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ROLES OF SCIENTISTS AND ENGINEERS IN RESEARCH AND DEVELOPMENT CONTRACTING

BY
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B. S., University of Dayton, 1962

THESIS

Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Arts in Public Administration
in the Graduate School of
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Larry Glenn Damewood, M. A.
Division of Public Administration
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The system of contracting for research and development in the federal government is a multi-disciplinary process involving billions of dollars each year. Scientists and engineers are key participants in the system; yet, they often possess insufficient knowledge of contracting activities, particularly the roles of technical professionals, to perform most effectively.

The objective of this research is to increase operational effectiveness by providing perspective on the contracting system for research and development and by describing the major roles of scientists and engineers in the process.

Multiple research techniques are utilized, including interviews and observation of contracting practices; however, the principal methodology is an analytical descriptive study of the literature, especially government regulatory documents, enriched by the author's twelve years of relevant experience.

The study of the contract system traces the evolution from the Constitution, through the war years and the post war period when contracting became a dominant method of

conducting research and development. Insight is also provided into the political, social and economic implications of the system. In describing the roles of scientists and engineers, the entire contracting spectrum is covered. Beginning with the early project planning activities, the study proceeds through the formal contracting phases of solicitation, proposal evaluation, negotiation and finally contract management.

The research indicates that most government scientists and engineers are administrators, participating in planning, execution and management of contract relationships with non-government institutions; however, these roles are generally viewed as temporary assignments rather than careers. Similarly, scientists and engineers have not recognized the contract system as a management tool; instead, they are more inclined to consider it a necessary evil. More positive attitudes on the part of management toward contracting and greater emphasis on educational techniques hold the most promise for constructive change. However, better integration of technica and business disciplines throughout the contracting cycle also offers potential for increased recognition and acceptanc of the "administrator" roles of scientists and engineers.

One of the more controversial aspects of the contracting process involves the informal relationship between government and nongovernment scientists and engineers. The research reveals both positive and negative results from this activity, and suggests that this is a prime area for further investigation.

The contract system is far more than a medium for bringing industrial resources to bear on government problems; it also facilitates compliance with legislation on equal employment opportunity, labor practices and the like, and provides a mechanism for control of labor resources.

The demand for informed scientists and engineers in contracting roles will grow as the technological endeavors become increasingly more complex. This research is a first step toward preparing technical professionals for the task.

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PREFACE

In observing scientists and engineers in government contracting, I frequently sense a lack of perspective of the system, particularly with regard to the roles of the technical professionals. Actually this is not surprising since scientists and engineers seldom have an opportunity to gain an overall perspective of the system. Generally, they come to the process without benefit of indoctrination and the assignments are limited to specific areas. In certain respects scientists and engineers in contracting roles experience the same frustration as the production worker who never views a complete system.

While scientific support is lacking, I am convinced that inability to see the whole picture and to understand one's role in a process has a negative impact on operational effectiveness. Scientists and engineers are key participants in a contract system which accounts for more than seventy percent of government expenditures for research and development,[1] and facilitates technological achievements such as the atomic energy and space programs. Recognition of the key roles of scientists and engineers in the contract system and awareness

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[1]Clarence H. Danhof, Government Contracting and Technological Change (Washington, D. C.: The Brookings Institution, 1968), p. 93.

of their need for better understanding of the contracting process motivated this research. The basic objective is to address the need of government scientists and engineers for increased knowledge of their roles in the contracting system. However, this entails a broader task, since the system within which the roles are played must also be understood. By providing overall perspective on the contract system and by describing the major roles of scientists and engineers, it is hoped that this research will ultimately have a positive effe on operational effectiveness.

The presentation is arranged in three parts; Part One concentrates on introducing the research objectives, methodology, and constraints, and providing an overall perspective on the contract system. It also capitalizes on previous research as reflected in the literature. The main focus of the research is captured in Part Two where the contracting process is analyzed from the perspective of the scientist and engineer. Government regulatory materials constitute the basic source data for Part Two, while the analysis and interpretations are based on the author's experience.

Finally, Part Three summarizes the presentation, provides conclusions and offers suggestions for further research. The presentation places emphasis on facilitating the reader's ability to grasp the thrust of specific areas without the necessity of reading the entire report. In so doing some redundancy is inevitable; however, the advantages of a degree of entity between chapters makes this an acceptable tradeoff.

The appendices are especially valuable for the reader with an interest in detail aspects of the contracting process. For example, Appendix 3, an official Request for Proposal, illustrates many facets of the process including contractual terms, work statements, evaluation criteria and types of information required for contractor selection.

While this study required the support and cooperation of many people, some of whom are recognized in the acknowledgment section, the author accepts full responsibility for the interpretation and presentation of the material. While I trus that the data presented as factual are accurate, this study is in no way to be construed as reflecting official government policy.

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ABBREVIATIONS

AEC - Atomic Energy Commission

ASPA - Armed Services Procurement Act

ASPR - Armed Services Procurement Regulations

BOB - Bureau of the Budget

DOD - Department of Defense

EO - Executive Order

GAO - General Accounting Office

NACA - National Advisory Committee for Aeronautics

NASA - National Aeronautics and Space Administration

NDRC - National Defense Research Committee

ONR - Office of Naval Research

OPA - Office of Price Administration

OSRD - Office Scientific Research and Development

PPP - Phased Project Planning

R&D - Research and Development

RFP - Request for Proposal

RS - Revised Statute

SEB - Source Evaluation Board

SSAC - Source Selection Advisory Committee

PART ONE:

PERSPECTIVE ON THE MODERN SYSTEM FOR SCIENTIFIC ENDEAVORS

CHAPTER I

GUIDELINES FOR RESEARCH

Focus on Effectiveness

Problem

Scientists and engineers play significant roles in Government[1] research and development (R&D) contracting but are often inadequately informed regarding role expectations. Understanding of one's role is a prerequisite to maximum effectiveness;[2] therefore it follows that operational effectiveness of the scientist and engineer is impaired by the lack of such knowledge. The degree of impact on effectiveness is an unknown, and will remain so until better methods of measuring subjective decisions are developed. However, few would disagree with the premise that increased understanding of one's role increases the potential for positive impact on effectiveness. This then, the "reduced effectiveness of the scientist and engineer due to inadequate understanding of roles in the R&D contracting process," is the problem to which this research

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[1]Government as used in this study refers to the federal government of the United States.

[2]Effectiveness in the context of this study refers to ability to perform duties with minimum guidance and supervision in a timely and accurate manner.

is directed.

Another premise basic to the research is the belief that the government R&D contracting system and the scientists and engineers' role in the process are matters of great importance, particularly to officials charged with responsibility for conducting the nation's R&D programs. A final premise is that increase in knowledge and consequently, potential for increased effectiveness in the conduct of a vast and important aspect of the government's business, such as the R&D contracting process, is ample justification for the undertaking reflected in this research.

Background to Problem

Full appreciation of the significance of this study requires an awareness of certain aspects of government R&D contracting and factors contributing to the problem. Both areas are discussed below.

Prior to 1940 there was relatively little government R&D in the sense of direct support to private concerns. The government's R&D efforts were conducted primarily by civil servants working in government facilities.[3] However, this changed drastically as did many facets of R&D management in the decades of the 1940's and 1950's. Perhaps the threat of war and war itself became the catalyst, but whatever the causal factors, there is no doubt that the early 1940's were the

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[3]Danhof, p. 93.

turning point, the beginning of a major transition in the method of conducting R&D and a phenomenal growth in the magnitude of expenditures. In 1940 expenditures were less than 100 million dollars, by 1968 they had grown to over 17 billion annually.[4] Essentially every government agency is now involved in R&D; however, only three organizations, the Department of Defense (DOD), National Aeronautics and Space Administration (NASA), and the Atomic Energy Commission (AEC) account for the lion's share of the expenditures. For example, of the 17 billion expended in 1968, 14 billion was expended by these organizations.[5] The phenomenal growth in expenditures was only one facet of the R&D revolution. An equally impressive occurrence was the change from internal performance of R&D by civil servants to extensive reliance on private concerns, universities and non-profit institutions. It is estimated that more than 70 percent of all federal expenditures for R&D now go to non-government organizations.[6] Some agencies allocate even higher portions of their budget to outside organizations. An example is the AEC, where 95 percent of the annual operating expenditures go to private concerns.[7]

[4]Michael D. Reagan, Science and the Federal Patron (New York: Oxford University Press, 1969), p. 320.

[5]Ibid., p. 321.

[6]Danhof, p. 93.

[7]Richard A. Tybout, Government Contracting in Atomic Energy (Ann Arbor: The University of Michigan Press, 1956), p. 10.

The medium by which the government accomplishes R&D through external sources is the contract system. Contracting has become a way of life for most government organizations. In fact it is the dominant method of R&D implementation in many operations.[8] The system is of such prevalence and importance that it is referred to in terms such as "federalism by contract,"[9] "the contract state,"[10] "government by contract,"[11] and "administration by contract."[12]

The transition from internal to external conduct of R&D brought other changes, changes that affect scientists and engineers more directly possibly than any other professional. Prior to 1940 government scientists and engineers were primarily practitioners of the traditional function--the tasks that have since been delegated to private organizations. What then is the new role of the scientist and engineer in government R&D organizations? It is that of an administrator, an active participant in the activities of planning, execution and mana the contracts through which R&D is conducted by private

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[8]Danhof, p. 95.

[9]Don K. Price, Government and Science: Their Dynamic Relation in American Democracy (New York: Oxford University Press, 1962), p. 65.

[10]H. L. Nieburg, In the Name of Science (Chicago: Quadrangle Books, 1966), p. 184.

[11]Michael D. Reagan, Politics, Economics, and the General Welfare (Glenview, Illinois: Scott, Foresman and Company, 1965), p. 95.

[12]Michael D. Reagan, The Administration of Public Poli (Glenview, Illinois: Scott, Foresman & Co., 1969), p. 222

organizations.[13]

Since scientists and engineers are deeply involved in the contracting process, why do they not have an adequate understanding of the roles they must play? There is no single answer; instead, there are multiple causal factors. First, technical professionals tend to view the contracting process as a "paper shuffling" operation, a necessary evil, rather than a valuable management technique. This attitude varies in degree among organizations and individuals, but is closely related to the philosophy expressed by the top management and the degree of exposure of the individual scientist and engineer to contracting. Participation in the process often results in greater appreciation for its importance and challenge and tends to foster a more positive attitude. Similarly, a positive attitude by top management reflected in organizational and policy matters tends to be copied somewhat by the lower levels.

Another causal factor is the general tendency of government organizations to encourage the "specialist" philosophy to the point that the different disciplines view contracting as sacred territory, to be traversed only by the "contract specialist."[14] This is not entirelv bad since certain functions are performed

[13]This description cannot be applied indiscriminately; some organizations engage in R&D in their own laboratories and many maintain at least a limited capability for internal research.

[14]Contract specialist is an official position title in the federal government, assigned to individuals specializing in contracting functions.

best by specially trained individuals. However, this is not adequate justification for the "hands off" attitude that seems to prevail in many organizations. While criticism for utilization of special skills is not the point nor is it appropriate, the "closed system" approach may well be a part of the problem. The healthiest environment, the most effective, appears to be the one that most closely adheres to a true team concept--a fundamental requirement of effective contracting.

Another contributor to the problem of inadequate understanding of roles is the general neglect of literature to address the subject. The scientist or engineer interested in learning about his roles in the contracting process would be sadly disappointed if he were to depend upon the medium of literature. Little material of a specifically related nature would be found with exception of government regulatory documents such as the procurement regulations. A study of the government documents would reveal procedurally oriented material couched in the language of the contract specialist. He would also discover that the books and other literature are for the most part oriented to either a very broad perspective with only cursory treatment of roles of scientis and engineers, or to a narrow aspect of the process which completely misses the scientists and engineers' area of interest.

These factors are partial answers to the question of "why the scientist and engineer is inadequately informed"; especially when the cumulative effect is considered. Perhaps these factors also contribute to the air of mystery that surrounds the government contracting process. The "mystery" observation was expressed by General Edmund O'Connor, speaking to the American Institute of Aeronautics and Astronautics when he stated "Marketing people and proposal and contract administrators tend to foster the notion that there is something mysterious about the Government procurement process."[15] Unfortunately, the mystery idea is more than a notion, for the contracting process is largely unfamiliar territory to many of the participants, particularly the scientist and engineer.

Author's Objectives

The primary objective of this research is to provide a better understanding of the roles of the government scientist and engineer in the R&D contracting system. This entails, first, providing perspective into the system of R&D contracting; and second, identification of the roles and descriptive analysis of what they mean in an operational environment.

The clientele to which the work is directed are chiefly scientists and engineers in government R&D organizations. While the greatest value is to those individuals directly involved in contracting, there is also benefit for scientists and engineers involved in other facets of R&D who are potential

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[15]Edmund F. O'Connor, Trends in Contracting that will Influence Spacecraft Design and Development, AIAA Paper No. 67-641 (Huntsville, Alabama: George C. Marshall Space Flight Center, 1967), p. 2.

members of the contract team. The management of government R&D organizations are a second clientele. A good case could be made for the position that many of the problems of scientists and engineers in contracting roles are associated with management's failure to appropriately train or otherwise familiarize the technical professional with role requirements. Also, it is in the management hierarchy that policies and operational philosophies are established setting the tone for the activities of an organization. A contribution to better understanding by management, therefore holds potential for major positive impact. Lastly, the work also holds value for that segment of the public possessing an interest, professional or otherwise, in the mechanism by which billions of dollars are expended annually for R&D by the government. This includes the academicians, particularly those concerned with public science policy, and the government's partner in R&D implementation, the private concerns, universities, and nonprofit institutions.

The objectives discussed above are, in a sense, only means; the ultimate value of increased knowledge is hopefully increased operational effectiveness. Qualification is necessary because knowledge is only one factor in achieving effectiveness. However, of the many variables, knowledge is one of the most important. To summarize, the value of the work is as follows: First, it provides a source for knowledge, thereby increasing the potential for effectiveness. Second, it improves effectiveness of the contracting process (assuming application of the knowledge), and third, the general clientele benefits from better appreciation of a major aspect of their government's system and practices for managing the multibillion dollar R&D activities.

Methodology and Techniques

Hyneman's definition of descriptive research, providing "an account of what actually exists and occurs"[16] comes very close to describing the primary methodology of this study. However, in the interest of accuracy, recognition must be given to the fact that interpretation of literature and observation of actual practices are highly subjective. This point is particularly important because this study deals with a multidisciplinary process which is itself largely subjective.

Objectivity and quality are sought by following a standard which Hyneman describes as a "scientific method,"[17] . . . conscientious, careful, systematic effort to find out what actually exists and goes on, and . . . to report the findings in a way that enables other students to evaluate the sufficiency of the evidence for . . . the conclusions and to test . . . the findings . . .

In conducting the research, emphasis was placed on analytically viewing the factors Dawe suggests for consideration

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[16]Charles S. Hyneman, The Study of Politics (Urbana: University of Illinois Press, 1959), p. 116.

[17]Ibid., pp. 78-79.

in descriptive study:[18]

1. Conditions, relationships, practices, elements, values and processes as they now exist.
2. The effects of the elements of the description.
3. Current attitudes, philosophies, and beliefs.
4. Trends that seem to be developing.
5. The association among the elements of description.

The primary methodology then is analytical, interpretative, descriptive analysis of the literature supplemented by unstructured interviews with government officials who are active in R&D contracting roles.[19] The author's several years experience as an observer and participant in the government R&D contracting system was relied upon for interpretation and analysis of the literature.

The literature search confirmed a suspected scarcity of material directly related to scientists and engineers' roles in the contract system; however, considerable material was discovered that provides a general treatment of the subject of government contracting. Contracting as a controversial subject received considerable attention, particularly in the 1950's and early 1960's, from writers in the area of

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[18]Jessamon Dawe, Writing Business and Economics Papers, Theses and Dissertations (Totowa, N. J.: Littlefield, Adams and Co., 1965), p. 11.

[19]Interviews supported conclusions; (1) scientists and engineers in government contracting roles are generally inadequately informed regarding the contract system and their respective roles, (2) descriptive literature treating the roles of scientists and engineers is essentially non-existent, (3) descriptive literature dealing with roles of scientists and engineers in government R&D contracting would be of substantial value. See bibliography for list of interviewees.

public science policy.[20] The major source materials for research on the roles of scientists and engineers are the regulatory documents of the federal government.[21] In the study of the contract system, however, private works constituted the major data source.

The Literature

The literature survey revealed a serious neglect of scientists and engineers' roles in the contract system. With the exception of limited government material, there appears to be no published work that deals specifically with the subject. There is a bright side, however, in that considerable work has been done in the general area of the R&D contract system. Some of the literature in this area is current and well suited to providing perspective. Some of the higher quality works in this category include Peck and Scherer's economic analysis of the military contracting system,[22] one of the most comprehensive studies in the area of government contracting. Danhof's work is an excellent treatment of the R&D contracting phenomena from a broad perspective. It provides insight into basic concepts and traces the history of R&D contracting.[23] Harold

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[20] Including Don Price, Michael Reagan, H. L. Nieburg, Harold Orlans, Clarence Danhof.

[21] Armed Services Procurement Regulations, NASA Procurement Regulations and AEC Procurement Regulations and supplemental material.

[22] Merton J. Peck and Frederic M. Scherer, The Weapons Acquisition Process: An Economic Analysis (Boston: Harvard Univ. Press, 1962).

[23] Danhof, Government Contracting and Technological Change.

Orlans' review of AEC's contracting experience provides considerable insight into the AEC decision-making process and some of the more challenging problems of the agency.[24] Tybout provides a thorough review of one aspect of AEC's contracting system--the selection and application of the contractual arrangement. The book also provides a good appreciation for the contract options, but has little value as a general reference.[25]

Several authors have treated the subject of the "contract system" as a part of a broader study of public science activities. Some of the more thoughtful works include Nieburg's presentation entitled "The Contract State,"[26] Price's "Federalism by Contract,"[27] and Reagan's "Administration by Contract," and "Government by Contract."[28] The titles of these works are unusually descriptive; each emphasizes a different area of the extensive political, economic and social implications of the contract system.

Another group of literature dealing with the subject of contracting accounts for the largest quantity of material, but holds little value for this study. This work is heavily oriented to the traditional purchasing system designed for

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[24]Harold Orlans, Contracting For Atoms (Washington, D. C.: The Brookings Institution, 1967).

[25]Tybout, Government Contracting in Atomic Energy.

[26]Nieburg, In the Name of Science.

[27]Price, Government and Science.

[28]Reagan, Administration of Public Policy.

standard equipment and the more routine procedures. The material is procedural in nature and generally out-dated. Examples of literature in this category include Mack's manual for purchasing officers;[29] Forbe's five year study of the functions of purchase systems in federal, state, county and municipal governments;[30] and Miller's study of military pricing.[31]

An additional literature source, the NASA Technical Library at the Manned Spacecraft Center, provided several unpublished studies having direct applicability to the research. These are for the most part government sponsored studies of specific aspects of the government contracting system. Examples of the type of material obtained from the NASA Technical Library include a study of the role of nonprofit institutions in contracting,[32] a study of the relationships between R&D and production contracts,[33] an examination of current attitudes

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[29]Clifton E. Mack, Federal Procurement, A Manual for the Information of Federal Purchasing Officers (Washington, D. C.: U. S. Government Printing Office, 1953).

[30]Russell Forbes, Governmental Purchasing (New York: Harper & Brothers Publishers, 1929).

[31]John Perry Miller, Pricing of Military Procurements (New Haven: Yale University Press, 1959).

[32]Peter L. Shaw, Administration by Contract: The Think Tanks, NASA Report N68-83275 (Washington D. C.: NASA, 1968).

[33]Edward Greenberg, Relationships between R&D Contracts and Production Contracts, NASA Report M34-07-03 (Washington, D. C.: NASA, 1967).

toward profit,[34] a review of gaming techniques in contracting,[35] and a description of an innovative approach to incentive contracting for major R&D projects.[36]

In summary, literature directly related to roles of scientists and engineers in R&D contracting is essentially limited to official government regulatory documents. These documents and various supplemental material constitute the basic source data. Secondary material including books, periodicals and special government sponsored studies, provi‹ the source data for that portion of the research directed to providing perspective on the contract system.

Research Boundaries

The problem addressed by this research has nation-wide political, economic and social implications. The government's R&D activities, particularly the system that governs its relations with private concerns, universities and nonprofit institutions, affect essentially every facet of public and private endeavor in the United States. Almost every federal agency and department is engaged in contracting for R&D; for some it is the dominant method of implementing objectives.[37]

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[34]Dave W. Lang, The Government's Attitude Toward Profit, NASA Report A65-10717 (Wash., D. C.: NASA, 1969), pp. 353-355.

[35]John R. Isbell, Contract Law and the Value of a Game, NASA Report N68-82102 (Washington, D. C.: NASA, 1969).

[36]George F. MacDougall, Jr., Planned Interdependency Incentive Method, NASA Report W68-10-656C1. (Wash., D. C.: NASA, 1968).

[37]Danhof, p. 95.

Setting the boundaries for a problem of such scope and complexity is in itself a challenging task. The research must be sufficiently broad to represent agencies and departments throughout the government to achieve the desired degree of universality; yet time and resource constraints of the author must be also recognized. An explanation of the solution follows.

The research for this study quickly revealed two significant aspects of government R&D contracting that facilitated establishment of research boundaries. First, it was discovered that the major share of all government R&D contracting is attributable to only three organizations, the DOD, AEC and NASA. To illustrate, in 1965 these organizations "accounted for about 98 percent of all federal expenditures on developme programs."[38] The expenditures of all other agencies for development programs ranged from "less than $50 million in 1960 to about $500 million in 1967."[39] The second point involves the contracting policies and practices of DOD, AEC and NASA. Ernest W. Brackett, former Director of NASA Procurement, reported that "Our statutory procurement authority is the same as that of the military departments, the Armed Service Procurement Act of 1947, and our procurement procedures follow quite closely those of the Armed Service Procurement Regulations. . . "[40]

[38]*Ibid.*, p. 16?. [39]*Ibid.*

[40]Ernest W. Brackett, *NASA Procurement Policies*, NASA Report N63-21153 (Washington, D. C.: NASA), p. 262.

Although the AEC is governed by Federal Procurement Regulations, the agency has developed detailed implementing instructions which are also based primarily on the ASPR.[41] Further research also revealed a high degree of similarity in contracting practices in the DOD, AEC and NASA. This knowledge provides a sound basis for the conclusion that research based on the policies and practices of the DOD, AEC and NASA is in fact representative of the organizations primarily responsible for government R&D contracting. Furthe that research based on these organizations has application to a wide clientele. Therefore, the DOD, AEC and NASA constitut the organizational parameters of the study. Any reference to policies or practices of other organizations is strictly for supplemental support.

In establishing the research parameters it was necessary to address the question, "To what level or detail will the research be oriented?" The answer of course depends upon the clientele to which the work is directed; which is, in this case, government scientists and engineers. The needs of this particular group are for better overall perspectiv of the contract system and greater awareness of their respective roles in the process. This consideration facil tated establishment of another parameter, the depth of the study. There is no attempt to describe every facet of the

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[41] Paul R. McDonald, Government Prime Contracts and Subcontracts (Glendora, California: Procurement Associates, 1964), p. A-1-16.

contracting process or the roles of scientists and engineers. The areas covered are limited to those which are in the author's judgment most significant to the effectiveness of the contracting system. Accordingly, the research emphasizes concepts and policy rather than the procedural aspects. Perspective on the contract system is provided through research of secondary literature supplemented by the author's experience. The major roles of the scientist and engineer are described through research and interpretation of primary source material, official government documents, supplemented by the author's experience.

The last major consideration in establishing research constraints was to select the area of the contracting environment for study. R&D covers a spectrum ranging from procurements valued at only a few dollars through major programs such as Apollo that cost billions of dollars and extend over several years. Procedurally and from the standpoint of roles of scientists and engineers, R&D contract requirements fall into two categories based primarily on the estimated dollar value of the contract. The criteria for categorization vary among agencies; however the common objective is to assure that contract requirements of high dollar value and/or major impact potential are subjected to appropriate management consideration at selected points throughout the contracting process. The smaller dollar value short term requirements are generally processed more routinely and subject to less formal procedures. Although there are only minor differences between the categories (from the viewpoint of scientists and engineers), the focus of this study is clearly on major R&D projects.[42]

Finally, it is important to recognize that no attempt has been made to research all government regulations relating to the contracting process. The basic policy documents of the DOD, AEC and NASA, the procurement regulations, supplemented by other pertinent material relating to specific aspects of contracting from government and non-government sources provides the basis for the research.

[42]NASA Phased Project Planning Guidelines describe a major project as follows: a major research or development project cannot be defined in specific terms. Therefore, a judgment must be made by the responsible Program Office and Center operating officials as to whether a particular R&D effort should be classified as major and therefore subject to specific approval by the Administrator or his delegate. Where there is uncertainty on whether a project should be considered as "major," the matter should be resolved with the Administrator or his delegate. A major project normally would have several of the following characteristics: (1) Require significant Agency resources, through run-out, in terms of manpower/funding/facilities. (2) Involve important relationships with external organizations, the public, or foreign governments. (3) Usually encompass design, development, fabrication, test and operations. (4) Require the identification or formation of a special organizational element which would devote full time to the execution of the effort.

CHAPTER II

EVOLUTION OF THE CONTRACT SYSTEM

Understanding the roles of participants in the government contracting system requires an appreciation of the fundamental aspects of the system itself. The system of contracting for R&D, as it presently exists, is a result of an evolution process that began in the 18th century and achieved the present stage only within the last thirty years. The purpose of this chapter is to provide perspective on the fundamental developments over the years which are the foundation for the system.

The presentation begins with a discussion of basic concepts which permeate the contract system. Next, the legal foundation, the development of laws and regulations are reviewed, and finally a brief review of the evolution of the R&D aspects of the contract system.

Basic Concepts

Contracting versus procurement

The differentiation between the terms contract and procurement is an area of confusion and misunderstanding. The terms are utilized interchangeably in the literature and in practice; yet, there seems to be some different emphasis of intent.

Government regulations contribute to the confusion by utilizing the terms interchangeably. For example, the regulations are almost invariably entitled "procurement" while the content applies the term "contracting."[1] The same is true in the case of laws, executive orders and other government documents. The definition found in government regulations for "procurement" seems to cover contracting as well, and is apparently intended to do so since a definition is not provided for contracting. The NASA defines procurement as:

> "Procurement" includes purchasing, renting, leasing, or otherwise obtaining supplies or services. It also includes all functions that pertain to the obtaining of supplies and services, including description but not determination of requirements, selection and solicitation of sources, preparation and award of contract, and all phases of contract administration.[2]

The term contracting appears to be related to t transition of R&D work from internal performance to contracted performance by private concerns. The transition, which began around 1940 and reached a peak in the 1950's prompted many congressional and other investigatory reports that used the term "contracting-out." Over a period of time, reference to purchasing activities associated with major R&D efforts became identified as "contracting" while purchases involving

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[1]The NASA Procurement Regulation and Armed Services Procurement Regulations are examples.

[2]NASA Procurement Regulation, NPC-400, through Revisior No. 14, p. 113.

standard commodities continued to be identified as "procurement."

Reagan addresses the point in a discussion of "contracting-out."

> . . . Contracts between government and the private sector for the supply of goods and services are, of course, not new. Office supplies, food, and equipmen for the armed forces and the construction of federal buildings are standard items of procurement. Contracting out, however, refers not to the purchase by government of existing products but to arrangements whereby the nongovernmental contracting party shares in the public task of developing something new - a weapons system, a method of desalinating water, even, on occasion, policy ideas.
>
> The difference is basic. We do not think of clothing manufacture as a public task, and thus contracts to supply army shoes raise no questions about the delegation of public decisions to private entities. Foreign policies, missile systems, defense strategies, reorganization plans for government agencies, and resource development policies, however, are inherently governmental "products," and it is contracts for research and development in such areas that do constitute a new relationship. Through such contracts private organizations share in the shaping of public business; in turn, many of them become dependent upon income from public contracts for their continued existence, creating the possibility, at least, of governmental leverage over their internal decisions. Contracting out therefore implies, as simple procurement contracting does not, the mixing of government with otherwise autonomous private organizations in ways that blur the line between government and society - a line that, according to pluralist political theory, is crucial to the maintenance of democracy.[3]

Although the traditional term for government purchasing is "procurement," the term "contracting" is most often utilized in reference to R&D endeavors. For purposes of this study, however, the terms are considered interchangeable with the same meaning as provided by the NASA procurement

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[3]Reagan, Politics, p. 95.

regulation.[4]

Advertising versus negotiation

There are two basic methods of contracting within the federal government, advertising and negotiation. All forms and techniques of contracting fall within these two categories

Formal advertising is the fundamental law governing all government purchasing; all purchases by negotiation must fall within one of the specific exceptions to basic law. An act of Congress passed in 1860, the basic law governing all government purchasing, provided that

> All purchases and contracts for supplies or services in any of the Departments of the Government, except for personal services, when the public exigencies do not require the immediate delivery of the article or articles, or performance of the service, shall be made by advertising a sufficient time previously for proposals respecting the same. When immediate delivery or performance is required by the public exigency, the articles or service required may be procured by open purchase or contract at the places, and in the manner in which such articles are usually bought and sold, or such services engaged between individuals. No contract or purchase shall hereafter be made, unless the same be authorized by law or be under an appropriation adequate to its fulfillment, except in the War and Navy Departments, for clothing subsistence, forage, fuel, quarters, or transportation, which, however, shall not exceed the necessities of the current year.[5]

The law requires

> (a) public advertising for bids responsive to detailed specification; (b) public opening of the bids at a specified time and place; and (c) award of the contract to the lowest responsible bidder complying

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[4]See footnote 2 of this chapter

[5]Danhof, p. 17.

with the conditions of the advertisement for bids.[6] Current requirements remain essentially unchanged with the exception of the negotiation authorities for certain purchases The law governing the DOD and NASA provides that

> . . . purchases of and contracts for supplies or services shall be made by formal advertising in all cases in which the use of such method is feasible and practicable under the existing conditions and circumstances. It further provides that, if the use of formal advertising is not feasible and practicable, negotiation of contracts is authorized under certain circumstances enumerated therein. . . . In accordance with this requirement, procurements shall generally be made by soliciting bids from all qualified sources of supplies or services deemed necessary by the contracting officer to assure full and free competition consistent with the procurement of the required supplies or services.[7]

Formal advertising is conducted in accordance with strict procedures. The basic steps are

(i) Preparation of the invitation for bids, by describing the requirements of the Government clearly, accurately, and completely, but avoiding unnecessarily restrictive specifications or requirements which might unduly limit the number of bidders. The term "invitation for bids" means the complete assembly of related documents, whether attached or incorporated by reference, provided prospective bidders for the purpose of bidding;

(ii) Publicizing the invitation for bids, through distribution to prospective bidders, posting in public places, and such other means as may be appropriate, in sufficient time to enable prospective bidders to prepare and submit bids before the time set for public opening;

(iii) Submission of bids by prospective contractors; and

(iv) Awarding the contract, after bids are publicly opened, to that responsible bidder whose bid, conforming to the invitation for bids, will be

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[6]Danhof, pp. 17-18

[7]*NASA Procurement Regulations*, p. 201

> most advantageous to the Government, price and other factors considered (or rejecting all bids).[8]

What are the difficulties involved in advertising? Why not formally advertise all requirements including R&D? Basically, the answer to these questions is simply that many procurements, especially for R&D, do not meet the prerequisites for advertising. For example, one requirement of advertising is that only a fixed-price type of contract can be awarded. The problem with fixed-price contracts in an R&D situation is that the nature of the work is such that realistic cost estimating is often not possible. So, if the government insists on a fixed-price arrangement, the contractor is inclined to include contingency factors to offset possible conservative estimates. There are also other reasons that advertising is not feasible or practicable in certain situations For example, the requirement for firm description of the work essentially rules out situations in which the task cannot be precisely defined in advance. Certainly, when the state-of-the-art is being advanced, as is normally the case in R&D, this criterion cannot be met.

At this point one might reasonably ask what procurements are suitable for advertising? Perhaps examples provide the best answer. Almost all standard equipment readily available in the commercial market such as furniture, office supplies, vehicles, and other items for which a definitive specification

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[8] Ibid.

is available may be advertised providing there are no other prohibiting reasons. The military successfully purchases by advertising, many complex equipments such as electronic and electrical components and in certain situations, even hardware systems. Advertising generally works well for items that are well defined and for which adequate competition exists. There are other factors such as time limitations that also influence the decision regarding advertising versus negotiation, but the basic factors are "description and competition."

Before leaving the discussion on advertising, comment should be made about a variation of the straight formal advertising method, which broadens the scope of the area to which advertising may be applied. Two-step formal advertising helps bridge the gap when the sole problem preventing formal advertising is lack of definitive specifications. The procedure and conditions for use are described in the regulations as follows:

> (1) Step one consists of the request for, and submission, evaluation, and if necessary, discussion of a technical proposal, without pricing, to determine the acceptability of the supplies or services offered. As used in this context, the word "technical" has a broad connotation and includes engineering approach, special manufacturing processes, and special testing techniques. When it is necessary in order to clarify basic technical requirements, related requirements such as management approach, manufacturing plan, or facilities to be utilized may be clarified in this step. Conformity to the technical requirements is resolved in this step, but capacity and credit . . . are not. Two-step formal advertising shall be used in preference to negotiation when all of the following conditions are present, unless other factors require the use of negotiation;

because of the limitations of the procedure, and the incompatibility with the ill-defined requirements which characterizes most R&D, negotiation has been authorized in certain circumstance as an alterante contracting method. Negotiation is the method accounting for the major share of contracted dollars, although advertising accounts for the largest quantity of items.

Negotiation is the process by which all contracts, regardless of dollar value, are consummated with the exception of contracts resulting from advertising procedures. The statutory authority to negotiate contracts results from difficulties encountered over the years in attempting to adhere to the stringent rules of advertising which are incompatible with the realities of the situation. The relevant negotiation exceptions to formal advertising are

> . . . purchase of or contracts for any service by a university, college, or other educational institution; . . . for property or services for which it i impracticable to obtain competition; for property or services that [are] determined to be for experimental developmental, or research work, or for making or furnishing property for experiment, test, development or research; . . . [for] technical equipment whose standardization and the interchangeability of whose parts are necessary in the public interest and whose procurement by negotiation is necessary to assure that standardization and interchangeability; [for] . . . technical or special property . . . [which] requires a substantial initial investment or an extended period of preparation for manufacture, and for which . . . formal advertising and competitiv bidding might require duplication of investment or preparation already made or would unduly delay the procurement of that property; [and if] the interest of industrial mobilization or of national defense in maintaining active engineering, research and development would otherwise be subserved.[10]

[10]Danhof, pp. 50-51.

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Negotiation does not preclude competition, although a lack of adequate competition is justification for negotiation. The government has the same obligation to obtain competition when possible in a negotiation situation as in an advertised procurement. The following quotation from government regulations illustrates the environment within which negotiated procurements are processed:

> In all negotiated procurements in excess of $2,500 in which rates or prices are not fixed by law or regulation and in which time of delivery will permit, proposals shall be solicited from the maximum number of qualified sources consistent with the nature and requirements of the supplies or services to be procured.[1]

Negotiation provides flexibility for the contracting parties to jointly resolve the problems encountered in developing mutually acceptable terms. It also enables the government to contract for work that cannot be well defined in advance by providing the flexibility of a variety of contractual arrangements. This is an especially important advantage in contracting for R&D since advance definition of the work is normally not possible.

Negotiation facilitates utilization of the terms and arrangement most appropriate and advantageous for the situation at hand. The prices and other terms of a negotiated contract are tailored to the requirements of the particular procurement.

Essentially all government expenditures by the government for R&D work are through the negotiation medium of contracting.

[1] <u>NASA Procurement Regulations</u>, p. 3

The agencies that account for 98 percent of the expenditures[12] rely heavily on the technique of negotiation. For example, AEC's contracts are almost exclusively the negotiated cost-plus-fixed-fee type,[13] the DOD places 80 percent of its contracts through negotiation,[14] and the NASA-MSC awarded 97 percent of its contract dollars by negotiation in FY 69.[15]

Development of Laws and Regulations[16]

The Constitution

The President of the United States, in his dual capacity as the Chief Executive Officer and Commander-in-Chief, is responsible for the direction of government purchasing functions Article 1, Section 8 of the Constitution authorizes Congress to enact laws affecting military procurement as one of the six specific war power grants. This particular war power grant also states that Congress shall have the right to raise and support armies but that no appropriation for this purpose shall be for a period longer than 2 years. The two-year provision has been interpreted to apply to such items as clothing, subsistence and pay but not to means for attack or defense.

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[12]Danhof, p. 169.

[13]Tybout, p. 10.

[14]McDonald, p. A-5-1.

[15]NASA, Annual Procurement Report Fiscal Year 1969 (Houston, Texas: Manned Spacecraft Center, Dec., 1969), p. 48.

[16]Much of the material in this section is based on information contained in McDonald's Government Congracts.

Congress controls procurement by controlling the appropriations to support it, a power specifically granted by the Constitution.

Early Statutes

In 1792 the Department of the Treasury was given responsibility for purchases for the Army. A Purveyor of Public Supplies was established in the Treasury in 1795 to act as the Government's purchasing agent. Congress declared in 1798, that "all purchases and contracts for supplies or services for the military and naval service of the United States shall be made by or under the direction of the chief officers of the Department of War and Navy respectively." The Purveyor of Public Supplies still remained responsible, however, for executing the orders received from the military departments. The first record of procurement problems indicates they resulted from activities of Congressmen in securing Government contracts for friends. In 1808 a law was passed requiring a clause in government contracts to state that no member of Congress might benefit from the contract. This prohibition still exists and the clause is included in all government contracts. [The "Officials Not to Benefit" Clause, ASPR 7-103.19.]

Development of Competitive Bidding

The ethics of both public officials and business firms in the early days of the Republic left much to be desired. Accusations of graft and favoritism in the award of government contracts were common. Congress soon realized that the only effective way to prevent abuses was to require that purchases be made by competition in the open market. Over a period of years a series of statutes extended the requirements for competitive bidding to all government purchases with only limited exceptions.

An Act of March 3, 1809, established a general requiremen that formal advertising be used in the procurement of supplies and services. This was the first in a series of Acts which was to lead to the establishment of formal advertising as the method for essentially all government purchasing. This statute provided that all purchases and contracts by the Secretaries of the Treasury, War and Navy would be made "eithe by open purchase or by previously advertising for proposals respecting the same." Other Acts passed in 1842 and 1843 extended the requirement for formal advertising; requiring the use of sealed proposals, public bid openings and satisfactory security for performance.

