the committee through the NASC.



Illustrative Organization with Coordinating Body.

Figure 6

SUMMARY AND RECOMMENDATIONS

Concern over the development and implementation of programs to prevent back contamination from space missions calls forth issues of administration of federal programs and agencies. Various investigations have focused upon the administration of federal programs and various attempts at reorganization of federal administration have been proposed. Direction, supervision, and review of federal programs and agencies are shared by the executive and legislative branches; statutory responsibilities are imposed and funding provided by both bodies acting in concert, day-to-day administration is provided by the executive branch, and periodic review is provided by the legislative branch. Statutory responsibilities and authorities established through legislative action constitute a formal and relatively stable pattern of organizational relationships. Programs that emerge over time often call for responsibilities, authorities, and relationships not foreseen in the earlier alignment of organizational structure; examples include the integration of programs for national security and space exploration. The prevention of back contamination from space exploration is another such example, although on a much smaller scale.

Responsibility for the prevention of back contamination from space exploration, while accepted by the U.S. in the Space Treaty, has not been delegated specifically to any federal agency; neither have necessary powers to perform been created. Development of effective programs to prevent back contamination requires as a first step the clarification of responsibilities for and authorities necessary to accomplish specified goals.

Various organizational strategies for prevention of back contamination have been identified and reviewed in this report. These strategies differ in the manner in which responsibilities are differentiated among federal agencies and the means of coordinating or integrating these responsibilities.

In summary, either of two proposed strategies appear most feasible: (1) centralization of responsibilities within NASA, or (2) differentiation of responsibilities among federal agencies and integration through an interagency committee and the NAS Council.

Centralization of responsibilities within NASA would clearly impose upon NASA the goal of preventing back contamination, an element now lacking. The coordination of planning space missions, exploring in space, developing space technology, and preventing back contamination would be facilitated through centralization. The advantages of specialization now present in NASA, PHS, Agriculture, and Interior would suffer; however, NASA would of necessity either develop competing specializations at considerable cost or develop means of sub-contracting and utilizing existing specializations.

The approach of pooled responsibilities coordinated through an interagency committee and a NAS Council would utilize existing specializations of disciplines and abilities. The integration of disciplines would be provided through the interagency committee and likely would be more cumbersome than integration through centralization wi nin NASA.

Choice between these two strategies must be judgmental. On balance, we favor the approach of centralization of responsibilities within NASA. NASA has demonstrated considerable ability in innovations in managerial organization, planning, and control in the past, and we judge it likely that similar abilities would be demonstrated in this instance. It is more likely that NASA will be able to develop effective means of coping with responsibilities for prevention of back contamination than it is that equally effective means will emerge from interagency efforts. Both legislative and executive action required to effectuate this strategy also appear less complex than that which would be required to effectuate in the interagency committee and council strategy.

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