The Civil Sundry Appropriations Act of March 2, 1861, was the fundamental procurement regulation under which the Civil War was fought. Problems arose early in the war over the use of formal advertised procurement procedures and exceptions to its use led to recriminations with regard to war profiteering and excessive profits. Both the North and the South were plagued by profiteering contractors, and scandals early in the war caused major shake-ups in the Administration of the North.

Upon revision and amendment in 1874 and 1878, the Civil Sundry Appropriations Act became known as Revised Statute 3709

In 1910, this Act was again revised re-emphasizing formal advertising as the required method of procurement; however exceptions permitting negotiation were provided for

(1) Emergency purchases in the event of a public emergency.
(2) Purchases less than $500. If negotiation was used, however, the approval of the Secretary of War was required in all cases over $100.
(3) Procurement from the Federal Prision Industry.
(4) Procurement of horses and mules.
(5) Purchase of proprietary items.
(6) Procurement of medical supplies.
(7) Procurement of classified items.
(8) Purchase of bunting.
(9) Purchase of dies and gauges.

R. S. 3709 was, with its amendments, the standard regulation governing defense contracting until replaced by the Armed Services Procurement Act in 1947.

World War I

When World War I began, the War and Navy Departments attempted to comply with the rigid competitive bid system required by R. S. 3709. However, circumstances forced a shift to negotiation for many items. Formal advertising was used almost exclusively, however, in the purchase of standard items. Shortage of facilities and lack of centralized control of the purchasing activities of the War and Navy Departments led to intense competition between the Departments and with the civilian economy. The use of cost plus percentage of cost contracting resulted in considerable abuse since it provided an incentive for waste and inefficiency in performing contracts.

Post World War I

World War I experience with advertising revealed its failure as an effective method of procurement in emergency situations. Also, the competition between the Services indicated that more centralized direction of procurement was needed. Unfortunately, rather than using these lessons to develop effective procurement practices and procedures, the period was one of recrimination and accusations against profit-making enterprise.

The War Policies Commission was established in 1930 to study and consider amending the Constitution to provide that private property may be taken by Congress for public use during war, methods of equalizing the burdens and to removing the profits of war, and a study of policies to be pursued in the event of war. A Senate Committee established in 1934, the "Nye Committee," was to investigate the possibility of the government monopolizing the manufacture of munitions. Considerable attention was also given to the possibilities of limiting profits by price control and taxation.

The Nye Committee also spent considerable time reviewing the industrial mobilization plan of the War Department. This plan proposed the use of a decentralized procurement system and provided for purchasing of specialized equipment without advertising. The War Department proposed the use of two types of contracts; a standard fixed price type for commercial supplies and simple construction, and a redeterminable form for noncommercial items and major construction. The redeterminable contract provides for government audit and payment to the contractor of all allowed costs of performance. The final compensation is based on the approved cost of performance plus a profit based on a rental charge for the part of the plant involved in the contract.

Congressional interest in war profiteering is evidenced by the fact that during a 20-year period between World War I and World War II, 200 bills and resolutions were considered which were designed to limit profits. However, few changes were actually made in procurement practices. The basic conflict between the interest of Congress in preventing procurement abuses and restricting war profits, and the interest of the War and Navy Departments in the winning of a war was not resolved. The United States entered World War II with a procurement system governed by undigested and uncoordinated legislation. Statutes, many archaic and conflicting, had accumulated over a period of more than 100 years. In the aggregate, they presented serious obstacles to efficient and speedy purchasing necessary in a major war. The situation was complicated by the fact that the War and Navy Departments were reluctant to give up the protection of formal advertising after experiencing the criticism of excessive profits

Some of the areas covered by special statutes were almost ridiculous; others, designed to serve a purpose in peace time, were outmoded in a war situation. Some were designed solely to protect special interests. Shoes and brushes had to be purchased from the Federal Penitentiary;

brooms and mops had to be purchased from nonprofit agencies for the blind unless purchased for use outside the United States. Hemp and steel had to be purchased from domestic sources unless it had first been advertised for 30 days in two daily newspapers in New York City. Special statutes required public competition for the purchase of guns, steel and armor. Shells and projectiles could be purchase only after proposals had been sent to all manufacturers of these items. To make purchases in the District of Columbi it was first necessary to advertise in "one daily and one weekly newspaper of each of the two principal political parties" and in "one daily and one weekly neutral newspaper." The only constructive piece of legislation developed during the period between World War I and World War II was an authorization in 1926 that permitted contracts for experimental aircraft to be awarded on the basis of design competition rather than price competition.

World War II

In 1937, Congress, with the consent of the President, passed the Neutrality Act with the avowed intention of keeping the United States out of the war. As the extent of the catastrophe became evident, however, it became necessary for the United States to choose sides. Increased emphasis on national defense led to a series of actions which slowly paved the way for the procurement practices of World War II which, with some modification, were to become the regulations under which contracts are currently awarded.

The major change was the transition from mandatory use of formal advertising to across-the-board application of negoti tion procedures. Another area of change, part and parcel of the first, was to provide flexibility in pricing procedures, permitting greater use of cost reimbursement contracts.

The slow transition from advertised procurement to the authorization for negotiated contracts is attributable primarily to experience with excessive profits and fear of favoritism and graft. A series of laws, discussed below, gradually eased the restrictions of RS 3709.

(1) The Public Works Act of April 25, 1939, authorized negotiation for construction of public works projects locate outside the continental limits of the United States, and the use of cost plus fixed fee contracts with fee limitations of 10 percent of estimated costs. The Act also authorized the employment, by negotiation, of outside architectural and engineering firms for the preparation of designs, plans and specifications for public works projects and construction of ships and aircraft.

(2) An Act of July 13, 1939, authorized the War Departm to negotiate for procurement of aircraft parts, instruments and accessories without regard to advertising when the classified nature was such that they could not be publicly divulged. However, an award could be made only after solicitation of at least three reputable firms.

(3) The Multiple Awards Act of March, 1940, authorized the Secretary of War to award contracts for aircraft, aircraft

parts and accessories to the three lowest bidders, thereby dividing the work and avoiding overload of aircraft production facilities.

(4) The Treasury was authorized by a National Defense Supplemental Appropriations Act of June 26, 1940, to deviate from the bidding procedures of RS 3709 in the purchase of strategic materials.

(5) An Act of June 28, 1940, known as the "Expediting Act," authorized advance payments to contractors of up to 30 percent of the contract price. It also authorized contracts for acquisition, construction, repair of alteration of naval vessels or aircraft to be made by negotiation without regard to requirements for advertising.

(6) An Act of July 2, 1940, permitted the Secretary of War to enter into such contracts and amendments as deemed necessary to construct government-owned facilities and to provide for their operation with or without advertising.

Each of the Acts prohibited use of cost plus percentage of cost contracts. Where cost-plus-fixed-fee contracts were permitted, the fees were generally limited to a maximum of 6 or 7 percent of the estimated cost. Even though Congress reluctantly granted exceptions to the use of formal advertising procedures, it maintained the position that advertising is the preferred method of purchasing.

The First War Powers Act

After declaration of war in December, 1941, the First

War Powers Act, signed by the President December 18, 1941, removed most of the traditional restrictinos on procurement activities of the government. It authorized departments and agencies engaged in the war effort to enter into contracts and modifications of contracts, and to make advance, progress and other payments without regard to the provision of law relating to the making, performance, amendment or modification of contracts, whenever such action would facilitate the prosecution of the war. On December 27, 1941, Executive Order 9001 authorized the War and Navy Departments and the U. S. Maritime Commission to exercise the full powers contemplated by Congress in the First War Powers Act.

Even with this directive some departments continued the use of competitive bidding. Finally on March 3, 1942, War Production Board Directive No. 2 directed the abandonment of procurement by competitive bidding and required that all contracts be awarded by negotiation. The directive emphasized three criteria to be applied to the placement of contracts. First, primary emphasis was to be on delivery; second, contracts for the more difficult items would be placed with concerns possessing the necessary engineering, managerial and physical resources, with the less complex items going to small business firms; and finally, contracts were to be placed with firms requiring the least amount of new facilities and equipment for performance.

Pricing Problems

The lack of interest in close pricing and profit control led to unfortunate results. Contractors soon recognized that the percentage of profit which they could retain, while theoretically based on efficiency and economy of performance, in actual practice became a percentage of cost incurred. This provided an incentive to spend as much money as was made available; and, in a more limited fashion, had the same effec as the cost-plus-percentage-of-cost contracts used in World War I. Concern by the Office of Price Administration (OPA) over whether or not defense material should be put under pric control and examples of excessive profits led to a re-evaluation of pricing policy, with the conclusion that the objective of negotiation and renegotiation was to secure economy in labor, materials and plant facilities, rather than control or recapture of profits.

The Tryon Conference

In October, 1942, the War Department held a conference at Tryon, North Carolina, to formulate new policies based on war experience. The objective of the conference was to promote more efficient use of labor, material and plant facilities, to limit profits to reasonable levels, and to prevent inflation. During the conference, the War Department reasserted its determination to secure equipment at the lowest possible cost, persuading the OPA to refrain from extending price regulations into the military field. It was recognized however that controls were necessary to keep prices close to costs and that close pricing and application of the best type of contract was a better method of price control than regulations. The conference recommended continued use of fixed price type contracts and close estimating.

Enforcement Powers

Early in the war it was determined that the suggestions advanced in the thirties regarding nationalization of munitions manufacture would not be followed; instead, voluntary methods would be utilized wherever possible. War is a seller's market however, and it was recognized that voluntary methods would not always achieve the objective. For this reason, Congress provided mandatory powers which were rarely used, but acted as a deterrent to unreasonable demands from contractors. These powers were:

(1) An Act of October 16, 1941, as amended gave the government power to requisition personal property.

(2) The Selective Training and Service Act of September 16, 1940, authorized the government to issue mandatory orders requiring persons to produce products of the type which they usually produced or were capable of producing.

(3) The Revenue Act of 1943 gave the Government the right to issue an order establishing fair and reasonable prices for future delivery in the event such prices could not be negotiated.

(4) Title 3 of the Second War Powers Act of March 27, 1942, gave the government the right to establish priorities and allocation powers.

(5) Title 8 of the Second War Powers Act authorized the government to inspect plants and to audit and inspect the records of contractors.

The use of priorities and allocations under Title 3 of the Second War Powers Act had more substantial effects than the other powers and was far simpler to administer. It essentially compelled firms to accept orders for goods even though they might object, since without defense contracts they were unable to secure necessary materials and supplies to contin in business.

Contract Settlement Act

During the war shifts in procurement requirements necessitated cancelling of many contracts. To provide a method of settlement in these cases, a termination clause was included in contracts which provided for negotiated settlement of termination claims. The clause also provided a formula for compensation in the event of failure to reach agreement. However, there was a lack of uniformity in practices among the services. For this reason, the Joint Contract Termination Board, created in 1943, developed a uniform termination clause and statement of principles for determination of costs upon termination. In anticipation o the end of the war Congress passed the Contract Settlement Act of 1944 to insure uniform and rapid settlement of terminated contracts. The Act provided a uniform termination procedures and cost principles for compensation of contractors. The Act also contained provisions which provided for recognition of claims by contractors who had acted without a contract, relying upon the apparent authority of an officer or agency.

The Armed Services Procurement Act

The majority of the laws and orders passed in World War II were temporary, necessitating a return, at the end of the war, to the provisions of R. S. 3709 with its emphasis on competitive bidding. The war, however, had demonstrated the inefficiency of competitive bidding in times of national emergency and the services had demonstrated that negotiation could be effectivel used in awarding contracts. Uncertain conditions after World War II also argued against reversion to business-as-usual which had taken place after World War I. Accordingly, the War Production Board recommended in November 1945, that government agencies propose new legislation to take effect upon expiration of the emergency procurement authority. The Board recommended that formal advertising be recognized as the preferred method of procurement but that provision also be made for authority to negotiate price and other terms when circumstances required; and that formal advertising be dispensed with during national emergencies. A bill was prepared and introducted in the 80th Congress on January 7, 1947, as H. R. 1366, the Armed Services Procurement Bill. This bill pulled together all DOD procuremen authority, and replaced the former laws, all in one statute. The Bill was approved by the President on February 19, 1948, as Public Law 113 of the 80th Congress, and became known as the Armed Services Procurement Act of 1947(ASPA). The Act states that formal advertising is the preferred method of procurement; however, it authorizes negotiation where circumstances require a departure. The Act also provides for the

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use of the type of contract best suited to the circumstances, permits advance payments, and provides for joint procurement between the services.

The Act sets forth 17 exceptions to the requirement for formal advertising, including many of those allowed as exceptions to R. S. 3709, and others resulting from experience during the war. The exceptions are:

(1) When determined to be necessary in the public interest during the period of a national emergenc declared by the President or by Congress.
(2) When the public exigency will not permit delay incident to advertising.
(3) When the aggregate amount involved does not excee $1,000.
(4) For personal or professional services.
(5) For any services to be rendered by a university, college or other educational institutions.
(6) When supplies and services are to be procured for use outside the United States and its possessions
(7) For medicines and medical supplies.
(8) For supplies purchased for authorized resale.
(9) For perishable supplies.
(10) For supplies or services for which it is impractical to secure competition.
(11) When the agency head determines that the purchase or contract is for experimental, developmental or research work or for the manufacture or furnishing of supplies for experimentation, development, research or testing.
(12) For supplies or services purchase of which should not be disclosed for security reasons.
(13) For technical equipment necessary in order to insure standardization and interchangeability of parts necessary in the public interest.
(14) For technical or specialized supplies requiring substantial initial investment or an extended period of preparation for manufacture when competitive bidding might require duplication of investment or preparation already made or would unduly delay procurement.
(15) When the bid prices received as a result of advertising are unreasonable or have not been independently arrived at in open competition.
(16) To make or keep available a supplier in the interest of national defense to meet a national emergency or in the interest of industrial mobilization.

(17) As otherwise authorized by law.

Armed Services Procurement Regulation (ASPR)

The Department of Defense (Army, Navy and Air Force) formulated policy and regulations under the Armed Services Procurement Act which was published as the Armed Services Procurement Regulation (ASPR). This Regulation, the basic procurement document for the military, is divided into the following seventeen sections:

- I General Provisions
- II Procurement by Formal Advertising
- III Procurement by Negotiation
- IV Special Types and Methods of Procurement
- V Inter-Departmental Procurement
- VI Foreign Purchases
- VII Contract Clauses and Forms
- VIII Termination of Contracts
- IX Patents, Copyrights and Technical Data
- X Bonds and Insurance
- XI Federal, State and Local Taxes
- XII Labor
- XIII Government Property
- XIV Inspection and Acceptance
- XV Contract Cost Principles
- XVI Procurement Forms
- XVII Extraordinary Action to facilitate the National Defense

Other Federal Regulations

While the ASPR was the catalyst, procurement regulations for all federal agencies and departments are now published in the Code of Federal Regulations (CFR). The first chapter of the CFR's provides the basic procurement regulations and subsequent chapters deal with individual agencies. The ASPR's are also published in the CFR's as Title 32 CFR 1.100 through 9.00 (Parts 1 through 30).[17]

[17]The Federal Procurement Regulation System is published in various chapters of Title 41 of the CFR. Pertinent references are: Chapter 1 - Federal Procurement Regulations - 41 CFR 1-1000; Chapter 2 - Federal Aviation Administration - 41 CFR

With minor exception the procurement rules are the same for the DOD, AEC, and NASA. The major exception is the AEC provisions for directed sources of supply and special indemnification of contractors.

The military departments, AEC, and NASA have followed the customary practice of issuing implementing instructions for the basic procurement laws. However the Air Force has recently decided to discontinue the practice and rely on the ASPR completely.[18] A comparative analysis of the regulations shows that

> The basic material on pricing, proposal preparation, cost and price analysis, types of contracts, standard terms and conditions (with the exception of patents and data), inspection, property, subcontracts, contract administration, termination and renegotiation is applicable, with minor exceptions, to all three agencies.[19]

2-1.101; Chapter 3 - Department of Health, Education and Welfare - 41 CFR 2-1.101; Chapter 4 - Department of Agriculture - 41 CFR 2-1.101; Chapter 5 - General Services Administration - 41 CFR 5-1.000; Chapter 6 - Department of State - 41 CFR 6-1.101; Chapter 7 - Agency for International Development - 41 CFR 6-1.101; Chapter 8 - Veterans Administration - 41 CFR 6-1.101; Chapter 9 - Atomic Energy Commission - 41 CFR 6-1.101; Chapter 10 - Department of Treasury - 41 CFR 6-1.101; Chapter 12 - Department of Transportation - 41 CFR 6-1.101; Chapter 12B - Coast Guard (Department of Transportation) - 41 CFR 6-1.101; Chapter 13 - Department of Commerce - 41 CFR 6-1.101; Chapter 14 - Department of Interior - 41 CFR 6-1.101; Chapter 18 - National Aeronautics and Space Administration - 41 CFR 18-1.100; Chapter 19 - United States Information Agency - 41 CFR 19-1.000; Chapter 22 - Office of Economic Opportunity - 41 CFR 19-1.000; Chapter 24 - Department of Housing and Urban Development - 41 CFR 19-1.000; Chapter 25 - National Science Foundation - 41 CFR 19-1.000; Chapter 29 - Department of Labor - 41 CFR 19-1.000; Chapter 39 - Post Office Department - 41 CFR 19-1.000

[18]Air Force Regulation 5-10, September 1969.

[19]McDonald, p. A-1-16.

Evolution of R&D Contracting[20]

The system of contracting for government R&D is a relatively recent development. There was little need for a contracting capability prior to 1940 because the government conducted essentially all R&D internally. However, during World War II a trend toward "contracting-out" emerged which has continued to the present. This phenomenon generated a need for a system of contracting that is more compatible with the ill-defined, complex requirements of the R&D environment. The purpose of this section is to review the highlights of the evolution of the R&D contract system.

The Fundamental Law in Practice

The fundamental law governing procurement of supplies and non-personal services, except for war periods, until 1947 was an act of Congress passed in 1860. The act required that all purchases by the government be made by advertising and competitive bidding. The system was practical and effective so long as the purchases involved items for which precise specifications could be developed. In the 1800's and early 1900's government contracting was almost entirely concerned with standard commodities and services which could be purchased on the basis of lowest price. The major exceptions were emergencies resulting from war activities where expediency was the prime criteria.

[20]Portions of the material in this section are based on information contained in Danhof.

Universal application of the advertising technique worked reasonably well until the government began to encounter situations that could not be defined in advance. The problem became particularly burdensome in the early 1920's when the military elected to support aircraft development. In 1924 House Committee concluded that the system of competitive bidding was destructive and recommended Congress pass a law to permit procurement of aircraft equipment by negotiation. The "Air Corps Act" was finally passed in 1926 providing flexibility to purchase items for experimental purposes by negotiation.

The services attempted to comply with the Act by holding design competitions. However, this technique proved unsatisfactory because the manufacturing capability of contractors could not be judged by the quality of the specifications they produced. The problems with design competition eventually lead to purchase by "sample." This was a practice of buying aircraft on the basis of a sample provided by the contractor. In the 1930's the sample technique was the principal method of purchasing experimental aircraft. However, in 1939 the procedure was largely abandoned because it was too time-consuming, particularly in view of the threat of war. A trend then developed wherein design competitions were limited to firms considered qualified to produce the aircraft. This technique evolved as the primary contracting method for R&D aircraft, weapons and other equipment during World War II.

By the late 1930's it was obvious that the country was in danger of another war and that greater procurement flexibility was needed. The National Defense Expediting Act of 1940 was a partial answer, enabling the services to utilize the technique of negotiation and fixed price or cost plus fixed fee contract arrangements. In addition, it provided for advance payments and authorized the government to furnish facilities to contractors when necessary for contract performance. The War Powers Act of 1941 provided even more flexibility by giving the President power to authorize contracting without regard to the laws relating to performance and other constraints as long as the contracts facilitated prosecution of the war. This authority was granted to the War and Navy Departments by Executive Order (EO) 9001 in December 1941.

Transition - Government to Industry

The beginning of the transition from government personne conducting R&D to contracting for the work was establishment in 1940 of the National Defense Research Committee (NDRC). The Committee was responsible for correlation and support of scientific research in the mechanisms of warfare, except for problems of flight, which were handled by the National Advisory Committee for Aeronautics (NACA). In addition, NDRC supplemented the experimental and research activities of the War and Navy Departments. NDRC quickly established a policy of operating primarily through contracts, a policy continued by their successor, the Office of Scientific Research and Development (OSRD).

OSRD's principal function was to determine the feasibility of projects and to identify organizations with capability for implementation. However, over the war years OSRD was also a substantial contracting force expending over $500 million dollars on R&D contracts. Many major projects, including th atomic energy program, were initiated by OSRD and continued by other departments and agencies.

While OSRD played a major role in contracting for R&D, many other organizations were also heavily involved in this facet of government business. The War and Navy Departments in particular were big sponsors of contracted R&D. The total federal R&D expenditures in the 1940-1944 period were almost 2 billion dollars, most of which was expended through the contract medium.

Post-war Contracting Problems

In the transition from war to peacetime conditions immediately following World War II, there was much concern regarding government's future role in R&D and how it should be implemented. Congressional feeling was largely in favor of maintaining a strong industrial base by continuing the contract and grant trend of the war years. Other problems, including the nature of procurement authority for the agenci and methods of contracting, also plagued the policy makers during this period.

OSRD was dissolved in 1946 but the Office of Naval Research (ONR) was reestablished and took the lead in contractin for R&D in areas related to the Navy's responsibility. Most of the major programs initiated by OSRD were continued by the military and other agencies. The Army was especially active in the area of university grants and contracts. For example, the Massachusetts Institute of Technology Research Laboratory of Electronics, Jet Propulsion Laboratory, and electronics development at the University of Pennsylvania were all Army-contracted projects.

Although federal organizations were established to cope with post-war R&D activities, the procurement authority question continued to linger. The War and Navy Departments' strong desire for the flexibility of the War Powers Act was reflected in a jointly drafted bill which recognized the problems of contracting for R&D under the formal advertising procedures. The bill was passed in 1947, with only slight modification, as the Armed Services Procurement Act (ASPA). The ASPA was a major breakthrough in the world of contracting. Although it continued the fundamental philosophy of the 1860 Act with regard to advertising, it also provided several exceptions by which contracts could be negotiated. Basically, the Act permitted negotiation when the circumstances of the particular situation are such that advertising is not feasible. Procurement flexibility was further enhanced in 1948 by a bill entitled "To Facilitate the Performance of Research and Development Work." This bill authorized long term contracts (up to 5 years), the furnishing of test equipment to contractors, indemnification of contractors against loss in certain R&D work, and simplification of administrative procedures. Civilian agencies, including the AEC, were given essentially the same authority as the military by the 1949 Federal Property and Administrative Service Act. The NASA's statutory procurement authority is the same as that of the military departments, the ASPA of 1947.[21]

"Contracting-Out" Philosophy Questioned

After the war most congressional action favored continuation of the "contracting-out" philosophy; however, certain elements supported the civil servant solution. Edward Condon, Director of the National Bureau of Standards, expressed the view that contracting was an invasion of civil service legislation and urged reform in civil service pay and administrative rules to enhance internal capability. However, the military and most civilian agencies pushed for continuation of the contracting relationships that had developed during the war. The military position was finally consolidated in 1949 when the Secretary of Defense established a policy that would assign to government owned laboratories only those projects that cannot be contracted for with academic or industrial organizations. The major civilian agencies such as the AEC and NASA have also relied heavily on contracting as a major method of R&D program implementation.

[21]See footnote 40 in Chapter I.

The Growth of R&D Expenditures

Since 1940 federal expenditures for R&D experienced a phenomenal growth, from slightly under 1 million dollars to about 17 billion annually in 1968. In the same period the ratio of government in-house R&D activities to contracted out work changed from almsot 100 percent government to an 80/20 split in favor of contracting. Contracting has become a dominant method of program implementation, particularly in the larger departments and agencies. This trend has been encouraged by the Congress to the point of actually requiring certain areas to be implemented by contract. The growth in contracting as a philosophy of management has also been influenced by factor such as civil service pay scales and the greater flexibility of the industrial sector for obtaining personnel and other resources.

Bureau of the Budget Guidelines

Post-war emphasis on contracting has not escaped criticism. The General Accounting Office (GAO) and the Civil Service Commission (CSC), particularly, have waged impressive battles in favor of more government involvement in R&D. Some of the more substantive arguments were that non-delegable functions are given to contractors, and that contracting is utilized to circumvent personnel ceilings imposed by Congress.

In 1961 the Bureau of the Budget (BOB) attempted to bring reason into the contracting environment by establishing "guidelines for contracting" in a circular entitled "Use of

Management and Operating Contracts." The circular took the position that contracts were unsuitable unless (1) contractor operations would be more economical than direct operations, or (2) the probably higher cost of a contractor would be outweighed by increased effectiveness of operation, or (3) the agency had no essential need for the in-service capability which would be acquired if agency personnel performed the function, or (4) the agency did not have a capability of the standard of excellence required, or (5) to assume full management responsibility. The circular also listed a number of specific functions that were not appropriate for contracting.

The Bell Report

In the early 1960's Congressional uneasiness with the manner in which R&D programs were administered was a factor in a major reexamination of contracting policies. The objective of the review was to establish better rational for use of contracts and their relationship to in-house activity. The main focus of the review was through a Presidential Task Force chaired by David Bell, then Director of the BOB. The Bell report confirmed the necessity for government to rely on the private sector for a major share of its scientific and technical work, and substantiated the wisdom of R&D contractir policies that had evolved since 1940. It also emphasized the importance of developing and maintaining in-house capabili as a device for improving management skills for administering R&D contracts.

To summarize, the decades since 1940 have witnessed a transition in long-established policies of the government accomplishing R&D with its own personnel to a new method of program implementation, the medium of contracting. In the evolutionary process, the method of contracting has also changed from formal advertising and fixed price contracts to negotiation and cost reimbursement arrangements. Contracting is now, in most federal agencies, firmly established as a primary management philosophy. Complex and important achievements have been made through this medium as evidenced by the atomic energy program, the weapondary of the military, and the NASA manned spaceflight programs.

CHAPTER III

FEDERALISM BY CONTRACT

The Modern System for Research and Development

The system of contracting for R&D that has evolved since 1940 is one of the most complex, important, and least understood aspects of all governmental operations. Its effect is political, economic and social, reaching into essentially every facet of public and private life in the United States. The contract system although of relatively recent origin is now the dominant method of R&D implementation in the government.[1] While the subject is much too complex and vast to cover in depth in this study, an overall perspective can be provided on the contract system and its implications.

Don Price refers to the relationship that has evolved between government and private institutions to accommodate the demands of technology as "federalism by contract."[2] Price says "the scientists have brought to its most complete development an improvised system of federalism that makes use of private institutions for the conduct of federal programs."[3]

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[1]Danhof, p. 95.

[2]Price, Government and Science, p. 65

[3]Ibid., p. 66.

The new system of contracting is not the traditional market affair where customers and sellers bargain and the lowest price is rewarded with a contract. Rather, it is more a matter of the government seeking out the best capability, financing the operation, assuming most of the risks and rewarding the seller by a profit for management talent.

The contract system is much more than a tool for purchasing goods and services. Indeed, there are indications that the system may well be a technique for extending the bureaucracy without the problems associated with civil service rules, manpower ceilings and the like. The "Hidden Bureaucracy"[4] is one of the more intriguing aspects of the contract system. Many private firms and institutions are arms of the bureaucracy, the 9/10 of the iceberg below the surface, that exists through the mechanism of the contract system.

Nieburg describes the postwar federal contracting environment as a "Contract State"[5] that "must be viewed as a drastic innovation full of unfamiliar portents."[6] Further

> . . . the government contract, improvised, ad hoc, and largely unexamined, has become an increasingly important device for intervention in public affairs, not only to procure goods and services but to achieve a variety of explicit or inadvertent policy ends - allocating national resources, organizing human efforts, stimulating economic activity, and distributing status and power.[7]

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[4]Reagan, Politics, p. 96.

[5]Nieburg, Chapter X.

[6]Ibid., p. 186. [7]Ibid., pp. 184-185.

Michael Reagan feels that

> . . . the notable process of "contracting out" which, perhaps more than any other single development, is blurring the traditional distinctions between public and private patterns of institutional organization - reducing the separation of government from such social groups as businesses and universities, . .

further that contracting out implies,

> . . . as simple procurement contracting does not, the mixing of government with otherwise autonomous private organizations in ways that blur the line between government and society - a line that, according to pluralist political theory, is crucial to the maintenance of democracy.[8]

Finally, Danhof provides perhaps the best summary of the R&D contracting system:

> . . . thus the quest for new scientific knowledge and technological improvement sponsored by the government rests upon a contractual system that intricately intermingles the interests and activities of the government with those of business firms, universities, and other private organizations with special capacities. Given the nature of the R&D process, this intermingling is essential to the system. It is difficult to believe that federal activities in science and technology could have reached their present magnitude except through the involvement of private institutions.
>
> The contractual system is, however, more than a device to get work done for a government agency. An agency's program is built upon contributions from many sources, public and private. There are numerous channels through which interested and knowledgeable groups may suggest courses of action to accomplish broadly defined objectives. A formal contract is merely a step in a process of interaction between private and public groups with an interest in a scientific or technical area. In this process the government agency assumes responsibility for preparing programs and seeing them through the normal authorization and budgeting routines. It also chooses among the proposals made to it those which it will include as contractual projects in its approved programs. In

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[8]Reagan, Politics, p. 95.

> both the formulation and the execution of its program the agency is heavily, and sometimes wholly, dependent upon the initiative of outside institutions in developing the expertise necessary to prepare the proposals and do the work.[9]

This new kind of federalism, according to Price, is based on at least five types of relationships with private institutions:

> The first and simplest is a contract for the improvement of a certain machine or weapon, for the development of a new one, or for any specific research project in an industrial laboratory or in a univeristy . . . A second and quite different type of relationship is involved in the contracts that the government makes with research laboratories and universities. . . . The third type of relationship in this new system is the special study. . . . A fourth type of relationship grew naturally out of the earlier ones. A military department saw that the development of an important new weapon or weapons system required the creation of an entirely new laboratory or plant. It understood, too, that the problem was not merely a scientific one. It required the creation of a competent and stable large-scale organization. That is to say, it required managerial competence in the conduct of a scientific enterprise. For this it turned to the major universities. . . . Finally, there are the special private corporations founded entirely for the purpose of carrying on governmental scientific programs.[10]

Miller concludes that the relationship between government and business and other private enterprises, carried out through the means of contract, add up "to an established system of 'administration by contract,' a new development in public administration and administrative law."[11] He sees considerable

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[9]Danhof, p. 5.

[10]Price, Government and Science, pp. 68-72.

[11]Arthur S. Miller as quoted in Reagan, Public Policy, p. 224.

danger in the use of contracts to accomplish nonprocurement goals and in the delegation of power to contractors. The charge "administration by contract" falls into two main categories:

> (1) the addition to the government procurement contract of mandatory clauses which have little or nothing to do with what is being obtained under the contract, but which accomplish some of the regulatory ends of government; and
>
> (2) obtaining, through consensual agreements with private institutions, the performance of a wide variety of services, many of which have hitherto been accomplished, if at all, by the government itself.[12]

In the first group, Miller refers to the contractual terms that deal with labor hours, wages, and discrimination. Other areas are the preferential treatment to small business concerns and the elimination of competition through the Buy American Act.[13] These provisions, according to Miller, are political intrusions that have little justification. The second category relating to the delegation of power can be summed up as follows

> Government by contract involves as complete a delegation of power as has been made; as great, for example, as that to the Atomic Energy Commission or those to the President in certain foreign commerce matters. Moreover, it is a delegation outside of the government itself, to private organizations. To cap it, these delegations are often made without express statutory authorization.[14]

Another view of the impact of the contract system is

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[12] Ibid.

[13] Buy American Act requires generally that government purchases be made within the United States or possessions.

[14] Reagan, Public Policy, p. 227.

expressed by Paul Hannah in referring to government procurement regulations, specifically the ASPR. He feels that the regulations give government "power without parallel," that "businessmen have to accept arbitrary judgments without any real recourse," and that "government procurement is a system not of laws but of men."[15]

Reagan provides insight into one of the more controversial aspects of the contract system by addressing the question of "contracting-out" versus internal conduct of R&D:

> Purchasing contracts for Army shoes, typewriters, building materials and labor, and other mundane items are as old as the government itself. Three other kinds of contracts, however, have arisen since World War II: those (1) for research and development, (2) for private management of a government-owned facility, and (3) for policy advice. Such contracts are generally lumped under the heading, contracting-out. This phrase means that, unlike normal procurement contracts, these contracts involve delegating to an outside body tasks that are essentially the government's own responsibility. Such delegation creates a need for staff who know how to handle complicated and subtle supervision and assessment of outside work, and it creates problems in the relationship between government and other social sectors.[16]

In another study Reagan provides a slightly different perspective by distinguishing between existing products and new developments:

> Contracts between government and the private sector for the supply of goods and services are, of course, not new. Office supplies, food, and equipment for the armed forces and the construction of federal buildings are standard items of procurement. Contracting out, however, refers not to the purchase by government of existing products but to arrangements whereby

[15]Paul F. Hannah as quoted in Reagan, Public Policy, p. 229.

[16]Ibid., p. 222.

> the nongovernmental contracting party shares in the public task of developing something new - a weapons system, a method of desalinating water, even, on occasion, policy ideas.[17]

The phenomenal transition from internal to externa conduct of R&D is an interesting facet of American hist("History" is an appropriate reference as illustrated by Nieburg's comment:

> The traditional arsenal system, by which government conducted a large share of military research and development through civil service agencies, is now practically dead, victim of the Contract State and of the revolutionary size, scope, and pacing of the public interest in technological change.[18]

The traditional system governed essentially all government R&D until the 1940's. However,

> . . . agencies which had long-established policies relying upon intramural facilities have since World War II sought authority to contract for R&D to supplement those facilities or to carry out new programs. Most of them received such authority and some of them in time came to rely heavily upon contracting.[19]

During the war particularly, most agencies and the military departments began a shift to the private sector, which has continued to the present. Congress has supported government use of the private sector. In fact, "In a few instances, Congress has specifically required that an agency's R&D programs be carried out by contract (or grant) - as in the case of the National Science Foundation or in the desalination program."[20]

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[17] Reagan, _Politics_, p. 95.

[18] Nieburg, p. 218.

[19] Danhof, p. 93.

[20] _Ibid._, p. 95.

The Second Hoover Commission, established in 1953, als- strongly supported the contract system. In its judgment

> . . . research and development and design operations are, in general, best performed by civilian agencies. Since the close of World War II, the Military Departments have greatly expanded their facilities and personnel for the operations of research and development. The operations performed there are generally at a lower level of effectiveness than could be realized if suitably placed in the civilian economy.
>
> It was further suggested that
>
> . . . even where operations must be done in military installations, frequently increased effectiveness and efficiency will be realized through operations by civilian organizations.[21]

The Eisenhower administration also favored the practic of "contracting-out" as illustrated by BOB bulletin 55-4 issued in 1955, which stated "commercial-industrial activities were not to be started or conducted if the product or service involved could be procured from private enterprise."[22]

The emphasis on contracting in lieu of internal performance did not escape criticism, particularly in the late 1950's and early 1960's. The GAO was especially critical, although it

> . . . has necessarily dealt cautiously with contracts in the R&D area since congressional policy has clearly been one of encouraging the agencies to secure the services of the best qualified individuals or group, whatever their institutional affiliation.[23]

However, GAO has continued to resist in selected areas

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[21] Ibid., p. 106.

[22] Ibid.

[23] Danhof, p. 109.

as illustrated by criticism relating to contracts calling for management services. In a contract in which the contractor was required to advise other contractors as to technical alternatives, GAO ruled that "such decision-making was a non-delegable responsibility of the government."[24] Other charges related to violation of civil service laws, manpower ceilings and fiscal restrictions. In the late 1950's, objections also began to come from congressional groups asking for better contracting guidelines.

Finally, in 1961 the BOB issued a circular, No. A-49 entitled "Use of Management and Operating Contracts," that established criteria for contracting.[25]

Criticism of the contracting-out philosophy reached a peal in the early 1960's when Congress and the Executive became concerned about administration of the large R&D expenditure In 1962 the President established a task force chaired by David Bell, then the director of the BOB, to conduct an examination of general policy with regard to use of contracts.

The Bell Report concluded in part that "there is not doubt that the government must continue to rely on the private sector for the major share of the scientific and technical work it requires;"[26] further, that the high degree of inter-dependence and collaboration between government and private

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[24] *Ibid.*

[25] Danhof, p. 112.

[26] *Ibid.*, p. 119.

institutions is desirable. General criteria was provided for deciding between internal and contract performance which based on two considerations:

> 1. Getting the job done effectively and efficientl with due regard to the long-term strength of the Nation's scientific and technical resources, and
> 2. Avoiding assignments of work which would create inherent conflicts of interest.[27]

One of the more significant recommendations of the Bell Report was related to the need for the government to maintain competence for managing R&D effort, particularly in the technical area. The report, thus became valuable support for the Federal Salary Reform Act of 1962, which was based largely on incompatibility between government and private industry salary scales. Nieburg interprets the Bell Report's real emphasis to be "on the need to rebuild and preserve government's in-house competence for R&D, systems engineering and management, contract evaluation, and yardstick."[28] He feels that the lack of a more obvious pronouncement of these objectives is "a deliberate tactic to neutralize the report's explosive potential."[29]

What has resulted from the Bell Report and the critici from the various objectors? Nieburg sums it up thusly:

> The failure to make real progress toward implementing the Bell Report was symbolized by the appointment in 1964 of another committee to study the same problems

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[27] Ibid., pp. 119-120.

[28] Nieburg, p. 336.

[29] Ibid.

> and to add to the mounting pile of such studies whose cumulative effect has been to defer rather than facilitate reform. The President's Science Advisory Committee called upon Dr. Emanual R. Piore, a vice president of IBM, to head the study. Piore told reporters he hoped the study would produce "a fundamental statement of policy on why the government needs its own laboratories." Such a policy statement could prove useful, he said, since there were increasing complaints from private resear industry about the competition from government laboratories. His statement made it clear that all the Kennedy-Johnson battles to roll back the influence of the Contract State, to discipline the contractor cult in the name of larger national values, were still inconclusively joined. Partial victories had not secured a stable beachhead; government still faced a massive assault to sweep it back to the lush heyday that the Contract State achieved during the fifties and has enjoyed almost unmolested ever since.[30]

The practice of extensive contracting followed by most large government R&D organizations follows closely the Congressional inclinations of the past three decades. The objectors have presented impressive arguments against the practice, but to date there are few indications of a swing in the opposite direction. If NASA's success in programs such as Apollo, Gemini, and Surveyor is construed as confirmation of the soundness of the "contract-out philosophy," the objectors may well be losing ground. One thing is certain, for the present the "Contract State" is a reality - the challenge is to manage it, to use it for the betterment of society.

Relationships in the Contract System

The process through which the government brings the

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[30] *Ibid.*, pp. 348-3...

resources of industry, universities and nonprofit institutions to bear on R&D objectives of the nation is often depicted as a sterile, formal, highly structured operation. The picture is completed by the notion that contracting consists of a series of independent steps wherein the government unilaterally decides what is needed, invites proposals and awards contracts for the lowest price. This description may be reasonably accurate for purchasing standard supplies and services, but it is grossly inaccurate for the R&D contract system. Contracting for R&D takes place in a dynamic, comple environment characterized by a high degree of interaction. The following discussion provides perspective on the relation ships, both formal and informal, that characterize the proces by which R&D projects are implemented by contract.

Perhaps the best way to begin is to review the total process from the project incubation through the contract performance phase. Table 1 illustrates the progression from informal, unstructured relationships in the beginning, throug a highly structured and legalistic framework in the proposal and negotiation phase, to the dual "formal and informal" relationships that characterize activities during contract performance.

Why is a perspective on the relationships important to understanding the roles of the scientists and engineers in R& contracting? Basically there are two reasons. First, the informal activities, those preceding the formal contracting actions are extremely important in shaping the prospective

TABLE 1

RELATIONSHIPS - CONTRACTING PROCESS

Pre-Solicitation	RFP - Evaluation - Negotiation	Contract Performance
Informal	Formal	Combination (Formal - Informal)
Maximum flexibility for personal interface	Contracting Officer and designated representatives deal with public sector	Formal roles of contract administration-monitorship
		Informal interface between gov't-contractor
Minimum rules	Maximum rules	Official functions by rules - much informal contact
	<u>Flexibility Scale</u>	
Extremely broad	Extremely narrow	Broad in certain areas - but narrow in others

project. Research findings even suggest that informal influences determine the contractors that ultimately receive contracts.[31] The second point is simply the importance of recognition of the nature of relationships in the various contracting phases.

...Interactions among the various interest groups are illustrated in model fashion by Figure 1. By visualizing the model as illustrative of the forces at work in the decision process and relating it to Table 1, it is possible to gain some appreciation of the complexity and interdependent nature of the contracting process. The degree of structure of relationships changes as the process moves across the spectrum of Table 1, but the interacting forces illustrated in Figure 1 continue to influence throughout the process.

Models help provide focus for understanding; however, an appreciation of the nature and implications of the contracting relationships require a deeper examination. First, a look at the pre-solicitation phase,[32] then the more formal solicitation

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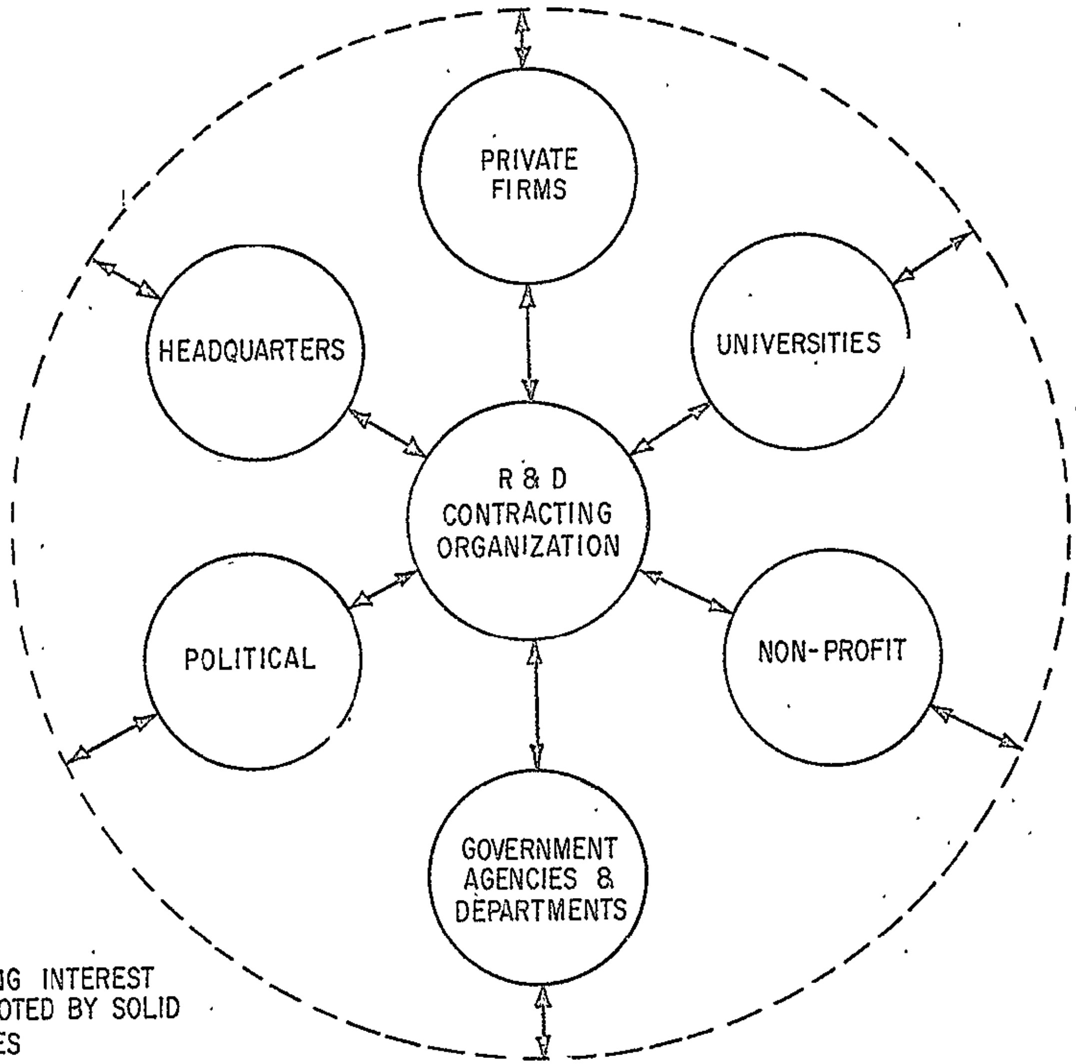
[31]Edward B. Roberts, International Science and Technology, No. 33, p. 75; Edward B. Roberts, "Questioning the Cost-Effectiveness of the R&D Procurement Process" in M. C. Yovits, et al (eds), Research Program Effectiveness (New York: Gordon and Breach, 1966); Gaylord E. Nichols, Jr., The Pre-solicitation Phase of Government R&D Contracting (Graduate School of Business Administration, UCLA, April 15, 1966), p. 2 (N67-13107); Raymond K. Elderd, Jr., A Literature Survey: How the Defense Department Awards Contracts and Grants for Basic Research (Georgia Institute of Technology, December 1967).

[32]Pre-solicitation phase are terms used by Nichols to describe activities preceding formal Request for Proposal, in a study "The Pre-solicitation Phase of Government R&D Contracting."

DESCRIPTIVE MODEL OF CONTRACTING PROCESS RELATIONSHIPS



NOTE: INTERACTION AMONG INTEREST GROUPS ARE DENOTED BY SOLID AND DOTTED LINES

FIGURE 1

evaluation, and negotiation phases, and finally contract performance.

Pre-Solicitation Phase

Prior to formal introduction of a procurement to prospective contractors through the RFP, many important actions have occurred. The RFP is the end of a long process of preparation, while it is the beginning of the formal contracting process. The pre-solicitation phase is a period in which many major decisions are made such as determining project objectives, roles of the contractor and the government, method of procurement, and the techniques for selecting contractors. The following over simplified, but realistic description captures the environment in which the activities are conducted.

The government R&D organization, the keeper of the purse, is surrounded by private and public institutions eager to participate in the projects. The government is dependent upon these groups for information on technical developments, and in some cases support, political and other types, for projects the government wishes to pursue. The contractors are highly motivated to maintain the best possible image and to be informed on the government and the competition's activities. They are also motivated to influence project decisions in the directi of their own interest and capability. Add to this picture the extensive interfaces between the parties due the many projects constantly in progress; the result is an environment in which contractor and government personnel with mutual interests in prospective projects have intensive, informal relationships. The relationships must change to more formal "buyer-seller" relationships as the project evolves into the formal contractor phases; therefore the pre-solicitation period presents the best opportunity for the parties to exchange information without the constraints of the formal procurement system. The implications of these relationships are suggested by comments of other researchers.

Nichols studied the effects of pre-solicitation activities on the outcome of R&D projects. His comments on the roles of the sponsor and contractore are pertinent:

> In the pre-solicitation phase of major R&D procurements critical decisions are made by the sponsoring agency in regard to the portion of a project to be done within the sponsoring agency and that which a contractor will undertake, the degree of system integration effort that the contractor will be required to undertake, the utilization of designs which may be dependent on existing capabilities which some, but not all, contractors possess, the requirements for liaison effort which may dictate the close geographical presence of a contractor to the sponsoring agency, the choice of ground-based testing programs requiring large-scale facilities, and the type of management information, project control, or configuration control systems to be used. All of these choices and decisions may, in some degree, favor some contractors over others. The foresight of potential contractors in re-orienting their company research, capital expenditures, and marketing efforts to anticipate the results of these early decisions increases the probability of receiving a contract award. These anticipatory measures on the part of potential contractors emphasize the use of company-sponsored research and studies, the results of which are fed to sponsoring agenices in order to elicit reaction or comment. Company intelligence estimates attempt to predict the progress and timing of project decisions so as to bring together at the appropriate time results of company-initiated advanced studies and the sponsoring agency need for information for decision. The objectives

of this activity are to shape early programmatic decisions and to be in a position to be totally responsive to the eventual Request for Proposal (RFP). Thus, in the pre-solicitation phase of a major procurement, there is a dynamic interaction of sponsoring agency planning and programmatic decision-making and company initiated and sponsored advanced studies whose purposes are to influence project decisions, [underlining added] anticipate an eventual RFP, and to build up a relatioship with individuals in agency project planning and management positions.

Some aspects of this interchange are beneficial for the sponsoring agency, as it helps to keep agency personnel aware of the state-of-the-art and provides a wider range of considerations in planning and decision functions. It is certainly beneficial to the companies involved, since it means ultimate competitive advantage insofar as their efforts are utilized in project planning and RFP preparation. The detrimental effect of this interchange is the introduction of a number of biased inputs into formulation of project plans and initiation of proposed procurements. This is particularly disadvantageous when it is recognized that the decision environment that exists in the pre-solicitation phase is characterized by high uncertainty regarding performance objectives and diffuse responsibility for decision making.[33]

McDonald offers the following advice for contractors, hopeful of improving their competitive stature through informal relationships:

The most difficult part of market research is to secure information concerning the future procurement plans of the various agencies. Usually when a particular item is known to the trade journals or to the public press, a considerable amount of planning has already been done. If a company does not get in at the planning stage of a major weapon system, it should not attempt to compete for the procurement.

and

Personal contacts are an important part of a market

[33]Nichols, pp. 3-4.

research program. However, a program of personal contacts must be handled intelligently. Because of the expense involved, no personal contacts should be attempted until all of the basic information has been developed and analyzed. Once the fundamental data necessary has been established, however, it is important that the data be used to pinpoint areas in which the company's products or services can be sold. This sometimes requires a system of personal contacts with the customer. While the available open sources of information are extremely valuable and are the cornerstone of a marketing effort, it must be remembered that this information is generally available to all comers. In certain cases, it may have to be supplemented with a program of planned contacts.[34]

Professor Roberts, of Massachusetts Institute of Technology also studied the pre-solicitation relationships and their implications; his conclusions have serious implications:

The real award process is one involving long-term person-to-person contacts between technical people in government and industry. They build up common experiences, attitudes, aspirations, confidences. And ideas are generated in this interchange. These are the ideas which later become government-sponsored R&D projects. When he is convinced that an idea has solid merit, the government scientist/engineer initiates a procurement request. He often feels, naturally, that the work should be carried out by the people in whose capabilities he has faith. Acting in what he believes to be the nation's best interest, he tries to secure "his" contractor. (He usually succeeds.) If he is confident of his judgment, he thwarts attempts to saddle his project with another contractor. Only when he regards several companies as being highly qualifeid does real competition prevail.[35]

The interaction among the parties becomes more meaningful when the activities of the pre-solicitation phase are examined.

[34]McDonald, pp. B-1-9 and B-1-11.

[35]Roberts, International Science and Technology, in Elderd, p. 70.

Although there are many variations as to technique, the sequence and events of project initiation generally follow a pattern. Nichols studied this phenomenon and utilized data obtained in interviews to develop the following model of the sequence of essential events:

> The sequence starts with planning studies whose purposes are to examine possible future projects and missions and their inter-relationship, to identify the degree of reliance on technology derived from present and past projects, and to forecast the state of technolog as a function of time. The second step is to investigate the various general concepts for, and characteristics of, systems which could accomplish the projects and missions identified in the planning study phase. From these general system concepts and characteristics various alternate system designs capable of meeting mission objectives may be studied, or a single system design may be developed to gain understanding of its capabilities. At this point specific technology and state-of-the-art advances necessary in the accomplishment of stated objectives should be isolated. This analysis should be develope in economic as well as technical terms and should be extended to include schedules, costs, and reliability requirements. The next step in the sequential planning process is the investigation of specific designs required to meet fairly definite sets of mission objectives. The goal of these studies is to establish feasibility and to examine the trade-offs between probability of mission success and extent of mission capability. At this point, an approximati of the level of risk should be available to determine if the specific designs considered should be pursued further. If so, the preliminary design phase begins to establish the precise system configuration, subsystem requirements, specifications, and interfaces. This sequential procedure should be punctuated by deliberations on study results and design reviews, followed by decisions on the direction in which further design activity should proceed. At the end of this process a firm basis presumably exists upon which to proceed with formal solicitations for system and subsystem contracted efforts.[36]

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[36]Nichols, pp. 7-8.

Actual practice often deviates considerably from the model due to outside influences such as headquarters preferences.

Nichols also investigated company marketing strategy in the pre-solicitation phase, and concluded generally that:[37]

1. Companies conduct company-funded research to mainta competitive stature.

2. The unsolicited proposal is a primary technique fo apprising potential customers of company efforts.

3. Unsolicited proposals result in a higher percentag of awards than that achieved through the formal RFP system.

4. One objective of unsolicited proposals is to give to the sponsoring agency the image of a responsive and aggressive contractor.

Danhof supports Nichols findings and suggests that participation in pre-solicitation activities is not only a general practice but is necessary for a firm to be successful in later phases.[38] Peck and Scherer also state that contractors generally recognize a need to conduct research on their own in order to keep abreast of technology and maintain a competitive position.[39]

The extensive interactions between government and potential sellers, and the industry practice of using advance research to achieve competitive advantage seem to be well established practices in the R&D contract system. What is the pay off,

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[37] Ibid., pp. 8-9.

[38] Danhof, p. 237.

[39] Peck, p. 531.

the incentive for private firms to engage in such activity? Perhaps Roberts' studies are the most revealing. In an examination of 41 DOD contracts, he concludes:

1. Most of the contracts were awarded to companies recommended by the project initiator.

2. More than 85 percent of the awards were "preselected" or based on factors existing prior to formal proposal solicitation.

A second study involving 90 contracts substantiated Roberts' earlier conclusion that most awards go to companies initially favored by the government technical initiators and evaluators.

Roberts is so impressed with the influence of the pre-solicitation activities on contractor selection that he concludes that formal procedures for solicitation of proposals and contractor selection are of little value and should be eliminated.[40]

Nichols' conclusion as to the effect of pre-solicitation activity also has significant implications:

> . . . that competition does exist in an intense, but unregulated form during the pre-solicitation phase. On the other hand, the possibilities for competitive advantage also are greater prior to formal initiation of the procurement by a Request for Proposal.[41]

RFP to Negotiation

Issuance of an RFP is a turning point in the cycle of

[40]Roberts, "Questioning the Cost/Effectiveness."

[41]Nichols, p. 18.

a project; it ends informal activities and begins the formal contracting process. Table 1 illustrates the abrupt change from almost complete flexibility in relationship to an environment in which all activities are conducted by rules. The government publicizes procurements to encourage participation; it also strives for an atmosphere of "equal treatment." The general procedure is to establish a contracting officer[42] as the single point of contact and official spokesman throughout the contracting cycle.

In large dollar value procurements it is customary, after an RFP has been publicized, to conduct a "pre-proposal conference" for the purpose of clarifying questionable aspects of the RFP. The conference also reduces the temptation for contractors to interface with government contracting personnel on an individual basis. Conferences are conducted in a formal environment in general accord with the following procedures:

> When a preproposal conference is to be held, the Chairman will make the necessary arrangements and will insure that he and some board member(s), as well as concerned procurement and technical staff, are present to conduct the conference. Normally, interested concerns will expect a general presentation followed by the opportunity to ask specific questions.

[42]NASA Procurement Regulations defines contracting officer "means any person who, by appointment in accordance with procedures prescribed by this regulation, is currently a contracting officer with the authority to enter into and administer contracts and make determinations and findings with respect thereto, or with any part of such authority. The term also includes the authorized representative of the contracting officer acting within the limits of his authority." Procurement Regulations, p. 111.

> It is preferred practice that questions be submitted, in writing, prior to the conference and that qualified NASA personnel be available at the conference to read the questions aloud and answer them. Consideration will be given to providing attending concerns with a transcript of questions and answers.[43]

After proposals are delivered, an even greater degree of control is established. The proposals are physically protected from unauthorized disclosure and personnel involved in the evaluation process operate under extremely strict control. Normally, there is little interface between government and participating private concerns except by officially designate individuals;

> During the course of evaluation proceedings, whether or not a Source Evaluation Board is utilized, NASA personnel participating in any way in evaluating proposals shall not reveal any information concerning the evaluation under way to anyone who is not also participating in the same evaluation proceedings, and then only to the extent that such information is required in connection with such proceedings.[44]

Proposal evaluation is the most sensitive aspect of the entire contracting process. Evaluations are largely subjective making control of personnel interfaces especially important. This is one reason evaluations are normally conducted under tight security procedures. If discussions with contractors are necessary prior to selection for negotiation, they are conducted in accordance with formal guidelines. Normally the chairman of the evaluation group will personally conduct the discussions or will designate specific individuals to perform

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[43]NASA, Source Evaluation Board Manual, NPC 402, 1964, p. 513.

[44]NASA, Procurement Regulations, p. 362.

this important function.

Although personal contact cannot be completely avoided, present policy and practices come very close to making evaluations an "isolated" activity. McDonald's comments illustrate the point:

> . . . it would also be foolish to state that the personal relationships of the procuring and technical personnel with particular firms and their particular preferences do not enter into the selection of a Contractor. However, the extent to which this effects the final determination is very slight, and if it occurs at all, it occurs at the first level of evaluation, namely the technical evaluation group.
>
> The evaluation procedures, and the exhaustive review by succeeding echelons of authority generally result in the selection of the proposal which is in the best interests of the Government. When a bidder loses out, therefore, he should attempt to find out precisely in what way his proposal did not measure up to the requirements so that he can use the mistakes in past proposals to improve his future ones.[45]

Negotiation

A new set of relationships comes into play with the beginning of negotiations, the final step prior to contract. One or several contractors with promising proposals may be selected and one of more contracts may be awarded depending upon the purpose of the contract. The process of negotiatio presents the ultimate opportunity for the parties to gain advantage through ability to influence, persuade or manipula Perhaps McDonald's comments explain why:

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[45]McDonald, p. B-5-24.

> The Contractor is not dealing with the Government in the procurement process. He is dealing with a Contracting Officer and the Contracting Officer's representatives. These representatives are individuals and have all the virtues and vices that other individuals have. Nowhere in commercial practice is a firm faced with the possibility that decisions by individuals will involve its welfare so substantially. There are many detailed regulations covering the Government procurement process. However, they only establish the broad limits within which the Contracting Officer and the Government representatives must operate. Within the regulations, the Government personnel have wide latitude in which they may exercise judgement. This latitude includes the selection of the Contractor, the price and the type of contract, the amount of fee allowed within the statutory and regulatory limitations, and in making interpretations and determinations under the terms of the contract.[46]

Negotiation of contracts for R&D is a multi-disciplinary process in which teams of professionals attempt to resolve issues in a mutually acceptable manner. The individuals on these teams represent many disciplines such as pricing experts, auditors, scientists, engineers, lawyers, and contract specialists. The success of a negotiation often depends on the skill of the negotiators; particularly the spokesman or team leader, to persuade or otherwise "sell" his position. The conduct of negotiations, the freedom for individual participation, is largely a matter of individaul technique. The normal practice is to designate a team leader, generally the contracting officer, who sets the tone and method of operation. A skillful negotiator utilizes the combined talents of the team to establish the most desirable contractual

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[46] *Ibid.*, p. F-1-2.

arrangement possible. The government tends to view the team leader as a coordinator in the application of skills:

> To the extent services of specialists are utilized in the negotiation of contracts, the contracting officer must coordinate a team of experts, requesting advice from them, evaluating their counsel, and availing himself of their skills as much as possible.[47]

McDonald Comments on the importance of the team approach thusly:

> A major procurement action may involve many complex problems connected with accounting, pricing, legal and technical areas. No one man can possibly be sufficiently knowledgeable in so many related fields. And, even if such a person did exist, he would not be able to handle the entire job of preparing, planning and executing a negotiation. The Government recognizes this and backs up the Contracting Officer with a team of experts whose advice and counsel covers the entire procurement area. The team members include engineers, auditors, price analysts, lawyers, inspectors, buyers, and negotiators, all of whom are specialists in their particular fields. The Contracting Officer is responsible to bring to bear on the problem involved the expert knowledge of the best qualified personnel available to him. For example, engineers and technicians insure that the item to be procured is properly identified in the specification.[48]

Negotiation teams generally have considerable flexibilit as to strategy and technique. In the "man to man" situation, the relationships, attitudes and methods are most important. Any member of the team may be the sole barrier or catalyst for an action involving millions of dollars. This is particularly true in the case of the scientist and engineer because the technical approach to a problem often presents many options as to impact on cost, schedule, and performance.

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[47]NASA, Procurement Regulations, p. 355.

[48]McDonald, p. F-1-6.

Negotiations contain elements of formality and informality; the degree of each being a reflection of members of the team. Negotiations are complex and challenging tasks to even the most skilled; it is a situation in which many disciplines function as a unit, making decisions extremely important to the parties. Although conducted in an atmosphere of formality, the informal relationships that have developed through associations in other areas, particularly the pre-solicitation activities, come into play in negotiations, frequently with positive results. In fact, informal relations seem to facilitate a more immediate and direct attack and resolution of the problems faced by the parties.

Contract Performance

Planning, evaluation, and negotiation are only means, for the goal to which all is directed is performance, the last and most important phase of the contracting process. From the standpoint of relationships, the performance phase presents different tasks for the participants. Basically, the government's taks is to assure that the contractor performs as required by the contract, while the contractor's task is to accomplish the work. This may appear to be a rather straight-forward, uncomplicated arrangement; however, such a view reflects lack of understanding of the nature of R&D work Major R&D projects are characterized by ill-defined objectives, complex trade-off alternatives where cost and schedule are considerations, and numerous technical options.

In addition to the complexity of the task with which a specific contractor is charged, there are normally many interfaces to maintain with contractors who are responsible for other segments of the project. This results in an extremely complex arrangement of government and contractor parties working toward common ultimate objectives. The complexity of a specific contractor's task and scientists and engineers' roles depends on such factors as position in the arrangement, that is, is he only a component supplier, or a major system contractor, and management technique employed by the government, detail management or more of a surveillance approach.

Relationships in the performance phase have been referred to as dual,[49] in the sense that a contract structures the relationships in a formal way for certain functions while others remain unstructured. For example, R&D contracts normally provide for government technical surveillance and establishes the broad guidelines within which the scientist or engineer technical manager performs. However, the detail methods by which the surveillance is accomplished vary from after the fact reporting to detail on-site monitoring of eve facet of the work. Much of the day-to-day interface is informally "working out the details."

Managing the R&D contract entails involvement of government scientists and engineers in the detail technical

[49]Refers to formality and structure of relationships rather than quantity.

aspects of the work. This means that the informal relationships are extremely important. Decisions are often subjective, bringing value systems of the individuals into play.[50] Relationships are also affected by the government's dual role of goal setter, the top level of the "directive," hierarchy and a party in conducting the work. In the goal setting position conflicts exist similar to those found in an industrial environment between management and labor, and between supervisor and worker.[51]

Relationships in the performance phase of contracting are also influenced by a progressive changing of the contractor's objectives. In the beginning the contractor is motivated to display maximum cooperativeness with the prospective customer, the government. As activities progress toward an actual contract, the contractor's success probability increases. At some point prior to contract execution the contractor has high assurance of receiving a contract. The motivation then often shifts to the more short range objective of making the contract as profitable a venture as possible. The changing objectives cause problems in negotiation, but are expressed most obviously in performance. The spirit of cooperation that existed earlier in the process is sometimes replaced with a more rigid "live by the contract" attitude. Again, this is an area where

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[50] Irwin D. Bross, Design for Decision (New York: Free Press), p. 86.

[51] C. West Churchman, Prediction and Optimal Decision (Englewood Cliffs, N. J.: Prentice-Hall, 1961), Chapter 3.

informal relationships tend to be supportive of the immediate task of fulfilling contract requirements. If it were not for informal relationships in the performance period, particularly when problems develop, the formal relationships may aggravate the situation causing more serious problems.

PART TWO:

PARTNERSHIPS IN TECHNOLOGY

CHAPTER IV

FOUNDATIONS FOR CONTRACTING

The contracting process is frequently thought to be concerned only with those activities associated with the Request for Proposal (RFP), proposal evaluation, negotiation and managing the contract. This view overlooks the extremely important planning and organizational aspects that are the very heart of the contract system. The purpose of this chapter is to examine some of the concepts that form the foundation and framework for implementation of R&D through the contract medium.

Project Planning

Major projects are seldom contracted in one great sweep. Instead, it is an incremental process extending over months of progressively narrowing of concepts to final selection of the most advantageous approach for achieving the objectives.

A major R&D project is normally initiated in response to mission requirements for which many alternative solutions are available. The earliest activities are concerned with investigating overall approaches or concepts and identifying the more promising for more intensive analysis. At this stage of the project numerous alternatives may be examined utilizing internal capability, contracted support or a combination, depending upon the capability of the particular organization. After preliminary study a limited number of the most promising alternatives are selected for comprehensive study and preliminary definition of the hardware systems. Cost, schedule, logistics and operational support considerations are also investigated in this second phase, which is generally contracted effort. The usual practice is to award parallel contracts to two (more firms with each contractor emphasizing a different alternative.

The final phases of project implementation involves selection of a single alternative, accomplishing the design and development and finally operations. Participation in t! hardware development phase is the primary objective of contractors because this is where the payoff lies. Normally, the contracts will involve large expenditure of funds, in itself a big incentive; however an additional factor is the positive effect on expansion of capability. This is especially important in the case of projects with potential for quantity production such as military aircraft.

The government attempts to maintain a competitive environment throughout a project. Competition is encouraged by permitting participation in the latter phases even though a company did not participate in the investigatory and design effort. Research indicates, however, that a company that has not participated in the early phases is at great disadvantage and will likely not be successful. For this reason companies occasionally conduct company funded parallel studies after unsuccessfully competing for a contract.[1]

Among agencies and departments there are many variations in method and techniques for project planning. For example, DOD uses a three-phase approach, consisting of concept formulation, contract definition and development.[2] NASA uses a four-phase approach consisting of preliminary analysis, definition, design, and development and operations.[3] Considerable variation also exists in the approach to contracting. One agency may rely on internal resources for the early investigatory work,[4] while another depends entirely upon the private sector. Similarly, parallel contracts may be considered unnecessary in one situation and absolutely essential in another. Also, phases may be combined in one contract depending upon the circumstances of the particular project. However, most major projects experience essentially the evolution illustrated in Table 2.

Government agencies have followed essentially the sequence illustrated in Table 2 for years. Only recently, however, has a serious effort been made to formally plan the total project in the early phases. The more common practice was to approach each phase as independent from the others,

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[1]Peck, Chapter 15.

[2]Air Force Regulation No. 80-20.

[3]NASA, Phased Project Planning Guidelines, NHB 7121.2, August, 1968.

[4]Ibid., p. 3-2.

TABLE 2.--PROJECT PLANNING PHASE RELATIONSHIPS[a]

PHASE A PREANALYSIS	PHASE B DEFINITION	PHASE C DESIGN	PHASE D DEV./OPERATIONS
Develop objectives	Refine selected concepts	Develop detail of selected concept	Develop and test
Assess feasibility			Manufacture
Identify research, technology needs	Systems analysis	Develop specific design and specifications	Check out
Identify support req.	Preliminary design/ specifications	Develop plans for manufacturing, testing, operations, supporting systems, facilities, etc.	Operate
Develop gross plans	Define support req.		Evaluate
Trade-off analysis	Assess preliminary mfg. & test req.		Distribute results
Identify favorable/ unfavorable factors	Identify adv. technology & development req.	Initiate required long-lead advance development & define plan for supportin development	
Define program relationships	Assess costs/ schedules	Develop schedules & estimates of costs	
	Define mgt. & proc. approaches	Refine management & procurement plans	
	Trade-off Analysis		
Concepts for detail study	Concept for detail design Preliminary specs Preliminary schedule, resource, mgt. plans	Project design & specs Schedule, resources, mgt & proc plans	Completed project

[a]NASA, Phased Project Planning Guidelines, NHB 7121.2, p. 2-4, modified by autho

especially with regard to the contracting requirements. Finally, in the mid 1960's the DOD and later NASA, established policies and procedures which required contracting organizations to accomplish basic planning for all phases of major R&D projects early in the cycle. The approach encouraged better planning, organization and management of resources, and facilitated integration of long and short range objectives.

Although the DOD and NASA project planning techniques differ in minor respects, the objectives and basic approach are much the same. NASA's planning procedures are the most recent development; they are therefore examined in greater depth. First, however, a summary of the DOD approach:

> In the Department of Defense, a project proposed for engineering development is subjected to an intensive review process. The first step is Concept Formulation, which is an attempt to determine whether the technical, military, and economic bases for a proposed effort exist and to be sure that alternative operational and technical approaches have been analyzed and that estimates of cost and operational effectiveness have been made. A conditional decision to initiate engineering development follows a favorable determination.
>
> In the second or Contract Definition phase, the technical, cost, schedule, and management aspects of the project are intensively reviewed. In this process it is determined that the needed technology is available and that the project requires engineering rather than experimental effort; that the nature and objectives of the mission are defined; that the best technical approaches have been selected; that the cost-effectiveness of the item compares favorably with competing items; and that the cost and schedule estimates are acceptable.
>
> If the analysis is favorable on all counts and validated on review at high levels, the final decision to undertake engineering development

depends upon broad strategic considerations.[5]

Phased Project Planning

In August 1968, Harold Finger, then Associate Administrator for Organization and Management for NASA, described the purpose of the newly developed "Phased Project Planning (PPP) Guideline" as follows:

> The purpose of PPP is to provide, through defined phases, an adequate basis for management decisions on the extent to which project activities can be properly undertaken and commitments made. However, these guidelines do not prescribe detailed format and content of plans and other documents and reports used to apply the PPP concept. Similarly, the work content of phases and the information requirements described herein are not checklists. They are included to assist in understanding the intent of the PPP concept and should not be viewed as rigid or inflexible.
>
> PPP, as a concept for orderly planning and definition of new major R&D undertakings, must be adapted to the peculiarities of each individual case. However, the flexibility permitted for adaptation should not be considered as a license for major variation which would compromise the objectives that underlie the concept.[6]

Perhaps the best way to obtain insight into PPP is to review the background to its development and the basic ground rules for application.

> Phased Project Planning (PPP) is a phased approach to the planning, approval and conduct of major research and development activity. This approach was selected because the development of advanced aeronautical and space hardware systems involves considerable risk and uncertainty--and the greater the degree of technological advance involved, the greater are the risks and uncertainties. Uncertainty

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[5]Danhof, pp. 158-159.

[6]NASA, Phased Project Planning Guidelines, preface.

> with respect to schedules and resource requirements of on-going projects seriously limits the Agency's ability to plan follow-on programs. PPP is directed at increasing the probability of achieving specified system performance with original resource and schedule estimates.[7]

The programatic aspects of PPP are extremely important; however, contracting considerations share an equally important role. In the final analysis, the major portion of most R&D projects are implemented through contracts. For this reason, the DOD and NASA place emphasis on maximum integration of programatic and contracting considerations in planning for major projects. This, that is the ability to program contracting and technical activities in an integrated plan, is one of the chief advantages of the PPP approach as indicated by the following policy statements:

> Procurement planning is an integral element of PPP. This planning requires consideration of costs, risk elements, competitive aspects, and budgetary and other constraints. Program and Procurement personnel will coordinate their activities through all stages of PPP in order to assure orderly procurement planning. This team approach will facilitate the consideration and handling of procurement problems, and the processing of necessary documents.
>
> Competitive concepts apply to all phases of PPP. In Phase A procurement, competition is based primarily on scientific and technical qualifications for specialized areas of R&D. In Phase B the more normal competition process applies. Phases C and D represent the full competitive process except that Phase C selections require a Phase D capability. Phase D selections are generally limited to successful Phase C participants.
>
> Phase C RFP's and synopsis should specificall state the Phase D capability requirement and

[7] _Ibid._, p. 2-1.

> that the Phase D competition will normally be limited to Phase C participants.[8]

Appendix 1 describes the procurement aspects of PPP, including comment on contract types for the various phases.

In summary, project planning is simply the process of identifying objectives and developing plans of action for their achievement. In the government, planning for implementation of major R&D projects is one of the most important and complex aspects of a project. Experience of the military and civilian agencies revealed a need for a more formal approach to planning across the entire spectrum of a project from concept formulation to operation of the equipment. The need was met by establishing requirements for planning and approval of the various phases of a project in a manner that assures integration of programatic and contractual considerations. The techniques of phased project planning provides an orderly approach to implementation and greater assurance that each successive step will be based on sound technical and business decisions.

Organizational Concepts

One of the most important aspects of a large scale technological endeavor is the organizational structure within which the activities are conducted. Contracting for R&D is no exception. The organizational approach to providing resources, policy guidance, and institutional support for the contracting function is often a factor in the success or failure

[8] Ibid., p. A-1.

of a project. This section reviews basic considerations in organizing for R&D contracting at the field level, and examines implications of various organizational arrangements.

Organizational arrangements are a reflection of many considerations including the attitude of management toward contracting, short and long range objectives of the project available manpower resources, management philosophy regardi contract management, and the approach with regard to multiple contracts versus a single contract.

Management attitude regarding the importance of the contracting function is a basic factor in shaping an organization. Management that views contracting as an important mechanism for bringing private resources to bear on government problems is likely to organize quite differently than will management that views contracting as a burden, a necessary evil. In the first place a more positive attitude results in closer ties between contracting and top management; there is recognition of the value of maintaining an open communication channel. The hierarchial position of the contracting organization will also be influenced by the attitude of management, since the position in the formal structure generally reflects management's view of the importance of the function. For this reason, the place in the organizational structure affects the attitude of the personnel. In an R&D environment where contracting is viewed as a major management tool, the contracting function will normally be integrated in some fashion with programatic functions so that it receives appropriate emphasis. This fact probably accounts for the popularity of the project form of organization in R&D activities.

The technical objectives of a project, the magnitude of the cost and the time frame over which the project is expected to extend--all have a bearing on organizational arrangements. Project objectives with international implications, involving huge expenditures and extending over a long time period wi·· generally require a different organization than will a smaller, short range project.

Organizations involved in R&D are generally engaged i a continual phasing in of new projects, simultaneously wit the phase out of older projects. In this situation manpow resources are in a constant state of transition from one project to another. This phenomena highlights an important characteristic of the R&D organization, that is its dynamic nature. The NASA Manned Spacecraft Center's experience provi a good example of such an environment. In the early 1960's three major projects were in various stages of completion.[9] From a development standpoint the phasing was such that each segment reached its peak at a different time, thus contractin resources were reallocated from one project to another in accordance with the needs of the projects. More recently with achievement of the lunar landings and tapering off of Apollo demands, new organizational arrangements have been established to accommodate future requirements. By modifying

[9]The Mercury, Gemini and Apollo Manned Spacecraft projects.

organizational arrangements, the Center has accommodated all projects without major perturbation in the personnel complement.

Another important consideration in organizing is the approach to contract management. Depending upon the philosophy with regard to monitoring the contractor's work, an organizatior may be small or large and the professional disciplines may vary substantially. This point is also made by Nieburg in a comparison of the NASA and Air Force approaches to contract management on the Centaur Project:

> An example of the quality of management came to the surface in 1962 as a result of the efforts of Wernher von Braun to achieve real government authority over the Centaur (liquid hydrogen upper-stage booster) project.
>
> Upon at last winning his point, von Braun felt it necessary to assign 140 technical people to supervise the contractor where the Air Force before had only eight, most of them clerical.[10]

The NASA approach clearly appears to be one of close surveillance of contractor activities as compared to the mc liberal approach of the Air Force. The significance of the point is that the philosophy on contract monitoring ultimately establishes parameters for the contracting organizational structure. Similarly, the degree of delegation of surveillance responsibility has substantial impact on the organization. For example, DOD tends to emphasize maximum delegation, particularly of administrative functions after award of a contract. The

[10] Nieburg, pp. 274-275.

NASA and AEC, however, tend to be more selective in delegation of administration functions and rarely delegate responsibility for technical surveillance.[11] The philosophies on such matters influence the size, professional mix, hierarchial relationships and many other facets of organizational planning.

Many ohter factors, such as external constraints by higher headquarters, influence organizational planning. However, the final point selected for discussion is the impact of decisions regarding "single prime contractor versus many contractors." To illustrate the significance of this point, the model in Table 3 depicts two extremes. One, the government organization performs as system integrator and contracts for the many sub-systems on an individual basis, selecting the contractors most suitable for the particular sub-system. This approach results in dozens, possibly hundreds of contracts to negotiate and manage. The other extreme is one in which the government selects a total system contractor to hold responsible for developing the total system including the systems which must be obtained from other sources. This approach results in one large contract to negotiate and manage. Most government R&D endeavors fall somewhere between the two extremes. However, at least one major agency, the AEC, holds to the latter concept in its contracts for operation of laboratories. The DOD has also adopted a "total package" concept for use in selected R&D projects. General Terhune

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[11]The terms "monitoring" and "surveillance" are utilized interchangeably in this study.

TABLE 3.--CONTRACT DELEGATION APPROACHES

FACTOR	Separate Contracts	Single Prime Contract
Number employees required to contract & manage	Many	Few
Interface	omplex - Gov't responsible for ntegrating all parties	Contractor integrates - accountable to government
Gov't control over contractors	aximum	Minimum over subcontractors - control is over the prime
Cost	ore for administration, less or profit - indirect cost	Less for administration more for profit - indirect cost
Schedule	Increased opportunity for slippage	Reduced probability for slippage
Problems	More for government	Less for government
Contract	Many to award - mana	One large contract

describes the procedure as follows:

> Under the total package concept, "all terms and conditions of the contract, including price are agreed upon at the outset, immediately after the completion of contract definition, but before the selection of a source for the development production contract and while the matters still rest in a competitive environment."[12]

There are of course many variations in degrees of application of either approach. NASA for example, in contracting for manned spacecraft, has applied both philosophic McDonnell Aircraft Corporation was given essentially complete responsibility for design and development of the Mercury and Gemini spacecraft although more than 50 percent of the costs were for subcontracted subsystems. On the other hand, major subsystems of the Apollo spacecraft, were retained for interna contracting and management. The "prime" contractor approach taken in the Apollo program wherein selected segments of the program are excluded from the main system contract seems to be the most popular approach in major agencies. Clearly, the approach selected for managing the project plays a significant role in the organizational arrangement.

While the preceding is by no means an all inclusive review of organizational considerations, it highlights some of the more basic problems with which management must deal in establishing an organizational structure for contracting. The presentation now focuses on a review of some of the

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[12]Major General Charles H. Terhune, "Total Package Concept," Defense Industry Bulletin, vol. 2 (February 1966), pp. 3-4, as quoted in Danhof, p. 229.

techniques employed by government organizations to accommodate R&D contracting requirements.

Government contracting organizations fall into two basic categories, the functional and the project. There are or course many variations within these broad categories, but all seem to essentially fit one of these molds. There are also several other generalizations which are illustrative of government R&D contracting organizations. First, operational organizations usually have functional elements to handle purchasing activities for standard operating supplies and services. These organizations are generally staffed wtih professional contract specialists, pricing analysts and related skills who function as service units to the mission oriented organizations. These are the more traditionally oriented groups that deal in large volume, smaller dollar value purchases of standard equipment. Procurement procedures are generally standardized facilitating a high degree of commonality of action. A second general characterisitc of contracting is that contract policy making and overall guidance is a highly centralized function. Contracting policy and general procedures of the DOD, AEC and NASA are centralized functions of the headquarters in Washington, D. C. The headquarters establishes basic policy on all aspects of contracting including contract terms, negotiation, contractor selection procedures and contract administration. Deviations to the policy set forth in the procurement regulations normally require formal headquarters approval.

Although the mold seems to be cast in favor of centralized control of policy, there are dissenting opinions as to the desirability as Orlans shows in a review of AEC's experience:

> The usefulness of a central contract staff was clear, if only to help resolve conflicting staff recommendations and to coordinate AEC practices with those of other government agencies. One observer suggested, however, that it also had certain unfortunate consequences, insofar as it tended to divorce the administration of contracts from the technical objectives they were designed to achieve. In his opinion, the contract was becoming too negative a document, cumbersome and difficult to negotiate, and calculated more to protect the AEC against possible legal disputes than to advance specific program objectives.[13]

On the other hand, the efficiency of decentralization as an operational philosophy is also challenged. The thrust of Zald's argument on the point is captured in the following quote:

> The amount of centralization or decentralization required for optimum performance depends on many factors: the complexity of technology and tasks, the degree to which decisions and operations can be routinized, the energy level of top executives, the competence of all executives, the efficiency of communications transmittal, and many other considerations. The actual amount of centralization and decentralization in any large corporation, however, is not determined just by a rational weighing of the possibility of reaching the optimum point. It is a product of the history of the company plus the present relative power or resource control of the major units.[14]

These generalizations are particularly illustrative o the DOD and NASA and to a lesser extent the AEC. Contractin

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[13]Orlans, pp. 121-122.

[14]Mayer N. Zald, "Decentralization - Myth vs. Reality" in Robert T. Golembiewski, et. al. (eds), Public Administration: Readings in Institutions, Processes, Behavior (Chicago: Rand McNally & Company, 1966), pp. 483-484.

policy for the military departments is established at the DOD level in the form of the ASPR, while operational activities are delegated down to individual field organizations. Similarly, NASA establishes policy in procurement regulations applicable to all elements, while the contracting functions are delegated to the various field centers. AEC has taken a slightly different course, evolving from a highly decentralized operation to one in which the major contract activities are managed by the Washington office. To illustrate, when AEC was established in 1947 there were 4133 civilian employees on the payroll with less than 200 in the Washington office. By latter 1958 the total employees were up to 5,000 with 700 in Washington. In 1965 there were still more employees in the field than in headquarters, but approximately 35 percent of the total were in headquarters assigned to regulatory and operational functions.[15] This is largely a result of AEC's practice of utilizing contractors to manage the various field operations. The procedure generally is that AEC headquarters negotiates a contract for operation of a laboratory, the contractor then assumes responsibility for purchasing activities of the laboratory. For example, since 1943 the University of California has operated the Los Alamos Scientific Laboratory under contract.

At the field level where most R&D work and contracting activities are conducted, organizational factors become extremely important to operational effectiveness. This point

[15]Orlans, p. 120.

is emphasized by Siepert in an essay dealing with the management climate for research in which he makes the following observations:

1. Today, research and development are both characteristically organized as a team process.

2 Internal staff alignment and career advancement require continuous management attention.

3 The organizational structure, fundamental policies, and work procedures should fit the particular unique characteristics of the laboratory.

4 Keeping the communication pipelines open to the professional staff is a constant responsibility of the management.

5. Research men want their immediate chiefs to talk much more often with them about what they are doing.

6. Maintenance of the interest potential of the job itself is the most important single element of satisfaction for the research and development professional.

7. Administrative resources ought to be, insofar as possible, under the control of the top technical leadership at the operating levels.[16]

Most government R&D organizations have common problems with respect to organization of the resources for optimum results. This may well account for the high degree of similarity in organizing the technical and business professionals for maximum flexibility. In larger field centers it is not unusual to find a multi-organizational arrangement of the contracting resources. Indeed, a completely project or

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[16]Karl B. Hill, The Management of Scientists (Beacon Press, 1964), pp. 92-95.

functional oriented organization is a rarity. More commonly the approach is to utilize both forms of organization as well as special adaptations for specific needs of the particular organization. Hjornevik describes this concept in practice in a major R&D center and discusses the functional and project approaches:

> The organization was created around the idea of projects. There were three major programs to conduct simultaneously - Mercury, then Gemini, then Apollo, in an overlapping sequence. From an organizational standpoint, this is quite different from a situation where you try to superimpose a project organization on one that has been traditionally functional. At MSC, we, in effect, grew a functional organization to support our programs.
>
> . . . the concept of the matrix organization - the overlay of programs across functions - is one of th basic management principles of MSC. Program management is necessary so we can coordinate and manage the spacecraft programs. Functional management is necessary to provide the skilled functional specialists (professionals) who furnish technical inputs used in managing the programs and to provide the reservoir of talent necessary to conceive and design new programs.
>
> . . . the program organization is one established for, and tailored to, a specific program such as Apollo, as a general management activity responsible for the planning, control, supervision, engineering, test, and manufacturing activities involved in producing the hardware end item. It is similar to the functional organization in that it is basically getting work done through people. It differs, however, in ways which have far-reaching effect. The program organization has very specific objectives which, when achieved, mean the end of the organization, which is anathema to professionals because they do not want their careers tied to the life or death of an organization. . . .
>
> Each of these organizational concepts has obvious advantages and disadvantages, and, in almost every case, the advantage of one coincides with a disadvantage of the other. For example, a program organization provides full-time attention of its personnel to

> accomplishing the program's objectives; a functional organization does not. A functional organization provides a reservoir of personnel skilled in a particular functional area; a program organization does not. A program organization provides program visibility and a focal point for all program matters; a functional organization does not. A functional organization provides relatively free interchange of ideas and problem solutions in a given functional area; a program organization does not.
>
> . . . it has been said that program organization has something in common with weaving: it involves the interlacing of the traditional vertical "strands" of organization with the horizontal "fibers" of program organization into a fabric-like matrix. Thus, two complementary management organizations exist: the vertical functional organization and the horizontal program organization, with a resulting matrix structure extending across such functions as engineering, budgeting, contract management, and procurement.
>
> . . . we believe that an organization of this type, with proper balance of responsibility and authority between the program and functional organizations, is the optimum one to take advantage of the positive aspects of professionalism and to minimize the negative aspects.[17]

Hjornevik also provided insight into other organizational techniques for project implementation.

> . . . we have experimented with various other means of facilitating goal-directed coordination between multidisciplinary professionals. These operational practices fall into a graduated order in which the degree of formalized organizational change is the distinguishing characteristic. The six practices that I wish to discuss here may be described as follows:
>
> 1. A multidisciplined effort achieved by assigning he required professionals to a project office or the duration of the project
> 2. A multidisciplined effort achieved by creating a small, coordinating project office but leaving the professionals in their respective organizations

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[17] Wesley L. Hjornevik, Issues in Public Science Policy and Administration (Albuquerque: University of New Mexico, 1969), pp. 17-20.

3. A multidisciplined effort achieved through informal working groups and panels without any organizational change
4. A multidisciplined effort achieved by physical colocation of personnel without any formal or informal organization changes
5. A multidisciplined effort achieved by assigning specific missions to an organization or individual
6. A multidisciplined effort achieved through a flexible personnel classification system that permits a diversified staff within any given functional organization.[18]

In summary, project planning and organizational considerations are among the first matters requiring management attention in R&D contracting. These are basic building blocks that affect the project from beginning to end. There are many techniques for dealing with these matters; however, a degree of commonality in basic approach has evolved in the major government R&D organizations. DOD and NASA have adopted project-planning procedures which provide perspective across the total project, but also segments the project into manageable phases. This approach facilitates decisions in a time sequence that is compatible with project milestones and provides maximum information for incremental decisions. There are many approaches to organizing for contracting. Again, however, there is a degree of commonality among government R&D organizations. The project approach is favored but functional elements also remain in many organizations. One of the major advantages to the project approach is the focalizing of resources and the increased opportunity for application of a

[18] *Ibid.*, p. 25.

"team concept." Project organizations are probably most effective for short range objectives; however, the functional approach provides greater flexibility and assurance of maintenance of a high skill level. Integration of contracting and programatic functions in an environment that promotes teamwork is likely to increase effectiveness by better communications and better appreciation of priorities. The functional approach seems to work better for the supporting purchasing activities such as standard supplies and services, but the method for maintaining close working relationships among all disciplines in R&D is most often the project approach.

CHAPTER V

CONCEPTS TO PROPOSALS

The literature, for the most part, pictures the scientist and engineer as playing a "behind the scene" role in the contract system, particularly prior to contract award. The contracting officer, the official agent of the government, is pictured as the leader of the team, the manager of the government's contracting resources. The technical elements are viewed as playing strong, silent supporting roles. In practice this image is often grossly inaccurate, especially in the R&D arena. In R&D, roles of scientists and engineers and other professionals is a variable closely associated wit three basic factors; attitudes of the management, age of the organization, and the organizational mission. The continuum in Table 4 illustrates the spectrum within which t contracting function exists. The new scientifically glamoro organization tends to experience a period in which contracti is considered a necessary evil, a paper work function that contributes little to the mission of the organization. This is a period when scientists and engineers are the real kingpins, the decision makers for the organization. Their ideas and methods permeate the entire organization with a "get the job done forget the contract attitude." The early

TABLE 4.--RELATIONSHIP OF ORGANIZATION AGE AND EMPHASIS

OLD		NEW
Business dominance	Team concept	Technical dominance
Contracting Officer official government spokesman	Participative approach	Scientist-engineer decisions
Maximum rules	Reasonable balance	Limited rules

experience of the AEC as described by Orlans is a fair representation of the environment of many R&D organizations in their infancy.

> There was very little formal contract "administration" in the days of the Office of Scientific Research and Development (OSRD) and the Manhattan Project, if that word means carefully drawn regulations under which a group of government employees direct, supervise, and evaluate the work of contractors. Attention was focused on getting the job done, not on costs, controls, and time consuming reports.
>
> At one university heavily involved in the atomic project, the main administrative responsibilities of OSRD were apparently consummated in a review that took a couple of hours and was conducted on the spot twice a year by Conant and two other senior OSRD officers. Decisions were made rapidly, and little attention was paid to the budget. Agreements were often verbal and contractual details were worked out later, sometimes after the work had been completed.
>
> . . . we needed to process sixty tons of uranium. It was impossible to set a price until the processes were worked out in more detail. . . . The only assurance I could give Mallinckrodt was that the Office of Scientific Research and Development would supply him with a letter of intent to work out a contract that would not leave him financially the loser. . . . Some months later, [after the Army had taken over] Colonel K. D. Nichols dropped in at my office. 'A. H.,' he said, 'you'll be interested to know that we have finally signed the contract with Malinckrodt for processing the first sixty tons of uranium. It was the most unusual situation that I have ever met. The last of the material was shipped from their plant the day before the terms were agreed upon and the contract signed.
>
> . . . "When Sengler was assured [that Nichols represented the Army and had authority to buy the ore] . . . he immediately noted on a sheet of yellow paper the conditions of sale of the ore. . . . These note were dated and initialed by Nichols and Sengler. Within a week the 1200 tons . . . were delivered. . It took another six months for the business officers on the two sides to agree upon the form of contract.
>
> "This," General Groves has written, "was typical of the way in which a great many of our most important

> transactions were carried out. Once the seller understood the importance of our work . . . he was invariably perfectly willing to deliver his goods or his services on our oral assurance that fair terms and conditions would be settled at a later date. We always promised that he would not be out-of-pocket for any expenses incurred if for some reason final agreement was not reached. And we always kept that promise."[1]

As is generally the situation early in the life of scientific organizations all of the ingredients were present in the AEC to place the contracting function on the extreme of the continuum where technical considerations are dominant. All major decisions were influenced or made directly by the technical hierarchy, placing the "official" spokesman for contract matters, the contracting officer, in an opposite role to that portrayed by the regulations.[2]

As an organization matures and the projects become less critical and less in the public eye, the contracting environment tends to move across the continuum toward and eventually beyond the midpoint of the participative approach. As an organization matures and moves across the continuum, scientists, engineers and contracting specialists tend to more closely approach traditional roles. Scientists and engineers become more of a "behind the scene" supporting element while the contracting officer takes the lead in contractual matters. Ideally, R&D organizations fall somewhere near the midpoint

[1]Orlans, pp. 116-117.

[2]The head of AEC field offices normally serves as the contracting officer, avoiding some of the conflict. See <u>ibid.</u>, p. 122.

where a "team" concept is the practiced philosophy. Fortunately, government R&D organizations for the most part, appear to be reasonably close to the ideal. Even the AEC has experienced the normal swing to more conservative contracting practices as so aptly described by Orlans:

> Both in spirit and in the humbler particulars of contractual and administrative practice, the heroic days of the Manhattan Project (the days of creation one is almost inclined to say) contrast strikingly with the increasingly ordinary years that have followed.[3]

R&D organizations seldom if ever approach the left extreme of the continuum in Table 4. Such an environment, however, is common in production and standard equipment purchasing organizations such as the Defense Supply Agency.

The point of the preceding discussion is simply to illustrate that the roles of scientists and engineers in the contracting process is related to the stage in development of the organization. A second important point is that the roles of scientists and engineers tends to become more deceptive as the organization matures in that it becomes more of a traditional, "behind the scene" activity.

A difficulty in describing the roles of professionals in the contracting process is selection of the parameters within which the process falls. The standard definition for procurement or contracting[4] seems somewhat narrow for the

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[3]Orlans, p. 116.

[4]Characteristics of terms "procurement" and "contracting" are discussed in Chapter I.

R&D environment because it excludes the "determination of requirement" activities. In practice the business of "determining and implementing" becomes highly integrated, making fine lines of distinction only theoretically possible. Since one objective of this research is to provide perspective on the "way things are" the presentation is not constrained by narrow definitions of the contracting process. For purposes of this study the process includes all activities directed ultimately to a contractual relationship as well as the post award management and administration functions.

Scientists and Engineers as Administrators

The revolution in the methods of implementation of government R&D projects, that is the installation of the "contracting-out" philosophy, has had major impact on the role of the scientist and engineer. The traditional concept of an individual in a white coat hard at work in the laboratory, is a far cry from the environment of the majority of modern day government scientists and engineers. A more accurate description for the majority would reflect business dress and a desk piled high with contract documents.

There was a day when government R&D work was performed by civil servants in government facilities. "In 1940 virtually all federal R&D programs were conducted within the government's own organization or as grants to state institutions; to a large degree the government relied upon developments in the private sector of the economy."[5] The modern approach, however,

[5] Danhof, p. 93.

is to rely on private organizations to conduct R&D in private facilities which are financed largely by the government. This transition has changed the roles of scientists and engineers to that of an administrator concerned with the planning, contracting and overseeing of the work of their counterpart in the private sector.

In many respects the new roles of government scientists and engineers are more complex and demanding than traditional roles. In a sense they are dual roles requiring not only the technical skills of the professional, but also the skills of an administrator. Scientists and engineers are key participants in every facet of the contracting process, but participation in traditional functions is more imagined than real. Instead, they are planners, schedulers, negotiators and managers, of work performed by contractors.

As in all things, there are exceptions to the generalization regarding roles of scientists and engineers. Many government R&D organizations maintain laboratories for the conduct of basic and applied research. For example, NASA maintains major basic and applied research laboratories at the Ames and Flight Research Centers in California and the Langly and Lewis Research Centers in Virginia and Ohio.[6] In addition, other field centers such as the Manned Spacecraft Center in Texas maintain supporting laboratories which have been described

[6] United States Government Organization Manual, 1969-70 (Washington, D. C.: Office of the Federal Register, National Archives and Records Service, General Service Admin., Govt. Printing Office), p. 465.

"as an in-house parallel to the Independent Research and Development Agreements that the Department of Defense (DOD) and NASA have with their contractors."[7] However, the overwhelming majority of government R&D is conducted by private concerns,[8] making roles of government scientists and engineers more administrative than the traditional practitioner. The remainder of this chapter and Chapter VI are devoted to identifying and describing more specifically, scientists and engineers' administrative roles in the contracting process.

Project Planning

The early planning and definition activities of a major R&D project offers perhaps the best opportunity for scientists and engineers to apply their talents in the more traditional manner. The period of incubation particularly, is when the government technical staff is heavily involved in analysis of alternate technical approaches and concepts, researching the many potential solutions to achieving agency objectives. Some agencies have a formal policy of utilizing internal resources rather than contractor support for the study of alternative technical concepts and determining the feasibility of further study and definition. For example, the NASA PPP guidelines state that contracted effort in preliminary analysis (phase A) activity is limited to auxiliary studies in support of the

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[7]Hjornevik, p. 21.

[8]Danhof, p. 93.

in-house activity.[9] This is an area in which the internal laboratories play a major supporting role. Hjornevik's description of NASA's Houston operation provides insight into the environment for the participants:

> Several conditions favorable to the environment of a good research laboratory are the following:
>
> 1. Strong personal emphases are placed on science-oriented values using one's ability rather than institutional values, having freedom to pursue ideas, and making contributions to basic scientific knowledge.
>
> 2. Frequent contact is made with colleagues in settings, with values, and in fields different from one's own.
>
> 3. The chief neither gives complete autonomy nor excessive direction.
>
> 4. Laboratory chiefs are themselves highly competen and motivated. Motivation and a sense of progress toward scientific goals are strong.
>
> 5. Chiefs employ participative leadership rather than directive or laissez-faire policies.[10]

The Air Force Systems Command provides a more detailed perspective on the roles of Air Force scientists and engin

> The scientist/engineer plays an important role throughout the entire planning, programming, and budgeting process. Early in the cycle, he is the major source of ideas for work in his area of technical interest which may become input to the TWP/LRP for his laboratory or be recommended as projects or tasks to be included in the nearer term program. In either case, the scientist/engineer must not only describe his technical ideas clearly and convincingly, but must also be able to advise management on the resources required to accomplish them.[11]

[9]NASA, Phased Project Planning Guidelines, p. 2-2.

[10]Hjornevik, pp. 21-22.

[11]AF Systems Command, Air Force Laboratory Procurement

Scientists and engineers as technical specialists perform project concept studies which cover the following types of elements:

--Development of project objectives in detail.
--Assessment of the feasibility of achieving project objectives.
--Identification of research, advanced technology and other project support requirements.
--Gross hardware requirements and plans for project implementation including manufacturing, test, logistic support, operations, etc.
--Determination of gross schedule for implementation
--Estimates of gross resource requirements (funds, manpower and facilities).
--Identification of the favorable and unfavorable technical, resource, and policy factors.
--Trade-off analyses to provide a basis for recommendations for follow-on action.
--Application to, or interface with, on-going or proposed projects.[12]

Upon completion of concept studies, analytical reports of findings and conclusions on the technical, management, financial resources, schedules and policy considerations are prepared to form a legitimate basis for recommendations. The following types of data would normally be developed:

- How the project objectives would contribute to agency and program objectives.
- Complete information on each approach studied.
- Preliminary specifications.
- Comprehensive comparative analysis of alternatives and trade-offs (including resource and schedule estimates for the project through completion).
- Identification of study contracts required.
- Statement of impact on Agency program and resources.
- Identification and plan for implementing research and technology tasks critical to the project.
- Relationship to on-going or proposed projects.
- Conclusions.
- Recommendations.[13]

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[12]NASA, Phased Project Planning Guidelines, pp. 3-2 - 3-3.

[13]Ibid., p. 3-3.

Another important aspect of the early planning activities in which scientists and engineers are key participants is the preparation of project plans for the definition, design and development phases. These plans will normally be detailed for the next step in the sequence and more generally describe the overall plan. For example, prior to initiating the formal definition phase, normally a contracted effort, the technical office (scientists and engineers), prepare the formal project plans for accomplishing the definition of hardware and associated work. This aspect of project planning, that is the detail planning is updated prior to initiation of each phase.

Procurement Planning

The regulations of the DOD, AEC and NASA require formal planning and prior approval of the detail implementation plan for major R&D contracts. The plan describes the objectives of the proposed contract, method of procurement, type of contract to be utilized and many other aspects pertinent to contracting.

Although formal contract actions such as issuance of the RFP are normally not taken prior to project approval, advance planning and preparation for contracting is often accomplishe in parallel with review and approval of the project plan. One of the advantages of an integrated organization is often displayed at this point. When the project plan has progresse to the point where there is reasonable expectation of approva the technical and business personnel join forces and initiate advance planning for contract implementation. This informal activity reduces the contracting time cycle after approval of project plans. Air Force comments on planning are

> The greatest possible benefits are obtained when procurement planning covers the entire period from inception of the work requirement to placement of a contract with the selected source. Planning should therefore begin as soon as enough data are available to establish meaningful and productive cont: between the technical organization and the contracting activity.[14]

One of the major areas of responsibility for scientists and engineers in the initial contract planning is preparation of the contract work statement. The work statement is a critical aspect of the contracting process because it is the foundation for all subsequent actions. The work statemen is the basis upon which contractors prepare proposals to demonstrate capability as well as the framework for the contract itself. Of all actions in the contracting process for which scientists and engineers are responsible, none are more important than preparation of the work statements. Air Force guidelines for scientists and engineers illustrate the point:

> The work statement is a vital part of the purchase request. Wrok statements for Air Force research, exploratory development, and advanced development are prepared in accordance with AFSCM 70-5. They can vary from simple statements of objectives to complex statements of performance requirements. Regardless of their simplicity or complexity, certain general principles apply to all of them. First, work statements must be neither so narrow as to restrict the contractor's efforts nor so broad as to permit the contractor to explore areas having little relationship to the particular work. Secondly, a work statement is a

[14] Air Force Laboratory Procurement Management, pp. 1-10 - 1-11.

controlling device which should be definitive enough to protect the Government's interests. Finally, a contractor, taking his ultimate direction from the statement alone, should be able to perform the required work. The work statement will affect the procurement beyond directing the contractor's effort and:

(a) May affect the number of good sources willing and able to prepare proposals for the work. If it is too broad, firms may choose not to propose, either because of the risks involved or because they are not able to immediately relate the work requirements to their talents. On the other hand, if it is too restrictive, the most capable (and desirable) sources may feel that their creativity will be stifled by Government overdirection.

(b) Will affect the type of contract that will be written. For example, if a certain level of effort over a specified period of time is desired, a fixed-price contract may be feasible. On the other hand, if the amount of effort required to perform the work very uncertain at the outset, a cost-plus-fixed fee (CPFF) contract may be necessary because of the inability to estimate costs accurately enough to set an acceptable fixed price.

(c) Can affect the basis on which the contract may be written. R&D contracts may be either completion or term contracts. The completion contract requires the contractor to complete and deliver a specified end product - such as experimental hardware. The term contract requires the contractor to apply a specified level of effort - by man-month or cost rate of effort for combined or separately designated categories of labor.

(d) Will affect the evaluation of proposals, just as it will affect the proposer's approaches to the work. Proposal evaluations must be based on the work statement - on what the Air Force has stated that it desires.

(e) Will affect the administration of the contract, since it defines the scope of work - what the contractor does and what the Government receives. The manner in which scope is defined will govern the amount of direction that the scientist/engineer can give and what the contractor will accept during the contract's life.[15]

[15] Ibid., pp. 2-1 and 2-3.

Transition of Responsibility

The early activities of planning and preparation for contracting, the concept analysis, project planning and work statement preparation are essentially technical responsibilities. The scientists and engineers are focal points of action; they take the initiative in moving the project forward. When problems develop, it is the scientist and engineer who come to the rescue. The contracting officer plays an active role in this period, but it is supportive and advisory.

The general premise is that the task of determining and defining the technical requirements is a responsibility of the technical organization, the scientist and engineer. However, a dramatic change takes place when specific contract preparations are initiated. When the items to be contracted are defined and the necessary budgetary arrangements complete the focus moves into a different arena, that of the contracti officer. At this point there is a noticeable shift of emphasis from the strictly technical consideration to the broader management aspects of contracting. While the contracting officer moves more to the forefront at this stage, the scientist and engineers continue to play strong supporting roles. This is the point at which the "team concept," fostered by most R&D organizations, begins to develop into formal relationships for the job ahead.

The Procurement Plan

One of the first formal documentation efforts, after approval of the project plan and identification of the segments of the project to be accomplished by contract, is preparation of a formal procurement plan:

> A procurement plan is a detailed outline of the method by which the contracting officer expects to accomplish the procurement task. The plan is an administrative tool designed to enable the contracting officer to plan effectively for the placement and accomplishment of assigned procurements by analyzing the requirement for, and determining the method to be used in, placing the procurement. It also furnishes justification for the contemplated method of procurement for use in connection with the review and approval of higher authority when applicable.[16]

Although the contracting officer has primary responsibility for the plan, preparation is a team effort in which scientists and engineers are key participants. Much of the information upon which the plan is based is developed by the technical staff and there are technical considerations which require the scientists and engineers' skills. Air Force comments on the point are:

> When a written procurement plan is required, it is the contracting officer's responsibility to prepare it and to obtain the necessary approvals. He depends, of course, on the scientist/engineer to furnish the technical information necessary to support the plan; for instance, the ratings derived from the pre-solicitation evaluation of prospective sources, the AF Form 111, "Research and Development Management Report," the technical work statement, and so forth.[17]

A sample procurement plan illustrative of a typical Ai Force situation is provided in Appendix 2. Table 5 is a mo comprehensive description of the considerations involved in

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[16]NASA, Procurement Regulations, p. 376.7.

[17]Air Force Laboratory Procurement Management, pp. 1-11 1-12.

TABLE 5

PROCUREMENT BY NEGOTIATION[a]

PROCUREMENT PLAN FOR ___

1. DESCRIPTION OF THE PROPOSED PROCUREMENT.

   a. Purpose and Description of Work, Supplies, or Servcies (including Quantities).
   b. Program and Project (including Identification of Project Approval Document).
   c. Responsible Technical Office.
   d. Installation's Plan for Technical Monitoring.
   e. Relation to Other Procurements - Past, Present, and Future.
   f. Performance Milestone (if Known) and Delivery Schedule.
   g. Total Estimated Cost.

2. FUNDING.

   a. Approved Project Funding by Fiscal Year.
   b. Funding of Proposed Procurement by Fiscal Year.
   c. Funding of Follow-on Procurements by Fiscal Year.
   d. Contingencies or Reserves Required by Fiscal Year.

3. SOURCES.

   a. Known Sources and Competitive Situation.
   b. Sources to be Solicited and Reasons for Omission of Known Sources.
   c. Synopsizing or Explanation of Exception.
   d. Justification for Noncompetitive Procurement.

4. JUSTIFICATION AND AUTHORIZATION FOR NEGOTIATION.

   a. Determination and Findings.
   b. Justifications Relating to Class D&F's.

5. TYPE OF CONTRACT.

   a. Recommended Type.

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[a]NASA, Procurement Regulations, pp. 378.2-381.

TABLE 5 (continued)

b. D&F for Method of Contracting.
c. Special Requirements.
d. Incentive Consideration.
e. Letter Contract and Complete Justification

6. ORAL BRIEFING OF PROSPECTIVE CONTRACTORS.

7. METHOD OF EVALUATING PROPOSALS.

a. Recommended Method.
b. Special Problems.
c. Source Evaluation Board Appointment Letter.

8. GOVERNMENT PROPERTY - DESCRIPTION, MONETARY EVALUATION, AND BASIS FOR REQUIREMENT.

a. Facilities.
b. Other Property Government-furnished.

9. RELIABILITY AND QUALITY ASSURANCE.

a. Reliability Assurance.
b. Quality Assurance.

10. MANAGEMENT INFORMATION SYSTEMS.

11. PRECONTRACT COSTS.

12. TECHNICAL DATA FOR REPROCUREMENT.

13. OTHER PERTINENT DATA.

14. PROCUREMENT ACTION SCHEDULE.

15. LEGAL REVIEW OF PROCUREMENT PLAN.

preparing a plan.

A procurement plan is the agency road map for selecting contractors, developing the appropriate contractual instruments and managing the contractor's efforts. It is first and foremost a management tool, a vehicle for assuring that the prerequisites for contracting have been met and that the organization has studied the alternatives and selected the best options for the particular situation. A procuremen plan is not intended to constrain or hinder, rather its purpose is to assure rational planning of the actions required to achieve project objectives.

The procurement plan is an integrator of the technical, business and management considerations into a feasible and coordinated course of action. Preparation of the procurement plan is multi-disciplinary activity. In major projects the plan is a product of a contracting team composed of scientists engineers, the contracting officer, pricing specialists, legal specialists and various other professionals.

Review and approval levels vary depending upon agency policy; however, plans for major R&D are generally reviewed at the highest levels of the agency or department. The items in Table 5, relevant to scientists and engineers, are discussed below.

Description.--Much of the data for the procurement plan is taken from earlier work reflected in project plans. For example, the descriptive information required by the procurement plan is also required for project planning. A difference, however, is that the procurement plan is related to a specific area whereas the project plan may be extremely broad. Also, the procurement plan is developed subsequent to the project plan thus reflecting modifications resulting from more recent developments. Scientists and engineers provide all necessary information to describe the contract work scope in specific terms such as technical objectives, performance measurement criteria, and deliverable products such as reports, prototypes and test specimens. A concomitant task of scientists and engineers is development of the performance milestones and schedules for the proposed contract work. This is an especially important function since the schedule must be integrated with project activities which are conducted by many other sources. An incompatibility in the schedule for one contract could easily jeopardize the overall project objectives.

Technical Monitoring.--Another contribution by scientists and engineers is the plan for technical surveillance or monitoring of the proposed contract. The plan must reflect management's philosophy regarding the degree of flexibility to be given contractors, that is to monitor the detail work or rely more on the reports and tests as evidence of performance. Stability of technical resources, feasibility of on-site monitoring and the possibility of delegation of certain functions to other government agencies, are factors that must be considered in developing the technical management plan. The plan will normally involve several internal organizations and possibly external groups making coordination and integration an essential requirement.

Sources.--Familiarity with project requirements makes the scientist and engineer the first sources of information regarding prospective contractors. Knowledge of the demands of the project and familiarity with the capability of the industrial firms are important considerations in establishing the potential contractor source list. The source list contains the firms that are believed to possess the capability and interest required to participate in the project. Skilled judgment in this area helps to reduce the possibility of encouraging unqualified firms to incur the expense of a formal proposal. More importantly, however, scientists and engineers provide increased assurance that interested, qualified firms are provided an opportunity to participate in the procurement.

Major R&D projects seldom meet the criteria for limiting the solicitation to a single source; however, in the event the technical authorities believe competition is not possible or practicable, a justification must be prepared to support such a recommendation. A non-competitive procurement recommendation is a serious matter; if followed, it eliminates the flexibility and other advantages of a competitive environment Nevertheless, certain requirements are not suitable for competition. Scientists and engineers are often uniquely qualified to make judgments in this regard. The following illustrates the factors that must be considered and explained in support of a non-competitive recommendation:

(i) What capability does the proposed contractor have which is important to the specific effort and makes him clearly more desirable than another firm in the same general field?
(ii) What prior experience of a highly specialized nature does he possess which is vital to the proposed effort?
(iii) What facilities and test equipment does he have which are specialized and vital to the effort?
(iv) Does he have a substantial investment of some kind which would have to be duplicated at Government expense by another source entering the field?
(v) If schedules are involved, why are they critical and why can the proposed contractor best meet them?
(vi) If lack of drawings or specifications is a guiding factor, why is the proposed contractor best able to perform under these conditions? Why are drawings and specifications lacking? What is the leadtime required to get drawings and specifications suitable for competition?
(vii) Are Government-owned facilities involved?
(viii) Is the effort a continuation of previous effort performed by the proposed contractor?
(ix) Does the proposed contractor have personnel considered predominant experts in the particular field?
(x) Is competititon precluded because of the existence of patent rights, copyrights or secret processes?
(xi) Are parts or components being procured as replacement parts in support of equipment specially designed by a manufacturer, where data available is not adequate to assure that the parts or components will perform the same function in the equipment as those parts or components being replaced?[18]

<u>Type of Contract</u>.--The type of contract most appropriate for the particular situation will depend on a host of factors such as the degree of specificity of the work statement, uncertainty of ability to achieve the technical objectives and the state of the art in the areas to be researched. Again, scientists and engineers by reason of their knowledge and familiarity with the project, are invaluable sources of

[18]NASA, <u>Procurement Regulations</u>, p. 358.

information. In an R&D situation, the nature of the work is such that with the possible exception of the definition studies, a cost reimbursement contract arrangement is generally the most appropriate. However, consideration must also be given to the appropriateness of incentives that would motivate the contractor to emphasize the governments objectives. There are numerous options for incentives, but a meaningful arrangement will almost always involve an integrated arrangement wherein cost, schedule and performance are incentivized. Selecting the right incentives is an extremely complex task requiring the participation of many disciplines, especially scientists and engineers. Expertise in performance characteristics of equipment is an essential ingredient in selection of contract type; since incentives are frequently tied to equipment performance parameters and other technical aspects.

The subject of incentives is of such importance and complexity that DOD and NASA recently joined forces in developing approaches to selecting appropriate incentives:

> The contemplated choice of contract type should be re-evaluated at every step in the preaward phase because the rationale may change significantly during the proposal evaluation or at any point between the RFP and the negotiation. The contractor's willingness to accept a high risk FPI contract should not be a primary criterion. Extracontractual influences may initially support the contractor's choice, but changing conditions may impact adversely on performance during the life of the contract. Values of performance between the minimum acceptable level and a nominal performance gaol should be carefully evaluated at different cost points to assure that the Government's trade-off decisions in stating a preference for a contract type are in accordance with the preferred performance objective.

In research, exploratory development, and advanced development effort, the type of contract to be used may include award fee incentives; however, research, preliminary exploration, or study contracts should be CPFF instead of CPAF where the level-of-effort required is unknown or where the performance measurement does not lend itself to the subjective evaluations required by award fee contract. In Advanced Development effort, CPIF incentives may be appropriate when realistic cost ranges can be estimated; however, actions beyond the control of the contractor may cause high sharing rates to be inappropriate. In the first two categories in the spectrum, there are quite often no definitive or measurable goals which are not subject to significant change. The decision to even consider an incentive contract may force a better definition and cost estimate which often leads to the proper conclusion that incentives are, in fact, inappropriate.[19]

Oral breifing.--Proposal briefings are conducted primarily to clarify questionable aspects of an RFP to facilitate better proposals. In R&D situations the areas difficulty are generally associated with technical aspects of the project. In the planning, scientists and engineers must consider the value of conducting an oral briefing, recognizing that there are penalties in time and effort involved. However, if a briefing enhances the quality of proposals, the time and effort devoted to the briefing wil pay high dividends.

Proposal Evaluation.--The major R&D agencies and departments have established procedures in which formal Source Evaluation Boards (SEB)[20] are appointed to

[19] Incentive Contracting Guide, NHB 5104.3A, Fm38-34, NAVNAT P-4283, AFP70-1-5, DSAH.7800.1 (DOD and NASA, October, 1969), pp. 57-58.

[20] NASA uses Source Evaluation Board; DOD uses Source Selection Advisory Committee (SSAC).

> . . . determine the most appropriate method of selecting, applying and reporting the criteria or factors which will best assist the Source Selection Official in deciding the source(s) with which final negotiations shall be initiated,[21]

in major contract actions. In the R&D environment, scientists and engineers are heavily represented on evaluation teams. The chairman is often a high-level scientist or engineer. There is also a technical committee consisting of scientist and engineers representing different areas of interest. In procurements not appropriate for the formal SEB procedures, scientists and engineers play an equally important role in evaluation of proposals. The statement, "Generally, procurement personnel are not qualified to evaluate proposals from a technical viewpoint and must rely on scientific and engineering personnel for this function,"[22] in the introductory provisions of NASA regulations is indicative of the scientists and engineers' role. The task of the procurement plan is to describe the techniques to be utilized for the proposal evaluation which comes later in the cycle.

There are many other factors in preparation of a procurement plan that involve scientists and engineers. For example, reliability and quality requirements and the information management systems must be identified and integrated into the planning.

In summary, the procurement plan is a framework for

[21] Source Evaluation Board Manual (NASA, Aug., 1964), p. 2-1.

[22] NASA, Procurement Regulations, p. 360.

contract implementation. Although the contracting officer is primarily responsible for preparation of the procurement plan, it is a multi-disciplinary activity. The technical staff, scientists and engineers, play particularly significant roles by providing much of the basic information and in providing assistance and advice to the contracting officer

Solicitation of Proposals

The formal introduction of the government's intent to contract is made through the medium of an official Request for Proposal (RFP), a standard vehicle for this purpose. In an R&D situation the RFP is normally a letter form document that describes the proposed contract requirements, the qualification and evaluation criteria that will be utilized to select contractors for negotiation, and the tentative terms and conditions for the contract. The RFP also identifies the information required for the government to evaluate and sele proposals for negotiation.

The RFP is one of the particularly important aspects of the contracting process; for the quality of contractor proposals and subsequent activities are in large measure directly related to the quality of the RFP. However, from the scientists and engineers' viewpoint an RFP presents few problems, providing the planning has been thorough. There are two exceptions, however; either or both can present major problems for scientists and engineers. First, the nature of an R&D project is such that it experiences constant change. Therefore, there are often significant adjustments in project requirements that must be incorporated into the RFP. If the impact of a change is substantive it may affect many aspects of the RFP requiring re-examination and possibly major revision. A second more difficult area, but one that is anticipated and planned is proposal evaluation. Scientists and engineers functioning as members of evaluation boards and committees, play an exceptional key role in the evaluation process. Although the actual evaluation is conducted several weeks subsequent to the RFP, the plans, particularly the criteria, must be completed concurrently or prior to the RFP. This is necessary for two reasons: one, the government's policy is to advise prospectiv contractors of the criteria that will be utilized to evaluate proposals and two, to avoid the possibility of manipulation of evaluation plans after receipt of proposals.

The scientists and engineers' talents are particularly valuable in establishing criteria. SEB guidelines describe the types of criteria found in RFP's:

> PROPOSED QUALIFICATION CRITERIA.--The proposed qualification criteria will consist of those elements of special experience, capability, facilities, or other factors which are critical to the program performance aspects of the procurement. In establishing "qualification criteria," care must be exercised to restrict them to those essential to the successful completion of the contract work. Stated otherwise, they are "go-no-go" criteria which will reflect minimum requirements for a particular procurement.
>
> PROPOSED EVALUATION CRITERIA. . . . The proposed evaluation criteria will consist of those elements which the Board must examine in each proposal to determine a concern's:
> a. Understanding of the requirement,
> b. Approach to the task,

c. Potential for completing the job in terms of the RFP, and
d. Comparative competitive status.[23]

A review of the basic policy and operational procedures of the SEB provides insight into the environment and the functions scientists and engineers perform in the evaluation process:

> The principal purpose of the SEB procedures is to provide a sound basis on which an informed and objective judgment can be made by the Source Selection Official, insuring thereby the selection of the contractor having the highest probability of best performing the specific contract tasks. The source evaluation process requires not only an appraisal of the concerns' written proposals for a particular procurement but consideration of other factors bearing on the performance potentials of a concern as may be appropriate or necessary to insure selection of the best possible contractor.[24]

This review illustrates the importance and complexity of the scientists and engineers' roles in planning for contracting. A copy of an official RFP, including all instructions for proposal preparation, evaluation plan, and technical criteria is provided in Appendix 3.

This review of the scientists and engineers' role in preparing the RFP purposely avoids the many facets which do not directly involve the technical professional. However, scientists and engineers should be aware of certain of these actions; they should know, for example, that proposed procurements are publicized daily in the Department of Commerce

[23] Source Evaluation Board Manual, pp. 5-2 - 5-3.

[24] Ibid., pp. 2-1 - 2-2.

synopsis for the purpose of informing industry of prospective procurements. In addition, copies of the RFP are publicly displayed for the same purpose.[25]

Pre-proposal Briefing

After an RFP is finally completed and mailed to prospective contractors there are two remaining activities for scientists and engineers prior to conducting the proposal evaluation. First, the RFP, and all pertinent technical material such as the work statements, evaluation criteria, quality and reliability requirements, and reporting requirements must be carefully re-examined for the possibility of errors, ambiguous provisions and items that may be affected by project changes subsequent to the RFP. In the event revisions in the RFP are desirable they must be accomplished in a timely manner to avoid impacting the contractor's effort in preparing a proposal. In major R&D projects the government normally requires proposals to be submitted within four to eight weeks after the RFP is mailed. Since the contractors are motivated to prepare the best proposal possible, time is extremely important. Therefore, it is to the advantage of both the government and the contractor that any necessary changes to the RFP are made as early as possible. Another aspect of this problem is the possibility that the contractors review of the RFP will reveal areas that require clarification.

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[25]NASA, Procurement Regulations, p. 170.

Unless there is a mechanism to accommodate questions, contract tend to seek advice on an individual basis by contacting the responsible technical representatives. This is generally inappropriate in a competitive situation and is highly discouraged. Experience confirms, however, the probability that many areas of an RFP, particularly the technical aspects, will require clarification before quality proposals can be prepared. One technique for accomplishing this is the pre-proposal briefing or conference. The customary practice is to plan the briefing in advance and provide notification in the RFP. This assures awareness and equal opportunity for participation on the part of all RFP recipients. Air Force guidelines on this subject are

> One of the best methods of insuring realistic technica and cost proposals is the preproposal briefing of prospective contractors after they have received the Request for Proposal. The basic purpose of the briefing, in which the contracting officer, the buyer, and the scientist/engineer participate, is to promote uniform interpretation or clarification of work statement and specifications. Among the factors considered in determining the need for a briefing are:
> (1) the complexity of the project.
> (2) the benefits likely from dissemination of backgrou data.
> (3) anticipated difficulties in contract administratic
> (4) exceptional demands on a contractor's capability.
> (5) the presence of unavoidable ambiguities in the statement of work.[26]

The pre-proposal briefing is a formal activity. In SE situations the Board will normally be represented and may

[26] Air Force Systems Command, Air Force Research and Development Contracting Officers' Handbook, AFSCP70-2, (Washington, D. C.: Andrews Air Force Base, 30 June 1967), p. 2-31.

even conduct the meeting. After the briefing a formal amendment is issued if RFP revisions are necessary. Scientists and engineers play major roles in the pre-proposal briefing activity, often being the principal target of questions.

The second and last matter to be dealt with prior to receiving the contractors' proposals is the final organization and planning for the evaluation. In major projects evaluation is a complex and time consuming activity, sometimes requiring several weeks depending upon the number of proposals, complexity of the procurement and other factors. For this reason, plus the probability of changes subsequent to the briefing, the time between pre-proposal briefing and receipt of proposals is a period of high activity; the final preparation period prior to the formal evaluation process.

CHAPTER VI

EVOLUTION OF A PARTNERSHIP

The presentation in Part Two has thus far focused on the preparatory activities which are necessary prerequisites to developing a contractual relationship. The thrust now changes to an examination of the process of selecting contractors for negotiation, the negotiation process, and finally management and administration of the contract.

The emphasis in the material that follows is on identifying and describing the role of the scientist and engineer. However, this is a task that at best can only be partially achieved due to the integration of the various disciplines into a "team" approach. This is particularly evident in the proposal evaluation and negotiation activities. Another important factor to be recognized is the thorough integration of scientists and engineers into the management hierarchy in government scientific organizations. For example, the current Administrator of NASA is a scientist as are many of the DOD and AEC top management people. This means that scientists and engineers fill many roles in addition to the strictly technical function. In fact, they participate in a management capacity in essentially all areas of the contracting process. The emphasis here, however, is on the role of the specialist rather than the generalist, the expert technical advisor, the consultant, the decision maker in technical matters throughout the proposal evaluation process.

Narrowing the Field

R&D, like many other areas, is characterized by an abundance of private institutions eager to perform the work. The government's policy is to encourage maximum competition consistent with the nature of the tasks. However, in the interest of the government and the public, concerns that do not possess the minimum qualifications and resources necessa to perform the proposed work are discouraged from incurring the expense associated with preparing proposals for competiti consideration.[1] Also, since there are often more concerns th meet minimum requirements than there are contracts to be awarded, the government employs techniques designed to identi the most capable contractors desiring to participate.

The process of selecting the most advantageous proposal and contractor to perform a particular segment of work can be viewed as a progressively narrowing process. The process begins with a broad spectrum of potential contractors in the early project planning period, reduced somewhat before formal contracting action by the firms own assessment of the competi further reduced by the screening of source lists "to eliminat sources clearly not capable of contract performance,"[2] and

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[1] Source Evaluation Board Manual, p. 4-1.

[2] AF Laboratory Procurement Management, p. 2-23.

finally through the terms and conditions of the RFP, especially the qualification criteria. To this point the narrowing process is conducted without formal interaction between government and the prospective contractors, and the terms, qualification criteria and other requirements of the RFP, are essentially objectively derived.

Upon receipt of proposals the narrowing process continues but two major changes occur in the process. First, the elimination process switches from dealing with the industry in general to dealing with individual companies. Second, the elimination decisions become more subjective, being based upon comparison of predetermined criteria with information presented by the contractor, supplemented by personal discussions and negotiations, and data received from other government sources.

Although the roles of the various participants in the proposal evaluation process are essentially the same in all types of evaluations, selection criteria are directly related to the type of competition designed by the RFP and the particula phase of the project to be contracted. The point of the latter comment is that qualification and evaluation criteria are likely to vary considerably in the different phases. To illustrate, in the definition phase the objective of the evaluation is to identify the best capability for a study, which may or may not require extensive facilities and resources. On the other hand, both facilities and resources are likely to be highly desirable assets for the development phase. There are many variations in approaches to competing major projects.

In a study of the forms utilized by the military departments, Peck and Scherer classified all forms into four basic categorie with the following features:

> (1) Advertised competitive bidding. The government publishes detailed specifications for the product, and bidders quote prices for delivery of the specified product. A fixed price contract is awarded to the lowest responsible bidder.
>
> (2) The design competition. The government issues performance specifications, either to any interested firm or to a selected group of firms. Bidders respond with detailed design proposals and sometimes models, along with estimated cost and delivery data. Over-all excellence of the proposed designs is the principa consideration in selecting the winner of a development contract (usually of the cost reimbursement type).
>
> (3) The prototype competition. The government again issues performance specifications, but in this case bidders respond with full-scale working prototypes to demonstrate their solutions to design problems. Over-all excellence of the prototypes as determined by testing is the principal consideration in selecting the winner of a development or production contract.
>
> (4) The management competition. The government issues a broad statement of its requirements. Bidders respond by submitting proposals which indicate the general technical and organizational approach to be employed in solving foreseen design problems and which describe, among other things, the bidder's relevant past experience and present capabilities. Contract awards are based upon considerations of company capability, experience, and interest as well as upon the technical approach proposed.[3]

Technological changes and difficulties have over the years resulted in almost total reliance on the "management" competition approach in the larger R&D projects. Advertising is inconsistent with the "unknowns" of R&D; design competitions are "paper" competitions, with no assurance that the contractor

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[3]Peck, pp. 343-344.

work will match the quality of his design; and the prototype is often too expensive to be a practical approach. The management competition technique has become the most popular method although it is of relatively recent origin.

> The Air Force was the first service to recognize the management competition formally by establishing in 1955 its System Source Selection procedure. However, all three services had conducted earlier source selections that were more like management competitions than design competitions. After 1955 the Army began holding formal management competition to choose sources for some of its guided missile programs, while the Navy Bureau of Aeronautics (now the Bureau of Weapons) modified its design competition procedures to include features characteristic of management competitions. The National Aeronautics and Space Administration has also used management competitions extensively to select contractors for further competition on the basis of study and preliminary design contracts.[4]

For purposes of this study it is important to recogniz that there are various techniques for obtaining competition However, since the management approach is utilized almost exclusively it also is the focus of the research.

In R&D contracting, technical considerations generally take precedence over other matters in the final decisions. Perhaps an appreciation of the reasons for this phenomena c be gained by reviewing pertinent comments from selected sources:

> In R&D contracting, technical competence is of chief importance, taking precedence over price and other business considerations for a number of reasons. First, since R&D work requirements cannot be precisely defined, technical competence is the main assurance that a cost reimbursement or a level-of-effort fixed-price contract will be performed at a reasonable cost. Since the work has not been performed before,

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[4] Ibid., p. 347.

the creative ability of the particular contractor, fully applied to the task, has to be relied on by the Air Force. Obtaining the highest quality of technical effort available avoids later technical questions that might cause duplication of effort if a contractor of lesser capabilities and skills had been used. Moreover, dollars effectively spent in research and development when a concept is still on paper can save many more dollars downstream in hardware efforts, where changes of material, technique, approach, or terminations are usually costly.[5]

Another reason for awarding R&D contracts on the basis of technical competence rather than price is that the latter practice may encourage submission of unrealistically low estimates and increase the likelihood of cost overruns.[6]

In research and development, the technical proposal is generally considerably more significant than any projected cost estimates, although not always more significant than the total business proposal. Where technical aspects dominate the selection, GAO is unlikely to second-guess the agency's decision.[7]

Technical competence is particularly significant in R&D and, since the R&D capabilities of industrial and academic organizations vary widely according to the oriented interest of the particular organization and the range of capabilities of the scientists, engineers, and technical staffs employed, a high degree of subjective judgment is inescapable.[8]

Particularly with respect to larger systems development, the final contractor selection process, once a more or less technical evaluation of the product models, has become a complex analytical task involving numerous technical factors, management problems, cost factors, and development risks.[9]

[5] AF R&D Contracting Officers' Handbook, p. 3-1.

[6] Ibid., p. 3-2.

[7] Paul A. Barron, Government Selection of Contractors for Research and Development, unpublished paper (NASA), p. D-31.

[8] Ibid., p. D-2.

[9] Danhof, p. 161.

> In research and development contracting, awards should usually be made to those companies that have the highest competence in the specific field of science or technology involved, although awards should not be made on the basis of research and development capabilities that exceed those needed for the successful performance of the work. . . . Technical evaluation should include the following:
>
> (i) the contractor's understanding of the scope of the work as shown by the scientific and technical approach proposed;
> (ii) availability and competence of experienced engineering, scientific, or other technical personnel;
> (iii) availability of necessary research, test, and production facilities;
> (iv) experience or pertinent novel ideas in the specific branch of science or technology involved;
> (v) the contractor's willingness to devote his resources to the proposed work with appropriate diligence; and
> (vi) the contractor's proposed method of achieving the reliability required.[10]

The review illustrates the high degree of importance attributed to the technical aspects of a contractor's proposal. It also illustrates the importance of the scientists and engineers' work in designing criteria and performing evaluations in which the findings are the primary basis for selection of contractors. From all perspectives the proposal evaluation process and particularly the technical aspects, represent possibly the most important phase of contracting with the exception of actual performance. The premise that the technological nature of R&D projects emphasizes technical consideratio[n] over others is supported by a case study of two DOD contracting organizations. In one organization, 36 out of a possible 41 contracts were awarded to the highest technically ranked

[10]NASA, Procurement Regulations, p. 360.

company.[11]

The systems for continuing the narrowing process after receipt of proposals are complex mechanisms that have been the subject of numerous studies. In one of the more comprehensive examinations, Parker described the SEB process as a social system:

> A significant feature of any system which is a decision-making process is its "social character." Indeed, a mechanism such as the NASA SEB process contains all the ingredients of a working social system: (1) Board members exhibit a variety of roles and statuses, (2) a series of values and norms are applied to scoring and evaluation techniques, and (3) primary and secondary groups develop among Board members.[12]

Although the systems are complex there is a high deg of similarity in operational procedures in the major agencies. Generally, a formal Board staffed by high level technical and business officials establishes the overall guidelines and operational procedures for technical and business evaluation committees. These groups, staffed by experts in various disciplines, establish criteria for evaluating proposals, while the Board supervises the work and determines relative importance of the criteria. Upon receipt of proposals the evaluation groups review and rank the proposals for considerat of the Board. Proposals found to be totally deficient or not

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[11]Richard H. Nolan, *The NASA Source Evaluation Board Process: A Descriptive Analysis*, unpublished thesis, San Dieg State College (Houston, Texas, MSC, Dec., 1967), p. 21.

[12]William A. Parker, *The NASA Source Evaluation Board: A Dynamic Technique of Decision Making*, unpublished paper (Houston: MSC), p. 44.

meeting the qualification criteria are immediately eliminated from further consideration. Barron summarizes the process from this point forward as follows:

> The SEB or SSAC, after completion of initial rankings, reviews them to determine those concerns which have a reasonable chance of later selection for final negotiation. This initial narrowing process is, in effect, preliminary or early "competitive range" determination and is based on judgment that concerns below a "breakpoint" are not reasonably in contention, even assuming potential for favorable clarification of ambiguities.
>
> The SEB or SSAC then conducts further evaluation eforts including oral or written discussions with these contractors, providing them the opportunity to clarify and upgrade their proposals. The extent of discussions and negotiations during this evaluative stage varies from agency to agency and from procuremen to procurement. Where technical considerations are overriding, detailed discussion on the business and cost proposals are given considerably less emphasis than the technical evaluation. Initially, the technical evaluators conduct their evaluation, for the most part, without consideration of the business proposal, or at least without the cost proposal. All this information is later made available and becomes a part of the evaluation of total technical and business considerations. Most agencies go through what is, in effect, a narrowing-down procedure. This narrowing-down procedure is undoubtedly reflected in the extent of discussions with the competing concerns.
>
> The SEB or the Source Selection Advisory Council are evaluating bodies and do not select or actually recommend selections to the source selection authority. They present comparative rankings and the considerations which entered into the ranking. The source selection authority or official makes the actual contractor selection.
>
> The negotiation and selection process differs somewhat between NASA and DOD agencies. Some of the factors considered only by the NASA Administrator (the term refers to the joint decision by the Administrator, Deputy Administrator and Associate Administrator - the NASA selection officials on major NASA awards) are, in fact, considered in DOD by the Source Selection Advisory Council. Also in NASA, normally, finally

negotiated contracts are not presented to the Administrator in the first SEB presentation and the Administrator selects one, two or possibly three concerns for so-called "final negotiations" including execution of contracts. After these "final negotiations," the final evaluations are presented to the Administrator for final selection.

In DOD the concerns ranked by the SSAC as "finalists" generally have negotiated contracts which are available for execution after the Department Secretary or other delegated source selection authority makes the final selection. While the procedures differ as indicated, common to both is the narrowing-down process. This narrowing process is essential because of the extensive time and effort invested in negotiations of final contracts. Detailed contracts are not fully negotiated with all concerns originally considered to have been within the initially-determined competitive range.

As can be seen, the narrowing-down process is essentially the same, but the function of narrowing-down those with whom final contract negotiations will be conducted is, in DOD, an SSAC function and, in NASA, reserved to the Administrator. In theory, the NASA system gives the Administrator a broader range of selection since, in effect, he does the final competitive-range narrowing. In practice, selection of other than the top-ranked concerns is rare. Thus the difference in procedures has little if any ultimate effect on the selection process.[13]

The alternatives of negotiating final contracts before presentation of the evaluation findings to the selection authority and the two-step process of presenting evaluation findings for selection of final contenders and subsequent final selection is a matter of judgment and agency preference. The desirability of either depends upon the circumstances. If, for example, the number of competing contractors is limited to two or three the "one shot" approach seems more desirable. However, if there are several contractors in the

[13]Barron, pp. D-20-21.

final running, negotiation of definitive contracts with each contractor may be extremely impracticable. The problem may be more theoretical than real since the number of final contestants in major R&D projects is generally not great.

Formal solicitation, responding proposals and finally contract award; the standard procedure for contracting, accounts for an overwhelming majority of the R&D contracts. However, a different technique, one in which private sources take the initiative, the "unsolicited proposal," accounts for "most of the DOD-sponsored basic research,"[14] and is becoming increasingly more popular as a vehicle to obtain R&D sponsorship. An unsolicited proposal is defined as

> A voluntary offer, plan, or article based on a novel design concept, idea, suggestions, or improvement of a proposed project, study, or development and submitted for evaluation in such form as to constitute a proposal for a specific project or contractual undertaking. Inclusion of the subject matter in a Government publication . . . does not constitute an act of solicitation by the Government, and proposals submitted on this basis are considered unsolicited.[15]

According to Barron:

> Unsolicited proposals are a growing subject of support from Government agencies. This is probably due to (1) the increased generation of new ideas and approaches generally, (2) encouragement through Government willingness, through overhead, to finance company IR&D, (3) advance publication by Government agencies of notice of needed technology, and (4) the probability of economic pay-off to the successful concern in follow-on work.[16]

[14] Elderd, p. 30.

[15] AF R&D Contracting Officers' Handbook, p. 2-33.

[16] Barron, p. D-13.

The significance of the unsolicited proposal as a vehicle for obtaining government sponsorship of research is suggested by Nichol's findings "wherein the company indicated that its acceptance rate of unsolicited proposals was 30 percent, a figure higher than the percentage of contract awards vs. the number of formal company bids."[17]

The subject of unsolicited proposals is important to this study for two principal reasons. First, it is an important avenue of government support of private R&D. Sponsorship is accomplished through grants and contracts making the unsolicited proposal an important aspect of the contracting process. Second, it is important because of the extensive role of scientists and engineers in processing unsolicited proposals.

An unsolicited proposal in certain respects presents more complex problems for scientists and engineers than the solicited proposal as illustrated by the following:

> Because an unsolicited proposal should be handled and treated as a sole-source offer, procurement personnel must make certain that they are dealing with a proposal that is truly unsolicited. This is frequentl an extremely difficult distinction to make. For example, technical personnel from industry and Government often develop close personal relationships through repeated meetings at scientific symposia, panels, and so on. At such a meeting there might be an inadvertent disclosure by Air Force Personnel of information relating to prospective Governemnt procurements. Taking advantage of such a disclosure, an unscrupulous or overambitious contractor might submit a proposal in advance of formal procurement action with the claim that his proposal is unsolicited

[17]Nichols, p. 13.

and deserving of special treatment.[18]

The unsolicited proposal presents a dual assignment for scientists and engineers. First, they must evaluate the proposal from the standpoint of technical and project desirability. If the decision is to support the proposal, the scientist and engineer must evaluate the appropriateness of competitive versus non-competitive processing.[19] From the viewpoint of the technical evaluation, the procedure is essentially the same as for any other procurement; a determination for competitive procurement would result in a formal solicitation and processing as a standard competitive procurement. A non-competitive determination results in negotiation with the source of the proposal and ultimately award of a contract. Appendix 4, a descriptive model of the decision process for unsolicited proposals, provides greater insight into the details of scientists and engineers' roles in the evaluation process.

Negotiation - A Mechanism for Focus

Regardless of the approach taken in selecting the final contestants, it is almost always necessary to conduct negotiations subsequent to the evaluation activities in order to establish mutually acceptable contractual arrangements. It is extremely unlikely in a major R&D situation that the

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[18]AF R&D Contracting Officers' Handbook, p. 2-34.

[19]NASA, Procurement Regulations, p. 426.

parties will be in complete agreement on the multitude of factors that the contract must include without first having a mutual exchange of views. The technical approach, detail implementation plans, reporting requirements and similar matters must generally be worked out in personal confrontations between the parties. Similarly, the contract cost and profit or fee arrangements, the regulatory provisions and schedules are directly related to the work requirements and must be jointly resolved.

Negotiations, particularly in large R&D situations, like most aspects of the contracting process, are a multi-disciplinary team effort. In situations involving formal evaluations by a Board, the negotiation process is often a continuation of evaluation activities. The advantages of continuity in evaluation and negotiation are recognized in the regulatory guidelines for SEB appointments, which state that

> In order to provide for continuity of evaluation and negotiation of the resulting contract, consideration should be given to including the individual who will negotiate the contract with the successful offeror(s) as a Board member when practicable.[20]

There is no essential difference in the negotiation techniques of a procurement utilizing SEB procedures and a non-SEB procurement. The team, in both cases consists of technical and business personnel involved in the particular procurement. Furthermore, in both cases it is a formal aspect of the contracting process which has the objective of "complete

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[20] Source Evaluation Board Manual, p. 3-1.

agreement on all basic issues."[21] Paul McDonald provides an excellent description of the process of negotiation as used in the context of government contracting:

> The word "negotiation" in Government contracts is used in a specialized sense. It is not considered to be a process of giving in or of mutual sacrifice in order to secure an agreement. It is rather an attempt to find a formula which will maximize the interest of both parties. These considerations, broadly speaking, apply to all Government negotiations. However, they are tempered, of course, by the environment of the procurement and the particular problem being negotiated. Some people consider negotiation to be mere "horse trading." In many cases, because of lack of preparation or lack of ability of the negotiators representing either the Government, the Contractor, or both, negotiation has many of the elements of "horse trading." Some people consider negotiation to be haggling or dickering as to what each side will accept. Professional negotiation is far more than either of these. It is not a process of mutual sacrifice for the sake of agreement. It is a means by which the buyer and the seller sit down and, by a specialized process of communication called "bargaining," reach agreement on the terms and conditions of the contract or settlement on the issue involved that will reflect a balancing of the interest of the two parties in both the short run and the long run. There are many types of negotiations. In some cases, one side or the other will attempt to secure a settlement heavily weighed in its own favor by a blunt use of bargaining position. The Government may do this where it finds out that the Contractor is extremely anxious to secure the contract. Contractors may do it when they are a sole source or selling a proprietary item to the Government. In these types of cases, either side may take an arbitrary, take it or leave it, position with the other. This is not negotiation, and while it may lead to immediate short range advantage, it generally results in the development of hard feelings and retaliation at the first available opportunity. Since most defense prime contractors and subcontractors are dealing with a very limited market, the use of a very hard nosed bargaining position will generally be detrimental to their long range interests.

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[21] ASPR 3-805.1.

> Negotiation is the use of the techniques of persuasion and logical argument to convince the opposing side to agree with your position. It is designed not to win an argument but to seek a resolution of a complete problem. It is not a series of major battles over individual issues, since who wins on an individual issue in negotiation is unimportant. The success or failure of one side or the other in a negotiation depends on how the total difference on all the issues involved in a negotiation are resolved in an overall solution. The final solution in each case must be considered in relation to its effect on the long range relationship between the two parties.[22]

Scientists and engineers' roles in negotiations are similar to the roles in the evalution process, that of the technical expert. The contracting officer looks to the scientis and engineer for advice and support in all matters directly or indirectly related to the performance of the work, the cost of performance, performance and schedule milestones, and the overall contractual arrangement. Air Force Instructions for scientists and engineers leave little question as to the importance of the role:

> The importance of complete agreement regarding the technical requirements of the work cannot be overemphasized. No meaningful negotiations can take place without such agreement since technical considerations vitally affect price, contract type, delivery schedule, and other contract provisions - indeed the whole contractual framework within which the contractor's performance will take place. Before and during negotiations, therefore, the scientist/engineer must insure necessary clarification or improvement of the work statement. Moreover, he must inform the contracting officer of the specific adjustments in the contractor's technical proposal that are necessary before a definitive contract can be awarded. At the same time, he must tell the contracting officer what trade-offs he can make from a technical viewpoint, in order to reach agreement with the contractor on

[22]McDonald, p. F-1-3.

> price, delivery, and other provisions of the contract. With such advice, the contracting officer can enter negotiations with confidence that the best overall arrangement for the Air Force will result. Otherwise, he is forced to proceed by guesswork which, all too frequently, results in unsound procurement and untold difficulties during contract performance.[23]

Negotiation is the last phase of the "narrowing down" process culminating in selection of the contractor or contractors that will form a partnership with the government. The nature of R&D work and the conditions under which it is performed are such that the best the parties can hope to achieve in the negotiation is a focusing of the many variables in a sufficiently narrow range to warrant the risks concomitant with the undertaking. The state of the art is pushed, the parties traverse unknown fields, and the cost, schedules and performance results can at best only be educated guesses. Government scientists and engineers bring to the negotiation process a disciplined approach to problems and professional skill that is essential to focusing the technical parameters in such a way to best serve the objectives.

Guiding the Partnership

Contract planning, solicitation of proposals, evaluations and negotiation are only means to achieve the ultimate goal of performance. The contractual instrument, the physical product that evolves from this process is in itself worthless; however, as a framework for guiding the efforts of the parties,

[23]AF Laboratory Procurement Management, p. 4-1.

the contract is an invaluable vehicle. The contract is a confirmation of agreements, but it is also the initiation of a partnership, a relationship of joint interest and obligation. The R&D contract is a mutual pact that will produce the desired results only if both parties fulfill their respective obligations.

Conducting a major R&D task is, like all other phases of the contracting process, a multi-disciplinary activity. Teams composed of technical and business professionals skilled in all facets of project implementation converge and join forces to carry out the contract objectives. The Air Force describes the relationship thusly:

> The individual rights and obligations of both parties - the contractor and the Government - are clearly established by the contract terms; however, the actions of one party will condition the other's ability to fulfill his responsibilities. This means that planning is necessary during performance to integrate the actions of both. For example, while the property to be supplied by the Government is specified in the contract, administrative action must be taken after contract placement to integrate plans for its delivery with the contractor's performance schedules and to see that it arrives on time. Other Government actions, such as approval of plans, inspection of mockups, performance of tests and evaluation, and provision of technical information to the contractor may also condition the contractor's performance under a contract.[24]

Scientists and engineers as key members of the government contract management team, perform many vital functions in assuring that the government's interest is protected and that the technical objectives are optimized within cost and

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[24] AF R&D Contracting Officers' Handbook, p. 5-1.

schedule constraints.

Ideally, contracts would be written in such complete terms so as to avoid the necessity for interaction. Such is occasionally the case in formal advertisements and simple negotiated situations; R&D however does not fit such a neat scheme. Its dynamic, ill defined nature dictates a continuous close relationship and exchange of information. An R&D contractor seldom operates in a vacuum. His efforts must normally be integrated with many others to make the total package play harmoniously. In addition, R&D contracts are typically cost reimbursement arrangements in which the contractor has little direct incentive for efficient cost management. In such an environment the government scientists and engineers' role in contract technical surveillance becomes a "Jack of all trades" task.

Roles played by individual scientists and engineers in contract management depends in large measure upon the overall philosophy of the management with regard to contract surveillance. Orlans' comparison of extremes in the AEC experience illustrates this point:

> At one extreme of tight technical control lies a program such as the development of reactors for the propulsion of submarines and other naval vessels, directed by Admiral Rickover, in which technical specifications and time schedules of exacting detail have been prepared, and inspectors have been posted in contractor facilities to monitor the work and test the quality of the product. Comparable controls have been maintained in the production of fissionable materials (in which the Commission has set the production goals and the volume of power, and supplied feed materials to the contractor) and of nuclear weapons (in which virtually every component is numbered

> and can be traced forward throughout the production process to the finished bomb assembly, or backward from the Mediterranean seabed to its originating subcontractor).
>
> At the other extreme, in the programs of basic research by university scientists, technical control has been entirely absent: essentially the only technical control in these programs has been the evaluation of the quality of the scientist and of his proposed work before a contract award or extension.[25]

Perhaps the in-between area is characteristic of most government contract relationships. The government tends to lean in the direction of maximum responsibility for the contractor with emphasis on "monitoring or surveillance" by government personnel. There are of course many exceptions, but for the most part the agencies and departments are oriented to monitoring performances through reporting, conferences, periodic inspections and similar techniques.

In the larger projects a contingent of government personnel are generally located at the contractor's facility or immediately adjacent. The DOD tends to rely on the regular plant representative staff more so than the AEC and NASA, who are more likely to assign their own personnel for the key roles of on-site surveillance. Overall project technical direction is usually under the management of a senior scientis or engineer located in the government contracting organization. The on-site representatives are delegated functional responsibilit for selected areas such as quality, reliability and inspection.

A general practice in R&D contracts is to include a

[25] Orlans, pp. 135-136.

provision identified as a "technical direction," or "technical surveillance" clause. The clause provides essentially that a government technical representative will be designated to perform technical surveillance of the work and technical direction within the scope of the contract. "Direction" is generally defined as filling in details, suggesting lines of inquiry, and in general more specifically defining the work. Such contract provisions almost always prohibit any action by the technical representative that would constitute a "change"[26] of a nature that would result in adjustment in any contract provision. Appendix 5 is a typical "technical surveillance" provision in government R&D contracts.

Danhof describes the impact of the technical direction clause thusly:

> Frequently, however, the contract will contain a "technical direction" clause. To this end government technical personnel will work closely with the contractor's engineers. The project then makes use of the technical know-how of government specialists and perhaps of the staff of one of the nonprofit research centers. Changes will be made at the initiative of the government's technical people or as the firm recommends. Such changes may number in the thousands on a large contract. Each requires approval as to design, and if an increased cost is involved, approval of that is also necessary. The relationship is, as is frequently pointed out, a cooperative one in which many contribute to the objective of obtaining a desirable if not optimum technical goal.[27]

Roles of scientists and engineers in contract managemen

[26] "Change" in contractual context refers to variations in work scope or procedures that warrant contract adjustments

[27] Danhof, p. 273.

are varied and complex. First they are the direct interface on technical matters between the contractor and the government, the contractor's source for clarification of technical requirements of the contract. They are the government's front line of defense in assuring that the technical aspects of the work are performed according to the contract. Scientists and engineers perform various quality and reliability tests and inspect products and reports for contract compliance. The list of specific functions goes on; however, it is sufficient to recognize that scientists and engineers are involved in all areas related to technical performance.

Another important role involves the technical advisor and support functions in assisting the contracting officer with the business management matters. For example, scientists and engineers are the technical experts for purposes of analys of proposed contract changes. They assist in determining if the change is appropriate and in evaluating the impact, if any, on schedule, cost and other contract terms.

Scientists and engineers, as coordinators and integrators, provide an interface between associate contractors and other parties; they provide data such as specifications and reports for the contractor's use, make arrangements for equipment or facilities required by the contractor, and assure contract compliance in areas relating to technical performance. If performance is not according to the contract, they assist the contracting officer in rectifying the situation; and, when the work is completed according to contract requirements, the scientists and engineers' certification is the basis for payment of profit or fee.

PART THREE:

AN OVERVIEW AND LOOK TO THE FUTURE

CHAPTER VII

TOWARD UNDERSTANDING AND PROGRESS

The presentation has, hopefully, achieved the author's objective of providing perspective and insight into the R&D contract system, particularly the roles of scientists and engineers in the process. The purpose of this chapter is to reflect on what has been presented, to discuss the author's conclusions and to suggest areas in which further research would be beneficial.

Guidelines for Research

Observation of participants in contracting activities in major R&D organizations of the government indicate that scientists and engineers frequently do not possess adequate knowledge of the contracting system or understanding of their respective roles in the system. This, it appears, impairs the operational effectiveness of scientists and engineers, and consequently the contracting process. In probing for causal factors, it was discovered that there are multiple causes including neglect of the literature to adequately treat the subject.

The ultimate objective of this research is increased operational effectiveness of the R&D contracting system. The means for achieving the objective is to increase the scientists and engineers' knowledge by providing perspective on the contract system and describing the major roles of scientists and engineers. The objective was pursued through multiple research techniques. The literature was analytically studied to identify pertinent concepts and attitudes, while the author's experience was relied upon for interpretative analysis. Unstructured interviews with government officials supplemented the research providing a well balanced base from which to draw conclusions.

While regulatory and other government related literature constituted the basic source data, the work of private authors was a valuable aid; particularly in describing the contract system. The study focused on the practices of three organizations, the DOD, AEC and NASA. This approach provided broad coverage since these organizations account for an extremely high majority of all R&D contracted by the government.[1]

A Summary

The federal government is the principal sponsor of research and development (R&D) in the United States. In fiscal year 1968, expenditures from all sources for R&D were approximately 25 billion dollars, with the government share being almost two-thirds. or 17 billion dollars.[2] The major share of

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[1]Danhof, p. 75.

[2]Reagan, Science and Federal Patron.

government expenditures for R&D, more than 70 percent,[3] goes to private industry, universities and nonprofit institutions through a complex system of contracting.

Government scientists and engineers play key roles in the contract system. The roles are primarily those of an administrator for the planning, execution, and management of contractual arrangements through which R&D is conducted.

The process of contracting is an inter-disciplinary activity implemented through the team concept. Scientists and engineers as team members, participate in all facets of contracting including preparation of proposal solicitation documents, evaluations, negotiation, and contract managemen

This research fills a void in the literature by providing perspective on the R&D contract system and describing the roles of scientists and engineers in the contracting process.

Perspectives on the Contract System

Evolution of contracting begins with the Constitution which authorized Congress to enact laws for procurement. In the late 1700's the Department of the Treasury was given responsibility for army purchases and in 1795 a Purveyor of Public Supplies was established as the government purchasing agent. An Act of 1809 established the formal advertising requirement which was solidly entrenched by the Civil Sundry Appropriations Act of 1861. There was little change in the law until the Armed Services Procurement Act (ASPA) was passe

[3]Danhof, p. 75.

in 1947. In the interim many problems were encountered due to the rigid requirements of the formal advertising competitive bid system. World War I demonstrated the inflexibility of the system, so in World War II, it was simply set aside and all purchases accomplished by negotiation. The advertising system presented major problems in situations where the work could not be well defined, which is always the case in R&D.

In the early 1940's R&D began to become a major contracting requirement but the negotiation authority of the War Powers Act temporarily avoided the difficulties of the advertising system. By the end of the war R&D contracting had become big business and greater flexibility was essential. ASPA was the answer. Although the ASPA covered only the DOD, the civilian agencies subsequently came under the same or similar statutory provisions.

Since 1940 when almost all R&D was an internal activity, contracting-out has become so popular that it is now a dominant method of project implementation.[4] With this transition, major revisions have also been made in contracting techniques. For example, the cost reimbursement type of contract has essentially replaced the traditional fixed price arrangement in R&D situations. Great strides have been made under the contract system; witness the atomic energy and space achievements confirming, for some at least, that contracting-out is a sound philosophy.

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[4] Ibid., p. 95.

The system for contracting for R&D is extremely complex and important. It has nation-wide political, economic and social implications for both the public and private sectors. Don Price's reference to the system as "federalism by contract"[5] typifies the general theme of most writers that have describe the system. For example, Hannah talks in terms of "regulatio of industry through contracting,"[6] and Nieburg describes it as the "contract state."[7]

Most government agencies have come to rely on the contract system as a primary method of R&D implementation. This fosters relationships between government and private institutions that tend to merge their interests in such a fashion as to distort the traditional "public-private" concept. Large corporations with vast lobbying resources apply pressure for support of projects commensurate with their own interests. Government makes life easy for the corporations by liberalizing the contract arrangements under which they perform, using cost reimbursement, low risk contracts as the standard vehicle for contractual relationships. In addition the government often provides the facilities and many of the operating necessities for the private concerns to perform the work. This type of environment frequently leads to charges of favoritism and corruption and continuous questioning of the "contracting-out"

[5]Price, Government and Science, p. 65.

[6]Reagan, Administration of Public Policy, p. 229.

[7]Nieburg, p. 184.

philosophy. Arguments against contracting-out include the accusation of using private sources to circumvent civil service rules, and congressional manpower ceilings and salary limitations In general, the "pros" argue that the contract system provides a vehicle for the government to tap the resources of the nation when needed rather than maintain large expensive laboratories for only occasional use, and further, that the environment of the private sector promotes greater scientific freedom and encourages innovation more so than government organizations.

Although the steady shift from government to private conduct of R&D continued at an ever increasing rate through the 1950's and into the 1960's, it did not escape criticism. Various investigatory groups criticized contracting practices, but with little noticeable impact. The GAO and Civil Service Commission generally discouraged contracting-out on the grounds that it violates restrictions on manpower and fiscal resources and often involves "non-delegable" type functions. Other investigatory groups such as the Second Hoover Commission and the Bell Committee favored the contracting-out philosophy but recommended it be applied with more discretion. These groups also recognized the value of internal laboratories for maintaining proficiency and increasing contract management skills and recommended increasing government technical capability. Certain elements of the DOD, especially the Navy, and the NASA, have followed the suggestion by establishing laboratories for government scientists and engineers. Overall, however, the contracting-out philosophy appears firmly entrenched as a technique for conducting major R&D projects.

The relationships between government and private sources in the contracting process are an interesting aspect of the system. In the period preceding formal contract activities private concerns are busily engaged in marketing strategy directed to making themselves more competitive. The strategy takes various forms from simple informal contacts and exchange of information to initiating unsolicited proposals for new concepts. Scientists and engineers are the principal government participants in these informal activities being the natural focal point for exchange of information. The significance of the relationships in the period preceding formal contracting action is suggested by the conclusions of several studies of the effect on selection of contractors. Roberts and Nichols' research suggests that the informal relationships between technical personnel is a factor in the eventual selection of contractors. Roberts is so impressed with the significance of the presolicitation activities he suggested elimination of the formal selection process.

After issuance of an RFP, relationships take on an air of formality in almost direct contrast wtih the earlier informal environment. The contracting officer, the official spokesman in contracting matters, becomes the government interface with the private sector. Throughout the evaluation and selection process relations are governed by an environment of "equal opportunity" for contractors. After contract award, scientists and engineers move back into a more direct relationship with contractors in performing the key role of technical surveillance. Although relationships are generally less formal after contract award than in the preceding period, they never revert to the degree of informality existing prior to issuance of an RFP.

Partnerships in Technology

Contractual relationships evolve from basic building blocks designed to establish a sound foundation to best achieve project objectives. Two of the more important foundational elements in R&D contracting are the project planning and organizational concepts.

DOD and NASA have adopted project planning procedures that provide perspective across the total project while segmenting the contracting requirements into manageable phases NASA procedures involve four distinct decision points; preliminary analysis of concepts, definition of concepts, design, and development, while the DOD combines design and development into one phase. The main value of formal project planning lies in its greater assurance of orderly, systematic implementation of projects.

The organization arrangement selected by an R&D contracti organization is closely related to such factors as management attitude toward contracting, project objectives, availability of resources, and philosophy on contract management. Certain generalizations however are characteristic of major government R&D organizations. First, it seems that the project approach is clearly favored over functional organizations. Project orientation increases emphasis on a particular project, but over the long period tends to dilute "expertise"; while functiona organizations maintain a high level of professional discipline. Most R&D organizations utilize a combination of approaches to accommodate the different requirements. Functional arrangements are generally used for purchasing standard supplies and services while the project approach is more common in major R&D areas. Another common characteristic is that the policy function is highly centralized, while operational responsibility is generally decentralized to field activities.

In an examination of contracting practices it is quickly observed that the image of the roles of the participants depicted in the literature is not necessarily indicative of those actually played. Official government literature often depicts the contracting officer as spearheading the contracting activities from start to finish while scientists and engineers play supporting roles. In reality the roles depend to a large extent upon the mission and age of the agency. Roles of scientists and engineers vary from almost total dominance in a young scientific organization politically in the limelight, with a gradual declining of dominance as the organization matures. A point is eventually reached where the contracting officer plays the more traditional role reflected in government literature. In the early life of scientific organizations administrative aspects of contracting are often given low priority; however, as the organization matures, normal management practices tend to receive higher priority.

The transition of R&D work from internal performance by civil servants to contracted performance has had major impact on the roles of scientists and engineers. The role of the government technical expert is a far cry from the traditional laboratory practitioner concept. For the most part scientist and engineers are administrators, planners, schedulers, and overseerers of the work contracted to their counterparts in the private sector. The new roles are more complex than the traditional roles requiring both the technical skills of the profession and the administrative skills of a manager.

Scientists and engineers are active participants in all phases of the contracting process, making identification of major roles highly judgmental. However, the project planning activities, including concept analysis preparatory to project selection, certainly are in the most important category. Here scientists and engineers are concerned with analyzing alternative approaches, selecting promising alternatives and planning the implementation program. An especially important aspect are the decisions regarding work to be contracted and that to be conducted internally. Trade-off analysis must be made to select options that best match capability and resources of the organization and external sources.

After project elements to be contracted are identified and the planning has been approved, the specific contract implementation plan is developed. Although the contract implementation planning (Procurement Plan) is primarily a responsibility of the contracting officer, scientists and engineers make important contributions. For example, the project descriptive data, the technical monitoring plan for the contract, potential sources to be solicited, and the proposal evaluation plan are based largely on contributions of scientists and engineers.

Depending upon the complexity of the project, it is often desirable to conduct briefings with prospective contractors prior to preparation of their proposals. When briefings are conducted, scientists and engineers are generally key participants, because briefings are heavily oriented to technical aspects of the project.

By this stage in the contracting cycle the formal contracting team is generally fully active. Scientists and engineers, like the many other disciplines, function as a team that begins to form early in the process and is completely operative by the time the procurement plan is finally approved. The team develops the RFP, conducts the pre-proposal briefing and after receipt of proposals performs evaluations and conducts negotiations.

Proposal evaluation in major R&D projects is a formal process conducted by an evaluation board staffed with technical and business professionals. The board evaluates the proposals in accordance with predetermined criteria and presents its findings to a selection authority. The selection authority selects contractors for final negotiation or for contract award depending upon agency procedures.

Throughout proposal evaluation and negotiation proceedings scientists and engineers are the government's technical experts and advisors. Their opinions are extremely important since "technical considerations" are the primary basis for contractor selection.

After consummation of the contractual agreement the scientists and engineers' role shifts to one of monitoring the contractor's performance. This last phase of the process is the most important; it is the ultimate objective to which all preceding work is directed.

The techniques for monitoring performance vary from post performance verification based on tests, reports and inspections, to close monitoring of actual performance with an on-site government technical staff. The general practice falls somewhere between the extremes; however, on-site representation is almost always a part of the monitoring plan.

The technical representatives, the scientists and engineers, and contracting specialists maintain a close alliance throughout the contracting process, each supporting the other to achieve the objectives of the contract.

Conclusions

This research confirms what many people suspect or know, that scientists and engineers are an important force in the dispensing of billions of dollars annually for R&D by the federal government. It adds knowledge to the literature bank by describing the roles of scientists and engineers in the system through which the dollars are doled out to private sources. The value of the attempt to provide perspective on the contract system lies in the separation of the "wheat from the chaff"; in the ability to examine the system through the eyes of its critics, leaving final judgment to the reader.

What does it all mean? There are different answers for different people because the meaning, the value, is dependent on many variables including one's value system, the perspective from which the subject is viewed, and the temperament of the time. The author's conclusions are discussed below.

Scientists and engineers have not awakened to the realization of their purpose in most government R&D establishments. Seldom is it ever acknowledged, if indeed even realized, that they are actually administrators. The reason for being for the overwhelming majority of government scientists and engineers is to administer the contract system. Failure to recognize and accept this fact is a major factor in a general lack of enthusiasm toward contracting. Scientists and engineers often view their roles in contracting as a temporary, interim assignment, not a career. Until there is more awareness of the true purpose, the real roles of government scientists and engineers, continued impairment of operational effectiveness in contracting is to be expected.

Scientists and engineers have not awakened to the realization that the contracting system is a tool, one that opens the door to the vast capability of the nation's industrial resources. Too often, the contracting role is viewed as a necessary evil rather than a technique of management. This negative attitude is related to scientists and engineers' failure to recognize their true roles.

The informal relationships that characterize the pre-solicitation phase of the contracting process holds value for both government and private concerns; there are also dangers. The lack of a regimented atmosphere promotes free exchange of information enabling both parties to keep abreast of technical developments. This tends to reduce duplication, and increases the probability that resources will be directed to the right priorities. A "sounding board" benefit is also derived even though high risks are associated with following the advise. The relationships encourage prospective contractors to continually "feel the pulse" of government, to be in tune with the problems. This in turn fosters anticipatory preparation for dealing with problems on the horizon, resulting in shorter lead times for projects. It is doubtful that the private sector could be as well informed or as prepared to respond to government needs without benefit of the informal interaction environment.

On the negative side of the "relationship" phenomenon, Roberts' conclusions that contractor selection is influenced by the pre-solicitation relationships suggests that there is a boundary beyond which informal relationships should not extend. But who is wise enough to know where to draw the line? Perhaps the greater danger lies not in the interaction so much as in the fact that it tends to be most prevalent among the favorite few; the big contractors who are continually involved in government projects. One could reasonably argue that this fosters the "them that has gets" environment. If there is merit to such an argument, logical questions are: Are government projects too narrowly conceived and are they overly influenced by what the private sector finds profitable rather than what is best for the public? The evidence is not conclusive or even sufficient to draw tentative conclusions; history indicates, however, that the pendulum often swings too far before correcting itself. Further study will be required before conclusions can be reached as to whether such is the case in the informal relationships of the contracting system.

The contracting system may well have become a justifiable end in itself. While the system evolved as a means to bring industrial resources to bear on government problems, its by-products are of extremely great importance to society. Whether one agrees with the legislation on labor practices, equal employment opportunity and the like, or not, the contract system is an effective method to gain compliance. Similarly, the contract system provides a handy vehicle for implementing government policy on control and distribution of labor resources. Peck and Scherer concluded that political considerations have not played a major role in choosing contractors for advanced weapon programs;[8] however, the selection process is heavily

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[8]Peck, p. 381.

judgmental providing flexibility for considering the extra-contractual variables.

Management must share the blame for the scientists and engineers' lack of appreciation of roles in the contracting system. Recognition of the "administrator" role and its importance is largely an educational process. This can be achieved by various training techniques; however, in the case of "contracting," an effective method would be for the management to display a more positive attitude, to advertise the importance of contracting roles.

There is a tendency for R&D organizations to be either "technical or business" oriented. This seems to be related to the priorities of the organization and indirectly to the age of the organization. Hopefully, new organizations can benefit from the experience of AEC and others in finding ways to achieve better balance. One approach would be to place greater emphasis on an inter-disciplinary team concept. This would provide appropriate balance between technical and business personnel in a team arrangement from start to finish on major contract efforts. The question of "appropriateness" is of course the key. The appropriate balance is whatever is required to assure consideration of all significant factors.

Perhaps the nature of government contracting is such that the critical, negative tone of the literature is to be expected. However, the criticism notwithstanding, some rather outstanding achievements by the United States would likely not have occurred without the system. The atomic energy program, and space exploration are notable examples. In reality the contracting process is far more obejctive and modern and far less subject to political and pressure group influence than suggested by the literature. The check and balance techniques of the contractor selection process are such that intentional manipulation is highly unlikely. Research with the objective of identifying the positive aspects of the contract system would be a valuable contribution to the literature.

Looking to the Future

The system of contracting for R&D is one reason the United States is the world leader in overall technological achievement In spite of its youth, the system is well instilled as a proven medium for accomplishing difficult scientific tasks. For all the criticism, no one has come forward with a better method of joining private and public resources to achieve government objectives. The indicators suggest that the future holds an even greater role for the contracting system and that scientists and engineers will continue to be key participants. With this in mind, some challenges for the forward thinking, those with vision for better things, are discussed below.

The present system for selecting contractors accomplishes the objective but extremely inefficiently. Contractors spend millions of dollars annually and tie up their best talent to prepare proposals. The government has numerous professionals working for months on every major R&D project preparing the solicitation documents and evaluating proposals. Is it all necessary? Elderd suggests that it is a "going through the motions" exercise, that little more than time and cost is added by the formal selection procedure.[9] Elderd's conclusion is based largely on Roberts' studies which indicate that the decisions are made in the pre-solicitation phase. While the author does not support these conclusions, there is an alternative to the selection system that warrants study. The alternate is based on the premise that the government has an operating system that can provide all essential information regarding a contractor's capability for a particular project without requiring a technical proposal by the contractor. The system consists of the government's network of plant representatives, and other data gathering sources such as the Defense Contract Audit Agency. With appropriate procedures, overall capability of a firm could be determined unilaterally. The same philosop extends to the contractor's capability to organize a managemen team to carry out a task. The theory is simply that the government system for obtaining basic information can be applied to the selection process; and further, that fair subjective evaluations could be made without significant interface with the contractor except to negotiate price and other terms.

Organizations that contract for R&D should consider methods of achieving better integration of technical and business disciplines in the early planning phase. Perhaps

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[9]Elderd, p. 71.

assignment of inter-disciplinary teams to be responsible for certain areas rather than specific contracting requirements would provide continuity throughout the contracting cycle as well as a desirable "balancing" effect.

Scientists and engineers assigned contracting roles should receive formal indoctrination and training prior to assignment and periodically, particularly in the contract management area. Many organizations could benefit from following the Air Force example in developing a contracting guidance document designed specifically for the scientist and engineer.[10]

All the conjecture regarding the effect of informal relationships notwithstanding, there has been no comprehensive research to determine the impact of extended interaction between government and private sources. This is an interesting and valuable area for further investigation. The study should focus on the relationships that continue over long periods such as those found in the contract management area on major programs. What effect, if any, do such relationships have on ability of government contracting personnel to negotiate equitable settlements? Can they continue to drive a hard bargain over long periods of time with the same people in the private sector?

A Final Note

A constant concern of the author while preparing this

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[10] Air Force Laboratory Procurement Management, AFSCP 70-3.

report was that the contracting process would be erroneously depicted as a neat sequence of well planned and methodically executed steps. Such an image would be erroneous indeed, fo the process is in reality dynamic, characterized by parallel activity and constant changing of plans.

It is by design that this study covers a broad spectrum rather than a more intensive investigation of selected phase of the contracting process. It is the author's belief that a broad perspective is the logical first step in gaining an understanding of a complex subject. This study is the first step in providing insight into the roles of scientists and engineers in R&D contracting. Hopefully, others will be encouraged by this beginning to extend the work into an in-depth analysis of the many facets of the subject.

The demand for informed scientists and engineers in contracting roles will grow as the technological endeavors become increasingly more complex. Application of computer technology and other scientific techniques in contractor selection and design of mutually optimizing contract terms are possible examples of tasks of the future. Perhaps the real value of this study is to encourage awareness of the importance of the subject; greater appreciation and understanding will come if there is sufficient interest and desire to learn.

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APPENDIX 1[a]

SUMMARY OF PROCUREMENT ASPECTS OF PHASED PROJECT PLANNING[b]

		PHASE A Preliminary Analysis	PHASE B Definition
1.	Number of Contracts	Individual study contracts (separate Work Statements).	Individual study contracts (normally separate Work Statements).
2.	Competition	Competitive, in the broad sense, based on scientific & technical competence in the particular study area (or noncompetitive, where appropriate, including unsolicited proposals).	Open competition (unless noncompetitive justified).
3.	Type of Contract	Fixed Price: Where costs can be realistically estimated. Cost Plus Fixed Fee: Where costs cannot be estimated realistically. Funding Levels: a. Amounts depending upon contractor's needs. b. Equally funded contracts where expected costs & experience warrant.	Cost Plus Fixed Fee: Where costs, includi subcontract effort, cannot be estimated realistically. Fixed Price: Where costs can be realistically estimated. Funding Levels: a. Amounts dependin upon contractor's needs; or b. Equally funded contracts where expected costs & experience warrant.
4.	Procurement Plan	Individual procurement plans	Single procurement plan[c]

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[a] _Phased Project Planning Guidelines_, pp. A-8 - A-9.

[b] This phasing is not a rigid process. If necessary information has been otherwise developed, phasing may begin a any phase and intermediate phases may be eliminated or combin

[c] Where more than one major system is involved, multiple plans (Single plan for each system) may be required.

APPENDIX 1 (continued)

		PHASE A	PHASE B
5.	Synopsis	Subcontract opportunity. Prime contract (unless non-competitive).	Synopsize.
6.	Request for Proposal (RFP)	RFP issued where appropriate (may be noncompetitive, including unsolicited proposals).	RFP issued.
7.	Contractor Selection	Contracting officer selection (unless SEB required or determined desirable).	Source Evaluation Board (SEB).

		PHASE C Design	PHASE D Development/Operations
1.	Number of Contracts	Two or more contracts[d] (single Work Statement).	One contract (single Work Statement).
2.	Competition	Open competition except restricted to contractors with capability to perform Pahse D.	Restricted to Phase C contractors (except for unusual cases).
3.	Type of Contract	Cost Plus Fixed Fee: For large contracts where costs, including subcontract effort, cannot be estimated realistically. Incentive: Phase D contract is motivating factor. Where single contractor, or other special cases, award	Incentive type which reflects achieved definition, highest reasonable risk assumption, & Government's objectives. Large NASA R&D projects have shown CPIF most suitabl More experience and better definition may permit FPI or FP. Smaller or less complex projects may permit FPI

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[d]Factors of funding, ability to develop sound cost estimate and incentive parameters, significance of time element, and limitations on ability to handle multiple interfaces may dictate selection of single contractors.

APPENDIX I (continued)

		PHASE C	PHASE D
		fee contract may be feasible.	or FP.
		Funding Levels: a. Amounts depending upon contractors' needs; or b. Equally funded contracts where expected costs and experience warrant.	
4.	Procurement plan	Single procurement plan[e]	Single procurement plan.[e] (Where applicable, hase C plan can be ıpdated.)
5.	Synopsis	Synopsiz	ynopsize (subcontract opportunity only) unless new contractors introduced.
6.	Request for Proposal	RFP issued.	Issue revised Work Statement and request revised contractor proposal.
7.	Contractor Selection	Utilization cf Phase B SEB desirable.	Utilize Phase C SEB to maximum possible extent

[e]Where more than one major system is involved, multiple plans (Single plan for each system) may be required.

APPENDIX 2

SAMPLE
PROCUREMENT PLAN[a]

Advanced Studies Branch, SEKMA

Buyer: S. L. Croucher, SEKMA   Date: 28 January 1966

1. Purchase Request:

a. Number - 6-3406, Dollar Amount - $250,000.00, Date Received - 26 January 1966 (Adv. cy.).

b. Year and type funds - FY 66/630

2. R&D Program Description:

a. This procurement is for an expansion and continuation of contract AF 33(657) - 11519 to define the requirements for the evaluation of chaff characteristics for tactical aircraft application.

b. Deliverable items shall be in accordance with the work statement.

3. Method of Procurement Action and Authority:

a. Negotiation

b. 10 U. S. C. 2304 (a)(11) - D&F Authority to Negotiate is attached.

4. Source Information:

a. Sole Source -

(1) Source - Tracor Inc.
4525 Ed Bluestein Blvd.
Austin, Texas

(2) Justification - see File Item 1. This office concurs in a sole-source solicitation of the above-named contractor. The concurrence with a sole-source solicitation is based on the facts that this work represents a direct follow-on and integral portion of the research being performed under contract AF 33(657)-11519. The project engineer has indicatdd to the undersigned buyer that this procurenent should be the final effort on the program. It

[a]AF Laboratory Procurement Management, pp. 1-12 - 1-13.

is not felt that any net advantages would accrue to the Air Force as a result of a multi-source solicitation for this final procurement effort.

5. Type of Contract Contemplated. It is contemplated that a Supplemental Agreement will be written to Firm Fixed Price Contract No. AF 33(657)-11519.

6. Record of Previous Procurement. A previous procurement of a similar nature is presently being accomplished under Contract AF 33(657)-11519. This information available from the basic procurement will be utilized for price compariso purposes where deemed feasible.

7. Delivery Schedule. A contractual period of 12 months is contemplated. Delivery dates for items to be submitted will be negotiated.

8. Contract Placement Date and Forecast of Significant Milestones. To be established upon receipt of funded copy of Purchase Request.

9. Technical evaluation of this procurement will be accomplished by personnel of SEAEM.

10. Reliability - Maintainability Requirements. To be continued in accordance with the basic contract.

11. Special Conditions or Considerations:

a. A request for extension of contract AF 33(657)-11519 beyond the 3-year limitation set forth in AFPI 1-357 is being forwarded to SEK for approval.

b. The use of milestone forecasting is not applicable to this program as monthly status letters will not be required.

12. Procurement Plan prepared by:

APPROVED:

S. L. CROUCHER
Buyer

R. A. Lawson
Contracting Officer

O. M. McGLONE
Chief, Advanced Studies
Branch, Directorate of
R&D Procurement

APPENDIX 3

REQUEST FOR PROPOSAL

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

FEB 2 0 1970

REPLY TO
ATTN OF KD5

TO : Prospective Contractors

SUBJECT : Request for Proposal No. 10-8423
Space Shuttle System Program Definition (Phase B)

1. You are invited to submit a proposal for the Space Shuttle System Program Definition -- Phase B. Your proposal should cover all work described in the enclosed proposed contract schedule and contract statement of work, including all exhibits and appendices thereto.

2. The fundamental purpose of the Space Shuttle System Program Definition Study is to define a low-cost, economical space transportation system for which the operational costs and development costs are appropriately balanced to minimize total program cost. The enclosures identified in paragraph 1 above describe an eleven (11) month contract period. The proposed contract will be for the Space Shuttle System Program Definition Study and will have the following as its primary objectives: (a) defining a Space Shuttle System, (b) accomplishing a preliminary design of the Space Shuttle (Orbiter and Booster) for both a high and low cross range capability, (c) obtaining an understanding of the scope, timing and cost of the Space Shuttle System, and (d) obtaining an understanding of the supporting research and technology which must be accomplished.

3. Your proposal should fully comply with all the instructions contained in this Request for Proposal and enclosures hereto. Failure to do so could result in your proposal being considered unacceptable and/or could cause delays and misunderstandings which could, otherwise, have been avoided. The following enclosures constitute requirements for this Request for Proposal and should be fully complied with as indicated in each enclosure:

a. General Information (Enclosure No. 1)

b. Instructions for Preparation of Proposals (Enclosure No. 2)

c. Proposed Contract Schedule and General Provisions (Enclosure No. 3)

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d. Statement of Work, Space Shuttle System Program Definition (Phase B) (Enclosure No. 4)

e. Certifications (Enclosure No. 5)

f. Certification of Nonsegregated Facilities (Enclosure No. 6)

4. It is anticipated that a Fixed Price Research and Development type contract will result from this solicitation. In view of the nature of the proposed procurement, the proposer is not encouraged to submit alternate proposals with regard to contract type.

5. a. To fully accomplish the proposed procurement (Phase B Study), NASA currently contemplates the award of up to three parallel contracts of the type described above. The plan for administering the contracts is to place contractual responsibility for one or more total systems studies at the Manned Spacecraft Center (MSC) and one or more total systems studies at the Marshall Space Flight Center (MSFC). The choice of contract assignment will be at the Government's option only. The respective Centers will designate Contracting Officer Representatives to provide the technical surveillance and interface coordination which will be required during the contractor's performance. The contracts will be performed concurrently over the eleven-month period.

b. During the Phase B Study effort both MSC and MSFC will be responsible for the technical direction of that part of the total system for which the Center will assume ultimate responsibility in later phases of the program. In this regard MSC will provide technical direction of the Orbiter element, with MSFC providing technical direction of the Booster element of each of the total systems contracts regardless of whether it (the Center) holds overall responsibility for that total systems contract. (See subparagraph c below.) The Program Study Office located at each Center will contain an integration group that will be composed, in part, of personnel from the other Center. Elements of these integration groups will also work with an integration team reporting to the Office of Manned Space Flight, NASA Headquarters. This Phase B Study Management Plan is graphically depicted in Figure No. 1 to this letter.

c. It is recognized that proposals may be submitted which are based upon the Orbiter design effort being performed by the offeror himself, and the Booster effort being performed by a subcontractor (or vice versa). In view of the Phase B Study Management Plan described in subparagraph b above and to insure that the technical emphasis given to various aspects of this activity is consistent with overall program requirements and long range planning, it will be necessary that MSC and MSFC receive information directly on a current basis from and have the capability to communicate technical

PHASE B SHUTTLE STUDY MANAGEMENT PLAN

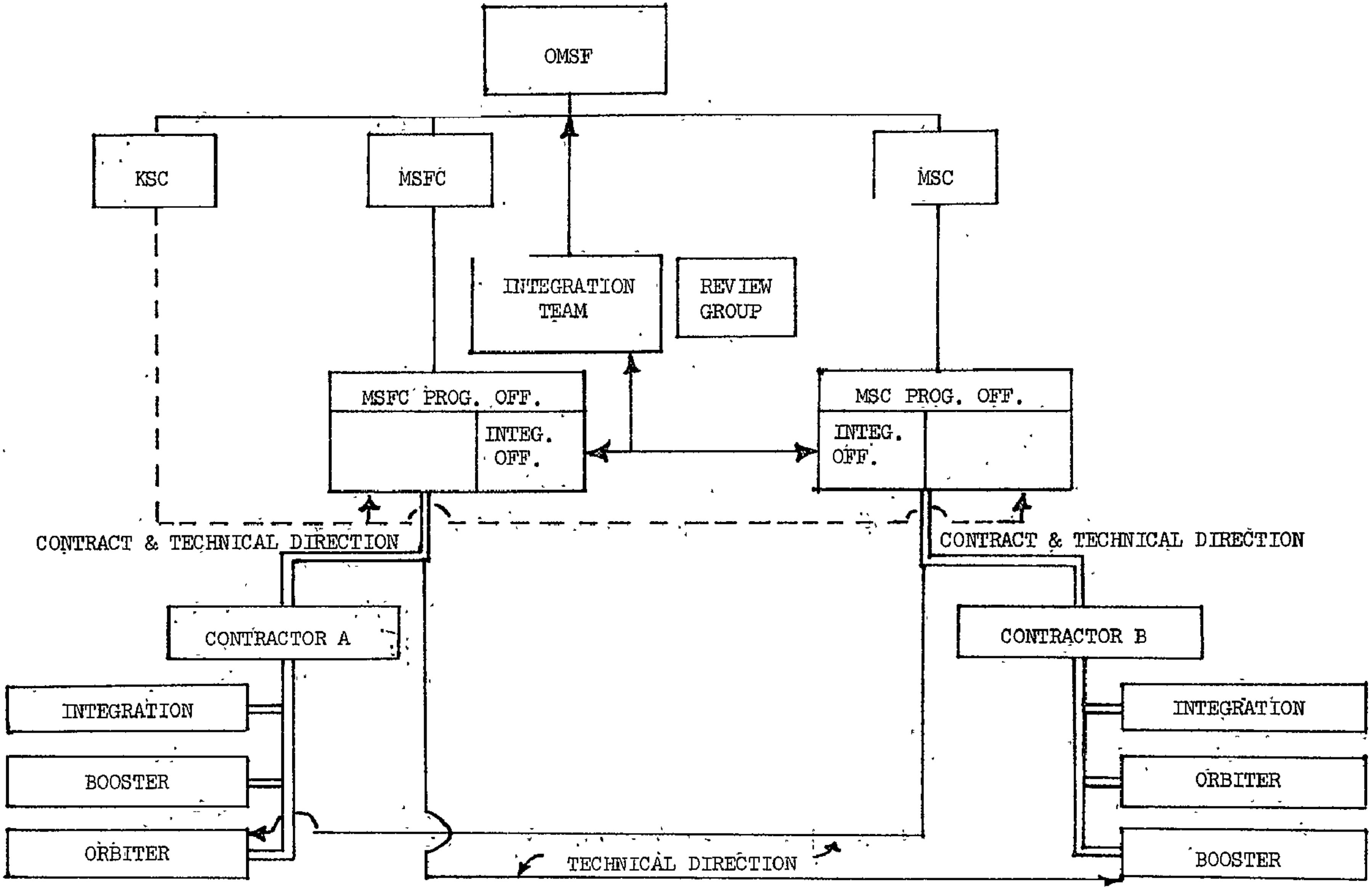

Figure No. 1

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direction to any subcontractor performing work in each Center's primary area of responsibility. Therefore, Schedule Article XII will be applicable to any contractor who proposes to enter into a subcontract for either the entire Orbiter or entire Booster design effort.

6. As noted above, NASA presently contemplates the award of up to three Phase B contracts. The exact number will be determined later based on facts and circumstances then existing. However, you are instructed to propose a Phase B -- Study Program based on $8 million worth of work. NASA reserves the right in any event to award a different number of contracts and at different funding levels from that now contemplated.

You are further advised that in accordance with the SOW paragraph 3.0, successful contractors will be required to submit a proposal for conducting a large scale structural demonstration program. Should NASA determine that such a program, as proposed and subsequently negotiated, meets overall program requirements, additional funding for the work will be provided by supplemental agreement to the basic contract.

7. For your further information, the results of the "Phase B" studies to be provided under the proposed procurement will be analyzed by the NASA to ascertain and identify the most desirable approach for the Space Shuttle Vehicle Program implementation. Consequently, no decision has been made relative to the specific contractual approach to be employed for any follow-on phase(s). For example NASA may contract for further design and development of the space shuttle on a total system basis, or award separate contracts for each of the major system elements (Orbiter, Booster and other). Accordingly, NASA intends to maintain complete flexibility to examine alternative program and contractual arrangements for any follow-on procurements, including complete flexibility as to contractor teaming arrangements. However, in the event procurement action is initiated for any subsequent phase or phases (reference NASA Headquarters Bulletin 7121.2 entitled "Phased Project Planning Guidelines"), it is intended that competitive procedures will be utilized.

8. A preproposal conference will be conducted at 9:00 a.m. on FEB 2 7 1970, in Room No. 6104, National Aeronautics and Space Administration, Federal Office Building No. 6, Fourth and Independence Avenue, Washington, D. C. The purpose of this conference is to provide prospective offerors an opportunity to obtain clarification on any aspect of this Request for Proposal. Limited accommodations make it necessary to restrict attendance at this conference to prospective offerors who have a reasonable expectation of submitting a proposal. For this reason, it is intended that a maximum of six

representatives will be admitted from each firm that has received a copy of the Request for Proposal. Names of the personnel who will attend must be furnished no later than FEB 2 5 1970 . Arrangements may be made for additional representatives, accommodations permitting, provided a written request is received no later than FEB 2 6 1970 .

In addition to the admission clearance requirements, questions for presentation at this conference and any questions in connection with the RFP should be submitted in writing to the National Aeronautics and Space Administration, Washington, D. C. 20546, Attention: Mr. Philip Sload, Code KD-5, by FEB 2 6 1970 . Questions arising at the briefing will, at the Government's option, either be answered at the briefing or will be answered later in writing to all firms indicating an intent, (in accordance with paragraph 13 below), to submit a proposal.

9. In the event that any subsequent questions arise during proposal preparation, they shall be submitted in writing to the address specified in paragraph 8 above (Mr. Philip Sload, Code KD-5). Any resulting interpretation or clarification by the Government shall be made in writing to all firms indicating an intent, (in accordance with paragraph 13 below), to submit a proposal. Any additions, deletions, or changes to the Request for Proposal will be made by NASA RFP Amendment. Each Amendment will be identified by number, and receipt thereof shall be acknowledged in your proposal. The NASA will not be responsible for interpretations or clarifications from any source other than that identified in paragraph 8 above and in accordance herewith.

10. The enclosed Contract Schedule, General Provisions and the Statement of Work, comprise, generally, the terms and conditions which the Government proposes to include in any contracts resulting from this solicitation.

Your proposal transmittal letter should include a statement of acceptance of these provisions and/or explanation regarding any objection you may have toward them. The proposed contract provisions which appear incomplete are subject to later resolution by negotiation.

11. All prospective offerors are advised that any data developed as well as that specifically used in performing work under any resulting contract, must be made available to the Government with unlimited rights to reproduce, use, and disclose the data, subject to special use restrictions, if any, agreed to by the parties for proprietary data. Further, the data required by any resulting contract may be utilized in the preparation of NASA in-house reports and, as needed, made available to any firm performing Phase B studies, and/or firms which may perform future phases or related efforts.

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Further, the data may be published for general distribution, subject to the use restrictions agreed to, if any, for proprietary data. This policy will be implemented in any resulting Phase B contract(s) by special data provisions. (See Articles XV through XIX of Enclosure No. 3, "Proposed Contract Schedule".)

12. Your proposal must be submitted in one hundred and fifty (150) copies to the address specified in paragraph 8 above. The proposal must be signed by an official authorized to bind the offeror, and it shall contain a statement to the effect that the proposal is firm for a period of not less than one hundred twenty (120) days from the due date specified below. Offerors shall identify in proposals a neogitiation team leader and the name, position, title and telephone number of the person or persons authorized and available to negotiate, change proposals, and bind the proposer with respect to this requirement. Proposals shall be properly identified with the RFP number and must be mailed or handcarried so as to arrive at the address specified in paragraph 8 above on or before 4:45 p.m., EST MAR 3 0 1970 .

13. You are requested to promptly acknowledge receipt of this Request for Proposal by providing written notification to the address specified in paragraph 8 above of whether or not you intend to submit a proposal.

14. a. Proposals submitted pursuant to this solicitation will be evaluated by a NASA Source Evaluation Board appointed by the NASA Associate Administrator for Manned Space Flight. The criteria to be considered by the Board in evaluation of proposals are set forth as numbered sections 1 through 6 in paragraph 2 of Enclosure No. 2. Numbered sections 1 through 3 are considered Technical criteria while numbered sections 4 through 6 are considered Business-Management criteria. In evaluating the three Technical sections, primary consideration will be given to the information received under numbered section 2 (Study Approach). Secondary consideration will be given to the information received under numbered section 1 (Configurations) and relatively less consideration will be given to the information received under numbered section 3 (Technical Experience/Capability and Personnel). In evaluating the three Business-Management sections, information received under numbered section 4 (Organization and Management) will be considered of primary importance. Information received under section 5 (Company Capability and Performance) and section 6 (Resources and Schedules) will be considered of approximately the same importance, but each individually will be considered of slightly less importance than the Organization and Management section.

Upon completion of evaluation of Technical and Business-Management sections, in accordance with the foregoing, the combined evaluated rating of sections 1, 2 and 3 will be considered in relation to the combined evaluated rating of sections 4, 5 and 6.

In this regard, the Technical evaluation will bear approximately twice the weight of the Business-Management Evaluation. However, contractors should recognize that those proposals which are evaluated highest in all sections will have the greatest competitive advantage.

b. The evaluation of your proposal will consider all material you provide and other factors which will include past performance records obtained from the NASA and the DOD contractor data bank. During the course of the proposal evaluation the Source Evaluation Board may conduct discussions with personnel who have overall responsibility for the preparation of the proposal. Such discussions may be conducted at the cognizant Government installation, in writing or by telephone as appropriate. In addition, offerors may be invited to make an oral presentation after submission of proposals. In the event a presentation is desired, offerors will be notified of the time and place for such presentation. The Board may also wish to visit your company to perform a plant inspection. Information obtained from the above may have an important bearing on final proposal evaluations.

15. The contractor must possess the capability to accomplish all requirements of the Phase B Study. While this capability may be totally in-house or through subcontracting or other appropriate acquisitions of the capability, the contractor must possess the capability to assume full responsibility for all elements of the Phase B Study described in this Request for Proposal.

16. The Government considers as capable of accomplishing all requirements of this Phase B Study only those concerns who evidence, to the Government's satisfaction, a capability to perform as a prime contractor for a major program element of Phase C and D. An integral part of such evidence is past experience as a major contractor in the research and development and integration of complex aerospace systems.

17. Finally, supplemental proposals or additional data submitted after the time and date specified in paragraph 12 above, unless requested by the NASA or resulting from oral or written discussions, will be treated as "late proposals". In accordance with the provisions of NASA PR 3.802-4(c), the Government reserves the right to consider proposals or modifications thereof received after the date indicated for such purpose, but before award is made, should such action be in the interest of the Government.

It is therefore essential that proposals as submitted be complete, definitive, and suitable for evaluation.

Dave W. Lang
Chief Negotiator, Space Shuttle
Program -- Phase B

Enclosures 6

Enclosure No. 1 - General Information
Enclosure No. 2 - Instructions for Preparation of Proposals
Enclosure No. 3 - Proposed Contract Schedule and General Provisions
Enclosure No. 4 - Statement of Work, Space Shuttle System Program Definition (Phase B)
Enclosure No. 5 - Certifications
Enclosure No. 6 - Certification of Nonsegregated Facilities

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ENCLOSURE NO. 1

GENERAL INFORMATION

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Enclosure No. 1

GENERAL INFORMATION

1. RIGHT TO CANCEL RFP

This request does not commit the Government to award a contract. The Government reserves the right to reject any or all proposals.

2. CONTRACTING OFFICER AUTHORITY

The Contracting Officer is the only individual who can legally commit the Government to the expenditure of public funds in connection with this proposed procurement.

3. INFORMATION AS TO SMALL BUSINESS CERTIFICATE (IF APPLICABLE)

The prospective contractor must state whether or not he has ever been refused a Certificate of Competency by the Small Business Administration.

4. COST OF PROPOSAL PREPARATION

This request for proposal does not commit the Government to pay any costs incurred in the submission of the proposal or in making necessary studies or designs for the preparation thereof, nor to procure or contract for services or supplies.

5. ADDITIONAL FACILITIES

In the event additional Government-Furnished facilities are required, the provisions of NASA Procurement Regulation 13.5102(b) will apply.

6. CERTIFICATE OF CURRENT COST OR PRICING DATA

If this procurement exceeds $100,000.00 the successful contractor is required to certify that the cost or pricing data furnished by him is accurate, complete, and current. The required form of this certificate is set forth in paragraph (b) of the "Contractor and Subcontractor Certified Cost and Pricing Data" clause (October 1969).

7. DISPOSITION OF DRAWINGS AND SPECIFICATIONS

Drawings and specifications furnished as part of this RFP shall not be returned to the Government unless otherwise specified.

8. USE OF AUTOMATIC DATA PROCESSING EQUIPMENT (ADP)

In all cases where the use of ADP equipment is considered, the following provision becomes operative: "The Government reserves the right to require the preparation and submission of feasibility and lease versus purchase studies by the successful contractor if the use of Automatic Data Processing Equipment is proposed."

9. DEFENSE CONTRACT ADMINISTRATION SERVICES REPRESENTATIVE

In order to facilitate price analysis, audit, or other surveys that may be required, the offeror agrees to make available to representatives of Defense Contract Administration Services Region (DCASR), or Defense Contract Audit Agency (DCAA), upon request by such representative, a copy of the proposal furnished to the Government.

10. COGNIZANT CONTRACT ADMINISTRATION AND AUDIT AGENCY

Offerors shall provide a list of Government agencies having onsite plant cognizance in which the offeror intends to perform the work or, in the absence of onsite plant cognizance, the area/regional/district Government agency office having cognizance over such plant(s) for the following factors:

a. Government contract administration.

b. Government-owned facility management, utilization and maintenance

c. Material, reliability and quality control inspection.

d. Inspection for Government acceptance.

e. Labor and industrial relations.

f. Utilization of Small Business and Labor Surplus Area firms.

g. Industrial and personnel security.

h. Government audits.

11. GOVERNMENT-FURNISHED PROPERTY

Unless otherwise specified and listed in this Request for Proposal, no property shall be furnished the contractor for use in performance of the contract.

12. PATENT ROYALTIES

If this proposal exceeds $2,500 and is not for the procurement of nonpersonal services, the following applies:

Upon timely notice by a patent owner to the Contracting Officer that this procurement will infringe his privately-owned U. S. patent, and upon a determination by NASA Patent Counsel that this procurement will infringe the patent, NASA may enter into a patent license agreement with the patent owner prior to an award of a contract pursuant to this Request provided the following conditions are satisfied:

a. The pertinent claim or claims of the patent have not been held invalid by an unappealed or unappealable judgment or decree of a court of competent jurisdiction or determined to be unenforceable against the Government by any department or agency in an administrative claim procedure;

b. The patent owner demonstrates that his patent is respected commercially as evidenced by one or more royalty-bearing commercial licenses under the patent, or the patent owner shows that his patent has been held valid by an unappealed or unappealable judgment of a court of competent jurisdiction;

c. The patent owner offers to license NASA for the proposed procurement at a reasonable rate which in no event should exceed the lowest rate at which he has licensed a private concern; and

d. The Contracting Officer, in consultation with NASA patent counsel, determines that entering into the license agreement will not unduly delay the procurement.

Under the agreement royalties will be payable to the patent owner only if the patented item is procured from an unlicensed source and only upon acceptance by NASA of the patented item. These royalties will be considered by NASA as a factor in determining the proposal which is most advantageous to the United States. Before any royalty payments are considered for evaluation purposes, each offeror will be given an opportunity to show that he is a licensee under the patent determined by NASA patent counsel to be infringed by the procurement. Any offeror who fails to show that he is a licensee under such patent will be regarded as an unlicensed supplier for evaluation purposes.

13. WAIVED INVENTIONS

If the "New Technology" clause (May 1966) is applicable, the following provision applies:

Waived Inventions (May 1966)

a. Under the NASA Patent Waiver Regulations 14 C.F.R. p. 1245.100 et seq., waiver of title to inventions made under NASA contracts may be requested at three different times. Waiver of title to an individual invention may be requested under p. 1245.106 after the invention has been identified and reported to NASA. Waiver of title to inventions not yet identified and reported may be requested under p. 1245.104, prior to execution of the contract, or under p. 1245.105, within sixty (60) days of contract execution. Waiver of title may be requested under any of these sections even though a request under a different section was not made or, if made, was not granted.

b. If you intend to petition prior to contract execution for waiver of title to all inventions which may be made under the contract, you must present such petition with your proposal. The findings which must be made in order for such a petition to be granted are set forth in 14. C.F.R. p. 1245.104 and in paragraphs 9.101-3(d)(1)-(6) of the NASA Procurement Regulations.

c. In the event that it is decided to negotiate a contract based on your proposal, your petition will be forwarded to the Inventions and Contributions Board for consideration. The Board will either make the necessary findings and recommend to the Administrator of NASA that the waiver be granted, or inform the Contracting Officer that facts which are readily available are insufficient to permit a decision to be made without unduly delaying the execution of the contract. In the latter event, you will be so notified and, upon execution of the contract, you may request the Board to consider the matter further. If your request for waiver is granted, Section IV of the "New Technology" clause set forth in 9.101-4 will be made applicable to the contract implementing the waiver.

14. HARD-CORE UNEMPLOYED

Business leaders have formed a partnership with the Government to seek to resolve the problem of hard-core unemployment in the nation's 50 largest cities. A new private and totally voluntary organization, the National Alliance of Businessmen, has been established with Headquarters in Washington, D.C., and branches in each of the 50 cities. Alliance goals are to have 500,000 hard-core unemployed on the job by 1971, and to find 200,000 summer jobs for needy youth of the inner cities.

Although funds for this purpose will not be available under this contract, you are encouraged to participate in this program, and to pledge jobs for and hire certified "hard-core" persons who might otherwise be unemployed. Pledges may be made through the local

NAB Metropolitan Office in your area. Additional information, including information about the local availability of certified employees and possible financial assistance for the excess costs of training under the program, can also be obtained from that office.

15. SMALL BUSINESS SIZE STANDARD

The Small Business Industry Employment Size Standard for purposes of this procurement is 500 employees. Offerors shall use this standard when completing section four of the attached form entitled "Certifications," (Reference Enclsoure No. 5). All applicable sections of this form must be completed and returned with the proposals.

16. FALSE STATEMENTS

Proposals must set forth full, accurate, and complete information as required by this RFP (including enclosures). The penalty for making false statements in proposals is prescribed in 18 U.S.C. 1001.

17. WAIVED PROVISIONS

The following provisions normally required in procurements of this size have been waived for this Phase B study effort only and will be a requirement of subsequent phases if any evolve.

a. NASA PR 3.501(lx) "Plan for New Technology Reporting"

b. NASA PR 3.102(b)(xx) "Cost Reduction Program"

18. PROPOSAL PREPARATION INSTRUCTIONS

The objective of Enclosure No. 2 is to provide specific instructions for prospective offerors to follow in the preparation of their proposal. These instructions are considered essential and must be fully complied with to assure that the Government receives the necessary information, in the appropriate format, to assure that the proposal can be evaluated.

19. PROPOSAL SECURITY CLASSIFICATION

Proposals must be constructed so as to exclude classified information.

20. TECHNICAL DATA

The proposal submitted in response to this request may contain technical data which the offeror, or his subcontractor offeror, does not want used or disclosed for any purpose other than evaluation of the proposal. The use and disclosure of any such technical data may be so restricted, provided the offeror marks the cover sheet of the proposal with the following legend, specifying the pages of the proposal which are to be restricted in accordance with the conditions of the legend:

> Technical data contained in pages of this proposal furnished in connection with RFP No. shall not be used or disclosed except for evaluation purposes, provided that if a contract is awarded to this offeror as a result of or in connection with the submission of this proposal, the Government shall have the right to use or disclose this technical data to the extent provided in the contract. This restriction does not limit the Government's right to use or disclose any technical data obtained from another source without restriction.

The Government assumes no liability for disclosure or use of unmarked technical data and may use or disclose the data for any purpose.

21. ORDER OF PRECEDENCE

In the event of any inconsistencies between provisions of this solicitation, the inconsistency shall be resolved by giving precedence in the following order:

a. Request for Proposal Letter

b. General Information (Enclosure No. 1)

c. Instructions for Preparation of Proposals (Enclosure No. 2)

d. Proposed Contract Schedule and General Provisions (Enclosure No. 3)

e. Statement of Work (Enclosure No. 4)

ENCLOSURE NO. 2

INSTRUCTIONS FOR PREPARATION OF PROPOSALS

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INSTRUCTIONS FOR PREPARATION

OF

PROPOSALS

1. INTRODUCTION

It is NASA's intent by providing the instructions set forth below, to solicit information that will demonstrate your competence to successfully complete the contract requirements (as specified in Enclosure No. 3, Contract Schedule and General Provisions and Enclosure No. 4, Statement of Work) and permit a competitive evaluation of your proposal.

2. GENERAL

a. Your proposal shall be bound in one loose-leaf three-ring binder entitled "Proposal to Accomplish Phase B - Space Shuttle Program." This volume will be divided into a summary and six distinct sections. Listed below are the six sections together with a brief synopsis of their intended purpose and the maximum number of pages each section can contain.

PROPOSERS ARE CAUTIONED NOT TO CONSTRUE THE PAGE LIMITS LISTED BELOW FOR EACH SECTION TITLE AS REPRESENTING THE RELATIVE VALUE OF THE SECTION FOR EVALUATION PURPOSES (SEE PARAGRAPH 14A. OF THE COVER LETTER).

Section Title	Intended Purpose	Page Limit
Summary	What are the salient features of your proposal? Where are they located? For example, what are key features that will contribute to low total systems costs including development & operations phases?	20
1. Configurations	What system design do you propose to study during Phase B? Why?	50
2. Study Approach	What is your approach and rationale for accomplishing the specified tasks set fort in part 4 of the SOW?	70
3. Technical Experience/Capability and Personnel	What pertinent technical experience/capability and personnel do you bring to this job?	20

Section Title	Intended Purpose	Page Limit
4. Organization and Management	How are you going to organize and manage your Phase B Study effort? What specific Management Techniques will you use?	50
5. Company Capability and Performance	What capability have you that will aid you in completing this job? What has your performance record been?	20
6. Resources and Schedules	How much will this Phase B Study cost? What are the techniques you use for estimating large scale R & D programs?	20
	Total Page Limitation	250

Instructions and detailed information regarding the specific content of each of the six sections are provided below in parts 3 through 9:

b. Material prepared by subcontractors or team members shall be integrated into each of the six sections of the proposal as applicable. To the greatest degree possible, each section shall be self-contained and not dependent upon reference to any other section. Appendices other than those specifically requested herein shall not be submitted.

c. The proposal text shall be typed, single-space, using pica type (or equivalent) and printed on $8\frac{1}{2}$" x 11" paper. Illustrations shall be legible and no larger than 11" x 17" foldouts, as appropriate for the subject matter. Foldouts are considered part of the page limitation and shall not exceed 30 of the printed pages. Elaborate artwork, expensive paper bindings, and expensive visual or other presentation aids are neither necessary nor desired.

3. SUMMARY

A concise summary shall be provided to present an overview of the salient features of the proposal. It shall include a brief review of each of the proposal's six sections. The purpose of the summary is to facilitate understanding and appreciation of the total proposal and to serve the evaluators as a users guide in readily locating information. To the latter end, the summary shall also provide a cross-reference index of the strictly technical portion of the proposal (described in Parts 4 through 6 below) to insure that all data and analysis concerning a particular system, subsystem, requirement or operation can be readily identified.

4. CONFIGURATIONS

a. This section shall provide a description of the two system designs, that is for orbiter high and low aerodynamic cross range, which the offeror proposes to employ at the outset of his indepth study of space shuttle systems. Descriptive information shall include the following in preliminary form, it being recognized that only cursory data may be available at the outset of the Phase B study:

1. General arrangement drawings
2. Mass properties data
3. Aerodynamic characteristics data
4. Structure and TPS basic design approach
5. System interface concepts between vehicle, ground facilities, space station and payloads
6. Configuration unique subsystem features

b. This section shall also discuss in detail the rationale for the selection of the system designs proposed for study with particular emphasis on those features which relate strongly to the basic objectives of the Space Shuttle System, the system and mission requirements, desired system characteristics and to anticipated problem areas entailing extreme difficulty or risk.

c. Should you have a system concept which meets the fundamental purpose of the Shuttle Program but which does not meet all of NASA's system requirements and desired system characteristics, you may propose this configuration as an alternate or in lieu of the system designs prescribed above. It is emphasized that alternate system concepts must meet the program objectives set forth in Section 2.0 of Enclosure No. 4 - Statement of Work.

5. STUDY APPROACH

This section shall describe in depth the offeror's rationale of approach to each of the specific tasks called for in section 4.0 - CONTRACT(TASKS of the Statement of Work. The material should be presented or identified in a manner which permits direct correlation with the individual task items of the Statement of Work. The presentation should include task definitions; plans for establishing subsystem selections and tradeoffs; approach to the selection of structures, materials and the thermal protection system and plans for supporting technology; rationale to be followed in accomplishing system analyses; integration of supporting technology investigation with analytical work to support the analyses or to provide proof of concept; and approach to the development of concepts of ground turnaround operations, payload handling, maintenance philosophy, logistics operations. The foregoing is illustrative only; the offeror should insure that his presentation of study approach is specific and meaningful for each and every task.

6. TECHNICAL EXPERIENCE/CAPABILITY AND PERSONNEL

The proposer will provide a discussion of relevant technical experience, delineating applicability to this effort so far as possible by identifying individuals who have had responsible positions and will support this effort. Resumes shall be provided for Key Personnel. Identify special test capabilities, design tools or data developed on other programs which will be utilized and describe any unique or special capability which the proposer believes important for this study.

7. ORGANIZATION AND MANAGEMENT

This section shall be broken into two (2) major subsections as follows: A) Organization and Management, and B) Application of Related Effort.

a. Organization and Management: Provide a Space Shuttle Phase B Study Plan. The plan shall include all necessary information to thoroughly explain how the company intends to organize and manage the Phase B Study effort. The plan shall be prepared in accordance with DRD No. MA080A (see Statement of Work, Enclosure No. 4). In addition to the plan, provide the following information as well as any other information you believe pertinent to answering the question: "How will the contractor organize and manage Phase B?"

(1) Provide appropriate chart(s) for the prime and participating companies' organizational elements that will perform the study. Define the responsibility and authority of each of the participants. Also, explain the company policy and practice on the selection and management of participants as applicable to this study.

(2) Define the responsibility and authority of the prime and participating companies' organizational elements that will perform the study.

(3) Explain the organizational relationships of the study effort with other organizational elements of the prime contractor, participating companies, and the Government.

(4) Identify the management techniques to be used for accomplishing the Phase B Program.

b. Application of Related Effort: Explain how the company and external resources will be brought to bear to assure accomplishment of Phase B requirements. Proposers shall identify the extent and means by which the results, data, equipment, and experience of related company sponsored, IR&D, and other contracted work will be incorporated into this study, and also provide such information for participating companies.

8. CAPABILITY, EXPERIENCE AND PERFORMANCE

This section shall be broken into five (5) major subsections as follows: A) Experience as a Prime Contractor, Associate or Subcontractor B) Corporate Interest, C) Personnel Policy and Labor Relations, D) Government/Contractor Past Relationships and, E) Participation in the Government Small Business and Labor Surplus Area Programs. Each subsectioi shall contain at a minimum the information requested below plus any other information you consider pertinent to answering the question: "What pertinent Corporate/Company Capability do you possess, gained through past R&D Programs, that will be directly applicable to the Phase B Shuttle Study?"

a. Experience as Prime Contractor, Associate, or Subcontractor: Provide information demonstrating the proposer's recent program management experience as prime, associate, and/or subcontractor in major contracts for the design, development, research, integration, or logistics support on space vehicle systems, high performance aircraft, and/or other advanced technology. For this purpose, "recent experience" means contracts completed or in progress at any time during the past three years, and "major contracts" means contracts having a value in excess of $1,000,000. Information is particularly desired with reference to three objectives: cost and schedule, and technical performance. For each such major contract within recent experience provide the following information as a minimum: (In addition, offeror may give information concerning contracts more than three years old and/or of a lesser dollar value than $1,000,000 provided offeror considers such contracts to have special significance for the Phase B shuttle study).

(1) Contract award and structure. Identify the Government agency, if any, placing the prime contract, the contract number, contract amount, contract award and completion date, summary of scope of work, incentive structure or other fee arrangements (as percent of estimated cost, if CPFF), and other unique contract provisions, if any, regarding cost/schedule/technical performance. State whether the award was made on a competitive or noncompetitive basis.

(2) Contract Performance. State results of the contracts in terms of three objectives: Cost, schedule and technical performance as follows:

(a) Identify and explain cost growths (including overruns) or underruns and provide and explain trends (graphically) for projected and actual program costs as a function of time from contract award through completion.

(b) Identify and explain early or late deliveries for first article and total program and provide and explain trends (graphically) for projected and actual first and subsequent article deliveries as a function of time from contract award through completion.

(c) Describe and explain necessary waivers to performance specifications. Describe flight or test results in terms of projected and actual contract requirements. Explain the nature of and reasons for any deviations in actual performance from contract requirements.

(d) Identify and explain any termination for default or convenience.

(3) Contract Management. Provide data to specifically identify the management techniques, procedures, systems, organizational concepts, operating philosophies and methods used during progress of the work to determine current status for each of the three objectives, cost/schedule/technical performance. Give specific examples of application of these methods to this procurement.

(4) Experience in overcoming program difficulties. Cite techniques and management approaches used in overcoming cost/schedule/technical performance difficulties. Identify any improvisations designed to meet the particular difficulty. Comment upon any demonstrated superiority or deficiency of these management methods in terms of achieving one or more of the cost/schedule/technical performance objectives under adverse circumstances.

(5) Relationship to Shuttle requirements. Describe the relationship, if any, between the disciplines and technologies involved in the major contracts and those anticipated for the Phase B Definition Study for the Shuttle.

b. Corporate Interest: Provide information to demonstrate and to inform the Government of the proposer's overall corporate interests which tend to complement the type of activity which would be required by the proposed procurement. Specifically identify the corporate interest in this program and how it relates to present and future corporate goals.

c. Corporate Personnel Policy and Labor Relations: Provide information to demonstrate and explain, as necessary, the overall corporate policies, experience, and planning in the areas of personnel policy and labor relations. The following and any additional pertinent data shall be provided:

(1) Current Organizational Chart identifying relationships from top corporate/company management to organizational elements that will perform the Phase B Definition Study. Identify key management personnel at the corporate level on such chart. State existing company policy for top management participation in the progress of major prime contracts including both R&D and production contracts.

(2) Corporate/union relations. Assessment of union relations and labor contract status.

(3) Corporate experience in implementing the Government's policies with respect to equal opportunity in employment and Executive Order 11246.

d. Government/Contractor Past Relationships: Provide information which demonstrates the proposer's and any subcontractor's past Government Contractor relationships established by the proposer on previous contracts, and the techniques and policies implemented to overcome any difficulties and their effectiveness in application.

e. Participation in the Government Small Business and Labor Surplus Area Programs:

(1) Record any unusual efforts which the contractor has displayed in subcontracting with small business and labor surplus area concerns, particularly for developmental type work likely to result in later production opportunities; and

(2) The effectiveness of the company in subcontracting with and furnishing assistance to such concerns, as compared to other comparable contractors; and

(3) Any other significant contractor participation in general areas of socio-economic action.

9. RESOURCES AND SCHEDULES

This section shall be divided into five (5) subsections as follows: A) Cost Proposal, B) Financial Status, C) Overhead, G&A Labor Rates and IR&D, D) Resource Estimating Techniques, and E) Facility Requirements. Each subsection shall contain at a minimum the information requested below plus any other information you feel pertinent.

a. Cost Proposal: Provide a firm fixed price proposal covering all work, materials, travel, etc., required to perform the Phase B

Study. The following information and any other pertinent data shall be provided:

(1) Salaries and Wages. Indicate the estimated totals for direct labor by labor classes. Support these totals by a listing of hours, labor classifications, and rates therefor. This information shall be provided as follows:

(a) Use enclosed DD Form 633-4 (NASA Edition), Contract Pricing Proposal, for details. Complete the summary dollar estimates and Blocks I through V on the reverse of DD Form 633-4. The completed form must be certified and signed by a person authorized to bind the company. Supplemental cost data must be detailed on the DD Form 633-4, and attached sheets in substantially the same detail as is outlined in the footnotes on the reverse of the form.

(2) Rates.

(a) Overhead and G&A Rates. Indicate the current applicable Overhead and G&A rates by all categories, and fully explain the basis of application. Separate Independent Research and Development rate from G&A rate or Overhead rate as applicable. Furnish (1) dates of your overhead periods; (2) the name, address, and branch of Government audit agency representative; and (3) certified copies of the agency approval of any rates proposed.

(b) Expenditure Rate. A cumulative planned expenditure and commitment rate chart shall be provided in statement and in graphic form in monthly time increments, for the proposed Phase B study period.

(3) Subcontracting and/or Other Arrangements. Indicate the total estimated cost of any subcontracting and/or other arrangements required in Phase B. Indicate applicable prime contractor and/or intra-corporate entities burden rates and profit, and the basis of application. Describe the method of applying prime contractor profit to items obtained by intra-corporate transactions or subcontracts to avoid the pyramiding of profits. If there are any agreements with Government agencies concerning the handling of intra-corporate transactions, submit a copy of the agreement.

(4) Material. Show any major items of material to be used in Phase B with all material cost. Indicate the method of pricing and the material handling rate, if any. Identify any anticipated priority/allocation therefor.

(5) Travel and Subsistence. Indicate the proposed number of trips and cost breakdown therefor.

(6) Other and Unusual Costs. Any elements of direct costs not covered elsewhere, shall be identified and explained.

(7) Taxes. Itemize all federal, state, and local taxes deemed applicable and include in the proposal.

(8) Royalty Information. If the response to this Request for Proposal contains costs or charges for royalties the following information shall be furnished, along with the Proposal, on each separate item of royalty or license fee:

(a) Name and address of Licensor.

(b) Date of License Agreement.

(c) Patent numbers, patent application serial numbers, or other basis on which royalties are payable.

(d) Brief description, including any part of model numbers, of each contract item or component on which the royalty is payable.

(e) Percentage of dollar rate of royalty per unit.

(f) Unit price of contract item.

(g) Number of units.

(h) Total dollar amount of royalties.

b. Financial Status: Provide a current financial statement and a history of earnings which will demonstrate the proposer's financial capability.

c. Overhead, G&A, Labor Rates, and IR&D: Provide information to demonstrate overall company history and projections in the area of indirect rates and direct labor cost. As a minimum, provide the following and any pertinent data:

(1) A curve of combined overhead, G&A and labor rates reflecting total cost per man hour (including both direct and indirect) excluding material and subcontract costs for the years 1966 through 1969 and a projection through 1972.

(2) Independent research and development financial policy and rate history including sharing ratios and application. Also provide projections through 1972 (or latest period available).

d. Resource Estimating Techniques: Discuss the proposer's approach to Resource, Schedule and Cost estimating for major research and development programs with emphasis on programs of the complexity and scope of the anticipated Space Shuttle Development Program.

e. Facility Requirements: Specify the facilities and special test equipment requirements for the Phase B Program. Identify as to location, ownership and availability of such facilities and equipment. Identify the cost of any additional facilities or equipment required in the performance of the work with information as to whether such additional facilities or equipment will be contractor-furnished or Government-furnished.

DEPARTMENT OF DEFENSE

CONTRACT PRICING PROPOSAL

(RESEARCH AND DEVELOPMENT)

Form Approved
Budget Bureau No. 22-R100

This form is for use when *(i)* submission of cost or pricing data *(see NASA PR 3.807-3)* is required and *(ii)* substitution for the DD Form 633 is authorized by the contracting officer.

PAGE NO. | NO. OF PAGES

NAME OF OFFEROR

SUPPLIES AND/OR SERVICES TO BE FURNISHED

HOME OFFICE ADDRESS *(Include ZIP Code)*

DIVISION(S) AND LOCATION(S) WHERE WORK IS TO BE PERFORMED

TOTAL AMOUNT OF PROPOSAL
$

GOVT SOLICITATION NO.

DETAIL DESCRIPTION OF COST ELEMENTS

			EST COST ($)	TOTAL EST COST[1]	REFERENCE[2]
1. DIRECT MATERIAL *(Itemize on Exhibit A)*					
a. PURCHASED PARTS					
b. SUBCONTRACTED ITEMS					
c. OTHER - (1) RAW MATERIAL					
(2) YOUR STANDARD COMMERCIAL ITEMS					
(3) INTERDIVISIONAL TRANSFERS *(At other than cost)*					
TOTAL DIRECT MATERIAL					
2. MATERIAL OVERHEAD 3 *(Rate % X $ base =)*					
3. DIRECT LABOR *(Specify)*	ESTIMATED HOURS	RATE/ HOUR	EST COST ($)		
TOTAL DIRECT LABOR					
4. LABOR OVERHEAD *(Specify department or cost center)* 3	O.H. RATE	X BASE =	EST COST ($)		
TOTAL LABOR OVERHEAD					
5. SPECIAL TESTING *(Including field work at Government installations)*			EST COST ($)		
TOTAL SPECIAL TESTING					
6. SPECIAL EQUIPMENT *(If direct charge) (Itemize on Exhibit A)*					
7. TRAVEL *(If direct charge) (Give details on attached Schedule)*			EST COST ($)		
a. TRANSPORTATION					
b. PER DIEM OR SUBSISTENCE					
TOTAL TRAVEL					
8. CONSULTANTS *(Identity - purpose - rate)*			EST COST ($)		
TOTAL CONSULTANTS					
9. OTHER DIRECT COSTS *(Itemize on Exhibit A)*					
10. *TOTAL DIRECT COST AND OVERHEAD*					
11. GENERAL AND ADMINISTRATIVE EXPENSE *(Rate % of cost element Nos.)* 3					
12. ROYALTIES 4					
13. *TOTAL ESTIMATED COST*					
14. FEE OR PROFIT					
15. *TOTAL ESTIMATED COST AND FEE OR PROFIT*					

This proposal is submitted for use in connection with and in response to *(Describe RFP, etc.)*

and reflects our best estimates as of this date, in accordance with the instructions to offerors and the footnotes which follow.

TYPED NAME AND TITLE	SIGNATURE	
NAME OF FIRM		DATE OF SUBMISSION

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DD FORM 1 APR 68 633-4 (NASA EDITION)

EXHIBIT A - SUPPORTING SCHEDULE *(Specify. If more space is needed, use blank sheets)*

COST EL NO.	ITEM DESCRIPTION *(See footnote 5)*	EST COST ($)

I HAVE THE DEPARTMENT OF DEFENSE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, OR THE ATOMIC ENERGY COMMISSION PERFORMED ANY REVIEW OF YOUR ACCOUNTS OR RECORDS IN CONNECTION WITH ANY OTHER GOVERNMENT PRIME CONTRACT OR SUBCONTRACT WITHIN THE PAST TWELVE MONTHS?

☐ YES ☐ NO *If yes, identify below.*

NAME AND ADDRESS OF REVIEWING OFFICE *(Include ZIP Code)*	TELEPHONE NUMBER/EXTENSION

II WILL YOU REQUIRE THE USE OF ANY GOVERNMENT PROPERTY IN THE PERFORMANCE OF THIS PROPOSED CONTRACT?

☐ YES ☐ NO *If yes, identify on a separate page.*

III. DO YOU REQUIRE GOVERNMENT CONTRACT FINANCING TO PERFORM THIS PROPOSED CONTRACT?

☐ YES ☐ NO *If yes, identify* ☐ ADVANCE PAYMENTS ☐ PROGRESS PAYMENTS *OR* ☐ GUARANTEED LOANS

IV DO YOU NOW HOLD ANY CONTRACT *(or, do you have any independently financed (IR & D) projects)* FOR THE SAME OR SIMILAR WORK CALLED FOR BY THIS PROPOSED CONTRACT?

☐ YES ☐ NO *If yes, identify*

V. DOES THIS COST SUMMARY CONFORM WITH THE COST PRINCIPLES SET FORTH IN NASA PR, PART 15 *(see 3.807-2(c)(2))*?

☐ YES ☐ NO *If no, explain on a separate page.*

INSTRUCTIONS TO OFFERORS

1. The purpose of this form is to provide a standard format by which the offeror submits to the Government a summary of incurred and estimated cost *(and attached supporting information)* suitable for detailed review and analysis. Prior to the award of a contract resulting from this proposal the offeror shall, under the conditions stated in NASA PR 3.807-3, be required to submit a Certificate of Current Cost or Pricing Data (see NASA PR 3.807-3(e) and 3.807-4).

2. As part of the specific information required by this form, the offeror must submit with this form, and clearly identify as such, cost or pricing data (that is, data which is verifiable and factual and otherwise as defined in NASA PR 3.807-3(e)). In addition, he must submit with this form any information reasonably required to explain the offeror's estimating process, including:
   a. the judgmental factors applied and the mathematical or other methods used in the estimate including those used in projecting from known data, and
   b. the contingencies used by offeror in his proposed price.

3. When attachment of supporting cost or pricing data to this form is impracticable, the data will be specifically identified and described *(with schedules as appropriate)*, and made available to the contracting officer or his representative upon request.

4. The format for the "Cost Elements" is not intended as rigid requirements. These may be presented in different format with the prior approval of the contracting officer if required for more effective and efficient presentation. In all other respects this form will be completed and submitted without change.

5. By submission of this proposal, offeror, if selected for negotiation, grants to the contracting officer, or his authorized representative, the right to examine, for the purpose of verifying the cost or pricing data submitted, those books, records, documents and other supporting data which will permit adequate evaluation of such cost or pricing data, along with the computations and projections used therein. This right may be exercised in connection with any negotiations prior to contract award.

FOOTNOTES

1 Enter in this column those necessary and reasonable costs which in the judgment of the offeror will properly be incurred in the efficient performance of the contract. When any of the costs in this column have already been incurred (e.g., on a letter contract or change order), describe them on an attached supporting schedule. Identify all sales and transfers between your plants, divisions, or organizations under a common control, which are included at other than the lower of cost to the original transferror or current market price.

2 When space in addition to that available in Exhibit A is required, attach separate pages as necessary and identify in this "Reference" column the attachment in which information supporting the specific cost element may be found. No standard format is prescribed, however, the cost or pricing data must be accurate, complete and current, and the judgment factors used in projecting from the data to the estimates must be stated in sufficient detail to enable the contracting officer to evaluate the proposal. For example, provide the basis used for pricing materials such as by vendor quotations, shop estimates, or invoice prices; the reason for use of overhead rates which depart significantly from experienced rates (reduced volume, a planned major rearrangement, etc.): or justification for an increase in labor rates (anticipated wage and salary increases, etc.). Identify and explain any contingencies which are included in the proposed price, such as anticipated costs of rejects and defective work, or anticipated technical difficulties.

3 Indicate the rates used and provide an appropriate explanation. Where agreement has been reached with Government representatives on the use of forward pricing rates, describe the nature of the agreement. Provide the method of computation and application of your overhead expense, including cost breakdown and showing trends and budgetary data as necessary to provide a basis for evaluation of the reasonableness of proposed rates

4 If the total royalty cost entered here is in excess of $250 provide on a separate page (or on DD Form 783, Royalty Report) the following information on each separate item of royalty or license fee: name and address of licensor; date of license agreement; patent numbers, patent application serial numbers, or other basis on which the royalty is payable; brief description, including any part or model numbers of each contract item or component on which the royalty is payable; percentage or dollar rate of royalty per unit; unit price of contract item; number of units; and total dollar amount of royalties. In addition, if specifically requested by the contracting office a copy of the current license agreement and identification of applicable claims of specific patents shall be provided.

5 Provide a list of principal items within each category indicating known or anticipated source, quantity, unit price, competition obtained, and basis of establishing source and reasonableness of cost.

ENCLOSURE NO. 3

PROPOSED CONTRACT SCHEDULE

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PROPOSED CONTRACT SCHEDULE

ARTICLE I - SCOPE OF WORK

The objective of this contract is to provide a Space Shuttle System Program Definition (Phase B). To accomplish this objective the contractor shall, furnish all necessary management, personnel, facilities, materials, tools, equipment, and services except as specified elsewhere to be provided by the Government, to accomplish the work as described and in the manner set forth in Exhibit A - Statement of Work, Shuttle Vehicle Definition (Phase B), dated , with Appendices A through G.

ARTICLE II - OPTIONS FOR ADDITIONAL EFFORT

A. The Government at its discretion, through the exercise of one or more options not to exceed six as described more fully hereafter, may direct the contractor to perform additional work over and above that required by the Phase B Definition contract. Such work may be based in part upon information derived from the Phase B Definition contract and will within its general scope include, but not necessarily be limited to, additional comparative analysis and detailed study aimed toward refining certain technical and managerial aspects associated with a single project approach; and further identification and definition of the interface between Phase B (Definition) and Phase C (Design) in an attempt to facilitate a smooth and orderly transition between them.

B. Each option shall establish a period of performance of one month and require the contractor to provide a minimum of and a maximum of direct manhours. Direct labor manhours shall be comprised only of those productive hours expended in performance of work under the contract and the costs of which are charged to this contract under the contractor's standard accounting practices as direct costs. Direct labor manhours do not include sick leave, vacation leave, holidays or any type of administrative leave. Notice of exercise of each option must be given the contractor in writing and will specifically identify, within the above context, the work required to be performed.

Notice of exercise of the first option may be given the contractor at any time up to one calendar month after physical completion of the Phase B Definition contract. Notices of the exercise of succeeding options must be given the contractor prior to the expiration of the period of performance of the option last previously exercised or one calendar month after physical completion of the contract, whichever occurs last. The Government may exercise more than one such option at a time. For each of above options exercised, the fixed price set forth in Article VI shall be increased as specified below:

Fixed Price - $ per direct manhour

ARTICLE III - COMPLETION OF WORK AND DELIVERY SCHEDULE

A. Work required under this contract shall be completed by the contractor no later than eleven (11)* months following the effective date of this contract as indicated on the Cover Page hereof.

B. This paragraph identifies and sets forth delivery requirements for end-item reports and other documentation to be prepared and submitted by the contractor. The listing within this paragraph may not be all inclusive, and the contractor shall furnish any additional data required by the contract General Provisions, Statement of Work, or other contract requirements, notwithstanding their omission from this paragraph. All data called for under this contract are considered "Subject Data" under the General Provisions hereof titled "Rights in Data."

The contractor shall provide the following:

(To be completed in negotiations.)

*NOTE: Other than documentation called for by Appendix "D" of the SOW as "preliminary", it is NASA's intent that the successful contractors concentrate the entire eleven (11) months on the design effort utilizing an additional month for preparation and delivery of final documentation.

ARTICLE IV - PLACE OF PERFORMANCE

The primary place of performance for the work called for hereunder will be the contractor's facility as designated on the cover sheet (NASA Form 437) to this contract and

Additionally, reviews and other meetings shall be conducted at other locations as contemplated in Exhibit A, Statement of Work.

ARTICLE V - EVALUATION AND ACCEPTANCE

Final evaluation and acceptance of end-item documentation and hardware items required by this contract shall be accomplished at the NASA-
by the Contracting Officer or his duly authorized representativ

ARTICLE VI - CONSIDERATION AND PAYME

The total fixed price of this contract is $, payable upon delivery, inspection and acceptance of all deliverable end-items called for in this contract.

NOTE: Monthly progress payments, if desired by the Contractor, will be considered during negotiations.

ARTICLE VII - SECURITY

It is anticipated that certain data resulting from these studies will be classified up to and including SECRET. The contractor shall comply with the security requirements set forth in the General Provision hereof titled "Security Requirements".

ARTICLE VIII - KEY PERSONNEL AND FACILITIES (Reference the General Provision hereof titled "Key Personnel and Facilities")

The following individuals and/or facilities are considerd to be essential to the work being performed hereunder:

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ARTICLE IX - LIMITATION ON PRINTING AND REPRODUCTION

The printing and reproduction requirements of this contract are subject to the Government Printing and Binding Regulations published by the Joint Committee on Printing, Congress of the United States. The contractor shall be required to comply with "Reports and Data Duplication". - Table XX, attached hereto and made a part of this contract.

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ARTICLE X - DESIGNATION OF NEW TECHNOLOGY REPRESENTATIVE AND PATENT REPRESENTATIVE

A. The purpose of facilitating administration of the clause of this contract entitled "New Technology" the following named representatives are hereby designated by the Contracting Officer to administer the clause:

Name	Title	Office Code	Address
	New Technology Rep.		
	Patent Representative		

B. Correspondence with respect to the clause should be directed to the New Technology Representative unless transmitted in response to correspondence from the Patent Representative.

C. For purposes of the New Technology clause, the requirement to identify the Contracting Officer in subcontracts set forth in paragraph (d)(1) of the clause may be satisfied by the inclusion of this entire provision.

ARTICLE XI - TECHNICAL DIRECTION AND SURVEILLANCE

A. The work to be performed by the contractor under this contract is subject to the surveillance and written Technical Direction of a "Technical Manager" who shall be specifically appointed by the Contracting Officer in writing. Technical Direction is defined as that Government direction to the contractor which fills in details, suggests possible lines of inquiry or otherwise more specifically defines the work set forth herein. In addition this Contracting Officer's Representative may act as the Contracting Officer's authorized representative for the purpose of the final evaluation and acceptance of end-item documentation and hardware end items required by this contract. The Technical Direction to be valid:

1. Must be issued in writing consistent with the general scope of the work set forth in this contract;

2. May not modify the Statement of Work or change the expressed terms and conditions of this contract;

3. Shall not commit the Government to any adjustment of the Fixed Price or other contract provisions.

B. In the event any Government Technical Direction is interpreted by the contractor to fall within the Clause of the General Provisions hereof entitled "Changes" the contractor shall not implement such direction, but shall:

1. Notify the Contracting Officer in writing of such interpretation within five (5) working days after the contractor's receipt of such direction. Such notice shall (i) include the reasons upon which the contractor bases its belief that the Technical Direction falls within the purview of the "Changes" clause; and (ii) include the contractor's best estimate as to revision in Fixed Price, performance time, delivery schedules and any other contractual provisions that would result from implementing the Technical Direction.

2. If, after reviewing the information presented pursuant to subparagraph (1) above, the Contracting Officer is of the opinion that such direction is within the purview of the "Changes" clause, he will issue unilateral direction to proceed pursuant to the authority granted him under the clause.

ARTICLE XI - TECHNICAL DIRECTION AND SURVEILLANCE (Continued)

3. In the event the Contracting Officer determines that it is necessary to avoid a delay in performance of the contract he may, in writing, direct the contractor to proceed with the implementation of the Technical Direction pending receipt of the information to be submitted under subparagraph (1) above. Should the Contracting Officer later determine that Change direction is appropriate, the written direction issued hereunder shall constitute the required Change direction.

C. Failure of the contractor and the Contracting Officer to agree on whether Government direction is Technical Direction or a Change within the purview of the "Changes" clause shall be a dispute concerning a question of fact within the meaning of the Clause of the General Provisions entitled "Disputes".

ARTICLE XII - SUBCONTRACTOR TECHNICAL DIRECTION

A. This contract was negotiated on the basis that part of the effort described in the Statement of Work relating to the (Orbiter) (Booster) would be performed under a subcontract with X Company, and the contractor agrees to enter into an appropriate subcontract (subject to General Provision hereof titled "Subcontracts")with X for such effort. The contractor further agrees to include the following clause in such subcontract:

TECHNICAL DIRECTION AND SURVEILLANCE

(a) The work to be performed by the subcontractor under this subcontract is subject to the surveillance and written Technical Direction of a NASA Technical Manager who shall be specifically identified by the prime contractor in writing. The subcontractor agrees to accept, treat, and act upon any Technical Direction from such NASA Technical Manager in the same manner as Technical Direction issued, or provided to be issued, by the prime contractor.

Technical Direction is defined as that Government direction to the subcontractor which fills in details, suggests possible lines of inquiry or otherwise more specifically defines the work set forth in this subcontract. The Technical Direction to be valid:

(1) Must be issued in writing consistent with the general scope of the work set forth in this subcontract;

(2) May not modify the Statement of Work or change the expressed terms and conditions of the subcontract

Technical Direction issued by the Government shall nc commit the Government or the prime contractor to any adjustment of the fixed price (or estimated cost and fee if this is a cost reimbursement subcontract) or other contract provisions, nor shall it create any obligation of any kind on the part of the Government.

(b) In the event any NASA Technical Direction is interpreted by the subcontractor to fall within the clause of this subcontract titled "Changes" the subcontractor shall not implement such direction, but shall:

ARTICLE XII - SUBCONTRACTOR TECHNICAL DIRECTION (Continued)

(1) Notify the NASA Technical Manager and the prime contractor in writing of such interpretation within five (5) working days after the subcontractor's receipt of such direction. Such notice shall (i) include the reasons upon which the subcontractor bases its belief that the Technical Direction falls within the purview of the "Changes" clause of this subcontract; and (ii) include the contractor's best estimate as to revision in fixed price (or estimated cost and fee if this is a cost reimbursement subcontract), performance time, delivery schedules and any other contractual provisions that would result from implementing the Technical Direction; and

(2) not be required to implement such direction unless he receives appropriate contractual direction from the prime contractor.

(3) In the event the NASA Technical Manager determines that it is necessary to avoid a delay in performance of the subcontract he may, in writing, request the subcontractor to proceed with the implementation of the Technical Direction pending receipt of the information to be submitted under subparagraph (1) above. However, compliance with any such request is voluntary on the part of the subcontractor, and shall be at his own risk in the event appropriate contractual direction is not subsequently issued by the prime contractor.

(c) In addition to reports and data required elsewhere in this subcontract, the subcontractor shall submit the following reports directly to the NASA Technical Manager at the address set forth below:

(To be completed in negotiations)

B. In addition to the above, the contractor agrees:

1. That any technical direction issued to the subcontractor by the Government as contemplated by this Article shall in the event of any conflict, take precedence over technical direction issued by the contractor, and that all direction issued to the subcontractor by the contractor, shall be consistent with and complement technical direction theretofore issued by the Government;

ARTICLE XII - SUBCONTRACTOR TECHNICAL DIRECTION (Continued)

2. To include in the subcontract the "Changes" clause set forth in NASA PR 7.304-1 (if the subcontract is fixed price) or the "Changes" clause set forth in NASA PR 7.453-1 (if the subcontract is a cost type) and the "Technical Direction" clause set forth in Article XI of this contract schedule, with such changes as are necessary to make these clauses appropriate for use in a prime -- subcontract.

3. To identify a Technical Manager to the subcontractor as contemplated in paragraph (a) of the subcontract clause set forth above.

C. The NASA Technical Manager will send a copy of all technical direction issued to the subcontractor to the contractor at the time of issuance. The contractor shall within   days thereafter communicate to the NASA Technical Manager and the Contracting Officer any problems or adverse impact which he feels could result from the Technical Direction issued.

ARTICLE XIII - CONTRACTING OFFICER REPRESENTATIVES

Wherever in this contract a Contracting Officer's Representative has been specifically designated by office or by name, or in any other manner, the Government reserves the right for the Contracting Officer unilaterally to withdraw such designation and (1) designate another person to act in the named representative's place; or (2) make any future designations extra-contractually; or (3) perform the related function himself, provided that notification of any such withdrawal and subsequent designation(s) will be given to the contractor in writing.

ARTICLE XIV - RESTRICTIVE LEGEND

In consideration of the award of this contract, it is agreed that NASA will no longer be bound by the restrictive legend appearing on the Contractor's Proposal and such proposal will hereafter be considered subject data under the clause in this contract entitled "Rights in Data."

ARTICLE XV - DATA USE RESTRICTIONS

A. In accordance with paragraph (f) of the "Rights in Data" clause of this contract, the Contracting Officer may require, in writing, the delivery of data otherwise excused from delivery by paragraph (f) of the "Rights in Data" clause. Thereafter, contractor shall promptly deliver or have delivered such data to the Government. The following legend and no other is authorized to be affixed on any data delivered pursuant to this provision, providing that the data meets the conditions for initial withholding under paragraph (f) of the "Rights in Data" clause. The Government will thereafter treat the data in accordance with such legend.

LEGEND FOR DATA USE RESTRICTIONS

This data is furnished under U. S. Government Contract No. (and Purchase Order No. , if applicable), and may be released outside the Government, except under the following conditions:

(1) Such data will be used only for emergency repair or overhaul work by or for the Government where the item or process concerned is not otherwise reasonably available to enable timely performance, or for assessment, integration, or quality assurance, and

(2) the party receiving the data shall contractually agree to the foregoing use restrictions, and to make no other use, release, or disclosure of the data.

These restrictions do not limit the Government's rights to use or disclose any data obtained from another source without restriction. This legend shall be marked on any reproduction of this data in whole or in part.

B. As to the prime contractor and/or subcontractors designated in the contract as "key subcontractors," if it is deemed necessary by the Government to acquire greater rights in data previously furnished pursuant to A. above, such prime contractor and/or key subcontractor will negotiate in good faith with the Government or its nominee, for a fair and reasonable compensation for such greate

ARTICLE XV - DATA USE RESTRICTIONS (Continued)

rights during the performance of this contract or within one year after final payment. If it is deemed necessary by the Government to use the data specified above with greater rights prior to completion of negotiations for such rights, the Government may do so upon giving written notice to the prime contractor and/or key subcontractor. This notice will specify the data which is to be so used, and will contain a brief explanation of the nature and conditions of the use. Thereafter, the parties shall promptly complete their negotiations for such greater rights. If an agreement is not reached within a reasonable time, the Contracting Officer shall treat the question of compensation for greater rights in data as a disputed fact under the "Disputes" clause of this contract. The following factors may, among others, be considered in determining a fair and reasonable compensation for such greater rights in data:

1. The benefit actually received by the Government from its use of the data.

2. The private expense incurred by contractor in developing the data.

3. The extent to which the data conferred a competitive advantage (in terms of petential for future business, whether commercial or Govermental) to the contractor at the time of its use by the Government.

4. The extent to which the competitive advantage in 3. above wa enhanced by virtue of the contract work.

5. The extent to which the field of technology to which the data pertains was developed by Government funds.

6. The nature of the Government's use, and the extent to which the contractor's interest were protected during the use.

7. Any obligations of the contractor to pay others for the use of the data.

8. The terms of any previous sales or offers of sale of the data or products to which the data pertains.

9. The extent to which the contractor's competence in the field was brought about by prior Government contracts.

ARTICLE XV - DATA USE RESTRICTIONS (Continued)

10. The degree of originality represented by the data (routine engineering versus high creativity).

C. When the amount has been determined for any compensation due the contractor or a key subcontractor by reason of the Government's acquisition of greater rights in data, a supplemental agreement shall be entered into with a contractor providing for payment of such compensation. Contractor will not burden the pri contract with indirect charges or fee when payments made under this provision are for a key subcontractor who has negotiated directly with the Government and/or proceeded in contractor's name under a Disputes proceeding in accordance with paragraph D. of the "Subcontractor Data Provisions" article.

ARTICLE XVI - SUBCONTRACTOR DATA PROVISIONS

A. Contractor shall prepare and submit to the Contracting Officer for written approval suitable clauses for inclusion in its subcontracts which will further implement the data clauses contained in this contract. Contractor shall include such approved clauses into all subcontracts where the performance of research, experiments, design, engineering, or developmental work is contemplated.

In the event of a refusal by a subcontractor to accept the clauses required above, the contractor shall promptly notify the Contracting Officer of such refusal and shall not execute the subcontract in question until other provisions have been approved in writing by the Contracting Officer for inclusion in said subcontract.

B. Contractor will not use his position as the Government prime contractor to restrict his research and development subcontractors from dealing directly with the Government or with other Government contractors participating in this program.

C. Data to be delivered by a subcontractor shall normally be delivered to the next higher-tier contractor. However, when data is to be delivered pursuant to paragraph A. of the "Data Use Restrictions" clause and is subject to the "Legend for Data Use Restrictions," a subcontractor may, at its option, fulfill such requirement by submitting such data directly to the Government rather than through the next higher-tier contractor.

D. Where a key subcontractor elects to deliver data directly to the Government under paragraph C. of this article, any negotiations for greater rights under paragraph B. of the "Data Use Restrictions" article shall be conducted directly between the Government and key subcontractors involved. If such negotiations do not result in agreement between the Government and the key subcontractors, and the Contracting Officer has rendered a final decision under the "Disputes" clause, the key subcontractor shall have the right to process an appeal to its legal conclusion in the name of the contractor. In such case, contractor will not have access to a key subcontractor's proprietary data or sensitive business information.

ARTICLE XVII - CONTRACTOR'S INDEPENDENT RESEARCH AND DEVELOPMENT ACTIVITIES

Contractor shall furnish a quarterly letter report describing in summary form the contractor's independent research and development activities which are specifically related to the contract work. Upon written request of the Contracting Officer, contractor shall also furnish such additional information as is available pertaining to these independent research and development activities. The quarterly letter reports shall be considered as data specified to be delivered by the schedule of the contract. Any additional information furnished pursuant to a request of the Contracting Officer under this paragraph shall be considered as though furnished under the "Data Requirements" article of this contract, and to be "subject data" under the "Rights in Data" clause of this contract.

ARTICLE XVIII - DATA REQUIREMENTS

A. To the extent that the following data is not elsewhere requir to be furnished to the Government under this contract, and is of the type customarily retained in the normal course of business, the contractor, upon written request of the Contracting Officer a any time during contract performance or within one year after final payment, shall furnish the following:

1. A copy of all data taken into account in developing the technical design required under the contract; and

2. A set of engineering drawings and other data which will be sufficient to enable the manufacture of items or equipment furnished under this contract by a firm skilled in the art of manufacturing items or equipment furnished under this contract or a set of flow sheets and other data which will be sufficient to enable performance of any process developed under this contract by a firm skilled in the art of practicing processes of the general type and character of such process. Such set or sets of drawings and flow sheets shall be reproducible copies incorporating all changes made in the items, equipment, or process delivered to the Government.

3. A copy of all data developed and used in the preparation of all other deliverable items under this contract.

B. All reports, data, and recorded information which are required to be furnished by the contractor under A above, as well as other reports of a technical nature required to be furnished under this contract, are "Subject Data" within the meaning of the "Rights in Data" clause of this contract.

C. Nothing contained in this "Data Requirements" clause shall require contractor to deliver:

1. Data contrary to the provisions of paragraph (f) of the "Rights in Data" clause and the "Data Use Restrictions" clause of this contract; and

2. Data previously developed by parties other than contractor, independently of this contract, and acquired by the contractor prior to its receipt of the Request for Proposal for this contract, under conditions restricting contractor's right to disclose the same.

ARTICLE XVIII - DATA REQUIREMENTS (Continued)

D. Any reproducible copies requested under this "Data Requirement clause shall be of a type and prepared in accordance with good commercial practice.

E. In the event the Contracting Officer requests the delivery of data by the contractor, as contemplated by A above, prior to final payment, such request, shall be treated as a change under the clause of this contract entitled "Changes" and an equitable adjustment in the price, if this is a fixed price contract, or estimated cost and any fee, if this is a cost-type contract, shall be made to cover the cost of preparing, editing, duplicating, assembling, and shipping the data requested under A above, but only to the extent that the contractor warrants that such costs were not included in the price (or estimated cost and fee) of the contract. The contractor shall comply with requests of the Contracting Officer made under A above within one year following final payment, provided that suitable provision is made for reimbursement of the additional costs being limited to the costs set forth above, and warranted to have been excluded from the price or estimated cost and fee of the contract. Any adjustment or payment under this paragraph (E) shall not include any amount for the value of the data, as distinguished from the costs set forth above.

ARTICLE XIX - KEY SUBCONTRACTORS

Pursuant to Article XV hereof entitled "Data Use Restrictions" the following firms are designated "Key subcontractors:"

(To be completed in negotiations)

ARTICLE XX - LIMITATION OF GOVERNMENT'S OBLIGATION

A. Of the total price of this contract the sum of $ is presently available for payment and allotted to this contract. It is anticipated that from time to time additional funds will be allotted to this contract until the total price of said items is allotted.

B. The Contractor agrees to perform or have performed work on said items up to the point at which, in the event of termination of this contract pursuant to the clause hereof entitled "Termination for the Convenience of the Government," the total amount payable by the Government, (including amounts payable in respect of subcontracts and settlement costs) pursuant to paragraph (e) thereof, would in the exercise of reasonable judgment by the Contractor approximate the total amount at the time allotted to the contract. The Contractor shall not be obligated to continue performance of the work beyond such point. The Government shall not be obligated in any event to pay or reimburse the Contractor in excess of the amount from time to time allotted to the contract, any thing to the contrary in the clause hereof entitled: "Termination for the Convenience of the Government", notwithstanding.

C. It is contemplated that the funds presently allotted to this contract will cover the work to be performed, as limited by the provisions of B above until the day of . In the event funds allotted are considered by the Contractor to be inadequate to cover the work to be performed until the above date, or an agreed date in substitution thereof, the Contractor shall notify the Contracting Officer in writing when within the next thirty (30) days the work will reach a point which, in the event of termination of this contract pursuant to the clause hereof entitled: "Termination for the Convenience of the Government," the total amount payable by the Government (including amounts payable in respect of subcontracts and settlement costs), pursuant to Paragraph (e) thereof, will approximate eighty-five per cent (85%) of the total amount then allotted to the contract. The notice shall state the estimated date when such point will be reached and the estimated amount of additional funds required to continue performance to the above or an agreed substituted date. The contractor shall, thirty (30) days prior to the date above written or agreed substituted date, advise the Contracting Officer in writing as to the estimated amount of additional funds which will be required for the timely performance of the contract for a further period as may be specified in the contract or otherwise agreed to by the parties. If after such latter notification, additional funds

ARTICLE XX - LIMITATION OF GOVERNMENT'S OBLIGATION (Continued)

are not allotted by the date above written or by an agreed date in substitution therefor, the Contracting Officer will, upon written request of the Contractor for the same, terminate this contract on such date or the date set forth in the request, whichever is later, pursuant to the provisions of the clause of this contract entitled: "Termination for the Convenience of the Government."

D. When additional funds are allotted from timeto time for continued performance of the work under this contract, the parties shall agree as to the applicable period of contract performance which shall be covered by such funds and the provisions of Paragraphs B and C above shall apply in like manner to such additional allotted funds and substituted date pertaining thereto and the contract amended accordingly.

E. If the Contractor incurs additional costs, or is delayed in the performance of the work under this contract, solely by reason of the failure of the Government to allot additional funds in amounts sufficient for the timely performance of this contract, and if additional funds are allotted an equitable adjustment shall be made in the price or prices (including appropriate target, billing, and ceiling prices where applicable) of said items or in the time of delivery or both. Failure to agree to any such equitable adjustment hereunder shall be a dispute concerning a question of fact within the meaning of the clause of this contract entitled: "Disputes."

F. The Government may at any time prior to termination, and, with the consent of the contractor, after notice of termination, allot additional funds for this contract.

G. The provisions of this clause with respect to termination shall in no way be deemed to limit the rights of the Government under the clause hereof entitled: "Default." The provisions of this clause are limited to the work on and allotment of funds for the items set forth in A above. This clause shall become inoperative upon the allotment of funds for the total price of said work except for rights and obligations then existing under this clause.

H. Nothing in this clause shall affect the right of the Government to terminate this contract pursuant to the clause of this contract entitled "Termination."

ARTICLE XXI - F.O.B. POINT

Delivery of all items shall be F.O.B. destination and shall be shipped at contractor's expense to the destination specified in Article XX.

ARTICLE XXII - SHIPPING AND MAILING INSTRUCTIONS

All items required to be delivered under this contract shall be shipped as follows:

A. Parcel Post Shipments

Ship to:

Mark For :
Mark With:

For reissue to:

B. Freight Shipments

Ship to:

Mark with:

For reissue to:

All shipments of hardware items (e.g. mockups) shall be accompani by DD Form 250, "Material Inspection and Receiving Report." The contractor will make distribution of DD Form 250 on day of shipme as follows:

Government Plant Inspection Officer, if any, 2 copies; Contracting Officer, 2 copies; Transportation Officer, 1 copy Contracting Officer's Representative, 1 copy. Two copies shall be included in the data package (if applicable) and four copies attached to box number 1 of the shipment.

ARTICLE XXIV - SUBMISSION OF INVOICES

A. The contractor's invoice shall be prepared and submitted in quadruplicate to the following address:

B. The invoice shall contain the following information:

1. Contract No.
2. Contract Title
3. Certification as to the total number of direct manhours expended.

ARTICLE XXV - CONTENTS OF CONTRACT

This contract, NAS consists of the following:

A. Cover Page (NASA Form 437)

B. Schedule, pages 1 through

C. Exhibit A, Statement of Work, Space Shuttle System Program Definition (Phase B), dated and Appendices

D. Table XX

E. General Provisions as follows, attached or incorporated herein by reference:

1.

Clause Title	NASA PR Reference
PRIORITIES, ALLOCATIONS, AND ALLOTMENTS (SEPTEMBER 1962)	1.307-2
COVENANT AGAINST CONTINGENT FEES (FEBRUARY 1962)	1.503
UTILIZATION OF SMALL BUSINESS CONCERNS (JULY 1962)	1.707-3(a
UTILIZATION OF CONCERNS IN LABOR SURPLUS AREAS (APRIL 1958)	1.805-3(a
BUY AMERICAN ACT(SEPTEMBER 1961)	6.104-5
DEFINITIONS (SEPTEMBER 1962)	7.103-1
ASSIGNMENT OF CLAIMS (SEPTEMBER 1962)	7.103-8
DISPUTES (SEPTEMBER 1962)	7.103-12
RENEGOTIATION (SEPTEMBER 1962)	7.103-13
OFFICIALS NOT TO BENEFIT (SEPTEMBER 1962)	7.103-19
INTEREST (JANUARY 1963)	7.103-53
NOTICE TO THE GOVERNMENT OF LABOR DISPUTES (SEPTEMBER 1962)	7.104-4
SECURITY REQUIREMENTS (SEPTEMBER 1962)	7.104-12
EXAMINATION OF RECORDS (OCTOBER 1969)	7.104-15
NOTICE OF DELAY (SEPTEMBER 1962)	7.205-50
PAYMENTS (SEPTEMBER 1962)	7.302-2
STANDARDS OF WORK (SEPTEMBER 1962)	7.302-3
INSPECTION (SECOND (LONG) CLAUSE) (SEPTEMBER 1962)	7.302-4
REPORTS OF WORK (SEPTEMBER 1962)	7.302-54
SCIENTIFIC AND TECHNICAL INFORMATION SERVICE (OCTOBER 1969)	7.302-55
CHANGES (SEPTEMBER 1962)	7.304-1
TERMINATION FOR CONVENIENCE OF THE GOVERNMENT (OCTOBER 1969)	8.701(a)

ARTICLE XXV - CONTENTS OF CONTRACT (Continued)

Clause Title	NASA PR Reference
DEFAULT (OCTOBER 1969)	8.710
NEW TECHNOLOGY (MAY 1966)	9.101-4
AUTHORIZATION AND CONSENT (SEPTEMBER 1962)	9.103(b)
NOTICE & ASSISTANCE REGARDING PATENT AND COPYRIGHT INFRINGEMENT (NOVEMBER 1964)	9.105
RIGHTS IN DATA (JUNE 1969)	9.203-1
CONVICT LABOR (SEPTEMBER 1962)	12.203
CONTRACT WORK HOURS STANDARDS ACT - OVERTIME COMPENSATION (NOVEMBER 1964)	12.303-1
WALSH-HEALEY PUBLIC CONTRACTS ACT (SEPTEMBER 1962)	12.605
EQUAL OPPORTUNITY CLAUSE (NOVEMBER 1967)	12.802-1
KEY PERSONNEL & FACILITIES (JUNE 1967)	1.352
SMALL BUSINESS SUBCONTRACTING PROGRAM (NOVEMBER 1965)	1.707-3(b)
LABOR SURPLUS AREA SUBCONTRACTING PROGRAM (APRIL 1968)	1.805-3(b)
CONTRACTOR AND SUBCONTRACTOR CERTIFIED COST OR PRICING DATA (OCTOBER 1969)	3.807-4
LIMITATION ON WITHHOLDING OF PAYMENTS (SEPTEMBER 1962)	7.104-21
SUBCONTRACTS (AUGUST 1969)	23.201-1(a)
COMPETITION IN SUBCONTRACTING (SEPTEMBER 1962)	7.104-40
APPROVAL OF CONTRACT (JULY 1968)	7.104-51
STOP WORK ORDER (JUNE 1965)	7.105-8(c)
FILING OF PATENT APPLICATIONS (SEPTEMBER 1962)	9.107
FEDERAL, STATE, AND LOCAL TAXES (NOVEMBER 1964)	11.401-1
REPORT ON NASA SUBCONTRACTS (JANUARY 1964)	16.902
GEOGRAPHIC PARTICIPATION IN THE AEROSPACE PROGRAM (JUNE 1966)	1.302-52

2. Alteration to "Rights in Data" Clause attached hereto.

F. Signature Page (NASA Form 437-1)

Alteration to Rights and Data Clause

Delete paragraph (f) of the "Rights in Data" clause (Clause 90) (June 1969) and substitute therefor the following:

"(f) Except for data specified to be delivered by the schedule of the contract and furnished by the prime contractor, or subcontractors designated in the contract as "Key Subcontractors," data need not be furnished for:

(1) standard commercial items incorporated into the design, which are manufactured and available for purchase from more than one source of supply; nor

(2) proprietary data for items incorporated into the design, which items were developed at private expense and previously sold or offered for sale, including minor modifications thereof,

if, in lieu of furnishing such data, contractor alerts the Contracting Officer to the fact that data is being withheld, identifies which data is being withheld, and upon written request of the Contracting Officer:

(1) contractor furnishes form, fit, and function data on the item, i.e., data pertaining to its size, configuration, mating, and functional characteristics and performance requirements; and

(2) as to standard commercial items, contractor also identifies at least two sources of supply, and provides sufficient identification to enable the Government to procure the item or adequate substitute;

provided, however, that upon request of the Contracting Officer, contractor shall further furnish all other withheld proprietary data (but not data pertaining to standard commercial items) in accordance with the "Data Use Restrictions" clause of this contract. For the purpose of this clause, "proprietary data" means data providing information concerning the details of a contractor's secrets of manufacturing methods or processes, treatment and chemical composition of materials, plant layout and tooling, to the extent that such information is not readily disclosed by inspection or analysis of the product itself and to the extent that the contractor has protected such information from unrestricted use by others."

July 1969

REPORTS AND DATA DUPLICATION - TABLE XX

Duplication, as permitted by the Government Printing and Binding Regulations, will be done at the lowest feasible cost to the Government. To achieve this end, the following standards shall apply unless a deviation is requested from and granted in writing by the Contracting Officer. Such request should be included with your proposal.

a. Covers shall be reproduced on 50-pound antique cover paper, Federal Specification UU-P-196, JCP L20, or 110-pound index paper, Federal Specification UU-P-258, JCP K10, color as required.

b. Covers shall not exceed the size of the text pages except to protect index tabs, and binding shall be accomplished by fastening with two wire staples in the binding margin. Documents in excess of stapling capability shall be prepared in two or more volumes.

c. Hinged covers, accos, binding screws, spiral combs, and plastic protective sheets are not to be used. Self-covered documents with the cover stock the same weight as the text matter shall be used wherever the page content and the use of the publication will permit.

d. Text and foldout pages shall be on 50-pound offset paper, Federal Specification UU-P-465, JCP A60, or 20-pound writing paper, Federal Specification UU-P-212, JCP D10.

e. Foldouts shall be held to a minimum with diagrams run broadside, where possible, to eliminate the need to be excess of page size. Image areas of fold-ins reproduced by the offset duplicating method shall be restricted to 10-3/4 by 14 inches. Fold-in requirements in excess of this size shall be reproduced by the diazo or microfilm process.

f. Halftones shall be square without borders. Silhouettes and vignettes shall not be used. Combinations and composites shall not be used unless absolutely necessary to insure clarity of detail.

g. Reproduction shall be by the duplicating process and shall be on both sides of the paper for all documents in excess of 100 copies.

h. Ink shall be single color black throughout, except where additional colors are approved as being functional. Functional approval must be obtained from the Contracting Officer prior to preparation of final camera-ready art.

i. Documents shall be drilled with three 3/8-inch round holes, 4-1/4 inches center-to-center, and corner stitched or banded for insertion into standard three-ring binders which shall be used if hard cover protection is required or if document is in excess of stapling capability.

j. Dividers and sectional tabs shall be reproduced one side only on 110-pound index paper, Federal Specification UU-P-258, JCP K10, color as required, and shall be flush or square whenever possible. Angle cut tabs will be used in lieu of die cutting when flush indexes will not suffice.

ENCLOSURE NO. 4

STATEMENT OF WORK

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February 1970
Enclosure No. 4 to
RFP No. 10-8423

STATEMENT OF WORK

SPACE SHUTTLE SYSTEM

PROGRAM DEFINITION (PHASE B)

OFFICE OF MANNED SPACE FLIGHT
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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STATEMENT OF WORK

SPACE SHUTTLE SYSTEM PROGRAM DEFINITION (PHASE B)

1.0 INTRODUCTION

A space shuttle system that can transport persons and cargo to low earth orbit and return the crew, passengers, and cargo safely to earth at greatly reduced costs over present systems is entering the preliminary design and planning or definition stage of development (Phase B). This statement of work presents the scope and tasks, as defined by National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD), that are to be included in the program definition study of the space shuttle system development.

Thus far, most of the space exploration missions have involved placing men, equipment, consumables, scientific payloads, and other types of cargo into low earth orbits (300 nautical miles or less) in order to support a low earth orbit, high earth orbit, lunar or escape mission. For the high earth orbit, lunar, and escape-type missions, low earth orbits serve either as a staging, or buildup area or as a parking orbit.

The accomplishments to date have been achieved through the use of expendable launch vehicles and spacecraft. For continued growth of space flight development in the exploitation and exploration of near and far space a reusable economical logistics system is required.

2.0 PROGRAM OBJECTIVE

The objective of the space shuttle program is to provide a low-cost, economical space transportation system. This requires that the development costs as well as the operational costs be minimized. It is emphasized that low operational costs alone will not meet our objectives.

In order to achieve this goal of a low cost space transportation system and other objectives, the following characteristics are identified:

a. An operational mode which will reduce costs an order of magnitude below present operating costs.

b. A flexible capability to support a variety of payloads and missions.

c. An airline-type operation for passengers and cargo transport.

d. A reusable system with a high launch rate capability and short turnaround and reaction times compatible with rescue missions.

Keeping the objective of low cost transportation clearly in mind, the contractor must perform a continuing review of the system requirements during the Phase B study and recommend changes which significantly affect the program objective.

3.0 STUDY OBJECTIVES AND APPROACH

This statement of work defines the study effort to be undertaken by the contractor on a two-stage, fully reusable space shuttle system.

The fundamental objectives of the study are as follows:

a. To define the space shuttle system.

b. To accomplish preliminary designs of the space shuttle with the orbiter optimized for:

- High aerodynamic cross range - 1500 n. mi.
- Low aerodynamic cross range - 200 n. mi.

c. To obtain an understanding of the scope, schedule and cost of the space shuttle system.

d. To obtain an understanding of the supporting research and technology which must be accomplished.

The contractor shall, with NASA guidance and direction, carry out an in-depth, eleven month design study of the space shuttle system supported in critical areas by experimental investigations to verify the results of analysis. The study will address two point designs. One design will optimize the shuttle vehicle combination for a high aerodynamic cross range performance capability in the orbiter of approximately 1500 n. mi. A second design will optimize the vehicle combination for minimum influence of cross range in which the aerodynamic cross range performance capability of the orbiter may approximate only 200 n. mi.

It is the desire of the government in examining these two designs to explore in depth the overall influence of a high or low aerodynamic cross range performance requirement on the acquisition of the space shuttle system and to establish an optimized system design which will provide the most attractive space shuttle system in the context of a national space transporation system.

The two designs may be of the same basic configuration or may be two entirely different configurations, the choice being left to the contractor. The intent is to examine the optimum approach under each of the two values of cross range performance.

In the event it becomes possible for the government to determine the preferred design during the course of the study, NASA may elect to discontinue the contractors work on one design to enable concentration of his remaining Phase B effort on the one preferred design.

This Phase B definition study shall include the following:

a. A requirements review to consolidate and verify ground rules, constraints, and desired system characteristics.

b. A definition effort to define the configurations, subsystems, operations, facilities, and ground support equipment.

c. A preliminary design effort to develop details and specifications, down to the assembly level, for the space shuttle configurations, and to identify all appropriate interfaces between the booster and the orbiter such that separate Phase C and D contracts could be let if desired.

d. A test effort in the areas of aerodynamic performance, stability and control, aerodynamic heating, thermal protection and structures to substantiate vehicle design features and weight estimates.

e. A documentation effort consisting of final reports for the Phase B study and the formulation of test, development and program plans for a Phase C/D effort.

f. A resource and cost analysis effort to obtain reliable estimates of total program costs, including recurring operational costs.

g. A continuing weight-and-performance, cost and schedule effort for the duration of the study.

h. An interface effort under NASA direction with the space shuttle technology programs and the main engine design studies.

In the definition and preliminary design phase, the contractor shall strive to establish configurational and operational concepts which promise the safest, most useful, and most economic system.

In addition to the operational analyses, design studies, test programs and program plans, the contractor will develop soft mock-ups of critical portions of the space shuttle system which will be used in engineering assessment of the system. Scale models (1:96 scale) of the space shuttle system shall be constructed by the contractor and provided to NASA.

In addition to the structural test effort in (d.) above, the contractor will fabricate and test large or full scale representative sections of the primary structure and thermal protection system. These test articles will also include tank structure and other critical structural elements if composite structures are involved or if unique construction methods are used which have not been demonstrated on a large scale. The intent is to demonstrate producibility as well as weight and thermal protection verification. The large scale structural demonstration program will be defined by a proposal submitted by the contractor early in Phase B and approved by NASA to be negotiated as a supplement to the basic Phase B program.

NASA and DOD have underway a series of supporting studies which are relevant to the Phase B effort. These supporting studies include supporting research and technology efforts which will be concurrent with Phases B and C efforts. These supporting studies, including space station and space base studies, integral launch and reentry vehicle studies, shuttle engine studies and DOD Space Transportation System studies shall be used as appropriate to the Phase B effort.

NASA's primary concern in this Phase B study is the accomplishment of the design effort to fully define the shuttle system. Consequently, the level of effort allotted to the development of the Program Acquisition Plans and other documentation required by Appendix D should be held to a minimum.

4.0 CONTRACTOR TASKS

The contractor tasks in this program definition study are designed to provide the technical and program information necessary for the initiation of Phase C of the space shuttle system. The contractor will be required to integrate his study efforts with inputs from continuing inhouse study efforts made by NASA and DOD and with data from other contractual sources as stated in paragraph 3.0. The contractor may be required during the course of the Phase B study to provide NASA with vehicle data for other studies.

Throughout the study special emphasis is to be given to the following which are critical to the feasibility or effective implementation of the space shuttle system.

a. Aerodynamics (configuration definition and verification including wind tunnel testing)

b. Integrated thermal protection system and structure

c. Integrated avionics

d. Propulsion

e. Reusability

f. Reliability, Quality and Safety

g. Maintainability (including refurbishment, inspection and retest)

h. Low-cost operations and minimized program cost

i. Mass properties

j. Performance and weight sensitivity

k. Dynamics and control

l. Development risk

m. Launch facilities

n. Engineering development and test programs

4.1 System Analyses

The contractor shall perform space shuttle system analyses to identify the most desirable approaches. These analyses shall be performed with respect to the design recommended by the contractor, using the system and mission requirements presented in Appendices A and B and the desired system characteristics of Appendix C. The contractor shall evaluate the desired system characteristics presented in Appendix C and, on the basis of trade-off studies, recommend revisions where analyses indicate that improvements in cost and effectiveness would result.

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4.1.1 System Safety Analysis

A system safety analysis shall be performed by the contractor. The analysis shall include, but not be limited to, the following tasks:

a. Identification and classification of the potential and inherent hazards of the space shuttle configuration and operations and of potential mission-payload configurations.

b. Conducting trade-off studies concerning the systems safety aspects of the configuration and analysis of the safety of the operational modes that will influence configuration and operational mode selection. The rationale for such trade-off decisions/recommendations shall be recorded and the influence of all assumptions on the system shall be evaluated in the trade-off studies.

c. Gross hazards analyses, making maximum use of available engineering and failure modes and effects analyses, both for missions and equipment.

d. Establishment of remedial safety measures such as self-help devices, escape and rescue provisions, and emergency techniques for damage control and isolation.

These safety analyses tasks shall cover all aspects of the program, including prelaunch operations, launch safety (abort, deorbit, entry and recovery), range safety provisions, in-orbit safety, escape and rescue missions including space station personnel, orbital space-debris and meteoroid protection, and recovery implications. The OMSF Safety Program Directive No. 1A, "System Safety Requirements for Manned Space Flight", December 1969, shall be used as a guide.

4.1.2 Mission Analysis

Mission analysis should be performed in sufficient depth to ensure that the total mission requirements are attainable. Flight profiles best satisfying performance, heating, loads and abort requirements will be established. Performance sensitivities due to variations in mission and vehicle parameters will be analyzed and their effect on vehicle design determined. Performance constraints shall be identified.

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4.1.3 System Integration

System analyses shall be performed by the contractor to assure that all physical and functional requirements for the subsystems and systems have been identified and satisfied in the most logical and economical fashion. The contractor shall establish the degree to which centralization of functions is desirable (e.g., weight critical situations, similar functional requirements) and the applications where decentralization is desirable (safety-critical functions, etc.). The desirability and feasibility of providing on board checkout by incorporating built-in test and self-test features in the system design shall be determined. The desired test levels, display requirements and crew participation in test initiation shall be defined.

To provide an integrated system, the methodology shall be structured to determine the relationships between the space shuttle and the space station and associated modules, the space shuttle payload, the ground systems, and the elements within the space shuttle. Preliminary interface control documents shall be prepared for each major physical and functional element. A design data book shall be maintained to provide up-to-date material for system design control and reference.

4.1.4 Operations Analysis

An operations and support analysis shall be performed in sufficient depth to establish the costs and efficiencies of various launch operations, mission operations, ground turn-around operations, logistics and support concepts to the point that they can be taken into account as primary design considerations. The analysis shall provide a basis for realistic estimates of site manpower requirements, excluding direct payload program support. It is desired that manpower requirements, by pay rate structure, be used in completing the requirements outlined in paragraph 4.7.7 and Appendix D. Areas where specific vehicle design features severely impact the ground or flight operational characteristics for flight or ground turn-around times, will be identified. The analysis of operations, facilities and support shall proceed in parallel with and continuously interface with the vehicle design study and the other system analyses called for in this section (4.1).

4.1.5 System Flight Characteristics

The contractor shall conduct flight characteristics investigations to determine stability, control, handling qualities, loads and flight performance characteristics through all flight aspects from launch to landing (including ferry, test flights and abort entries). Control system design and handling qualities from initial entry through landing shall be evaluated by fixed-base, six degree-of-freedom piloted simulation studies. The contractor shall conduct trade-off optimization studies for the flight control system, to include system integration, system control law, system function interfaces, manual participation and automation. The maximum permissible center-of-gravity ranges are to be established and methods of control over these ranges shall be investigated. Consideration shall be given to staging, including separation technique, the maximum cross range maneuver, booster and orbiter dynamics and physical and aerodynamic interference.

The contractor shall submit as a part of his proposal for NASA approval an aerothermal wind tunnel test program and proposed test schedule utilizing both government and contractor facilities. The wind tunnel program shall include the appropriate speed, angle of attack and Reynolds number ranges to evaluate the aerothermo characteristics as specified in the preceeding paragraph.

All aerothermal data (force and moment, pressure distribution, phase change heat transfer, oil flow, etc.) generated during the Phase B contract shall be submitted to NASA as specified in Appendix D.

4.1.6 Payload Integration

An analysis shall be conducted by the contractor to determine the interfaces between the space shuttle, the space station, the science applications experiment modules, the unmanned satellite projects, and ground facilities and services. The results of the Space Station Phase B studies and ancillary experiments studies for payload module identification will be used for this analysis to establish Shuttle interfaces with Space Station payload and experiment modules. A standard interface between the space shuttle unpressurized payload bay and representative payload container modules shall be defined. The interface shall include provisions for installation, deployment and retrieval of payloads. Provision shall be made for providing space orientation data updating to the payload satellites or experiment modules.

4.1.7 Aborts

The contractor shall investigate intact abort for the space shuttle in order to provide for crew recovery and critical cargo retrieval. Intact abort implies the capability of the booster and orbiter to separate and continue flight to a safe landing; the orbiter to land with a full payload.

The abort-regimes shall be derived and applicable abort techniques, including the use of ground facilities and other aids necessary for abort commitment and targeting, shall be established. Any limitations or constraints on mission abort capability for the space shuttle shall be clearly identified.

4.1.8 Unmanned Versus Manned Booster

The contractor shall conduct trade-off studies of manned versus unmanned booster configurations. These trade-off studies shall include consideration of reliability of booster recovery, complexity and overall effectiveness of automatic or ground-controlled unmanned configurations, and safety and complexity of manned configurations. These considerations shall be applicable to abort, ferry-flight, and normal-launch phases. For manned operations, the requirements imposed on the systems shall be defined, and the operational techniques required shall be evaluated for feasibility.

4.1.9 Reliability and Quality

The contractor shall recommend a reliability and quality approach for the design of the space shuttle. The effort under this task should place emphasis on optimizing the approach to systems design redundancy and maintainability with an appropriate review of failure modes and effects analyses. Whenever design trade-offs are performed, reliability and quality must receive consideration and the affect on reliability and quality shall be evaluated and documented.

4.1.10 Maintainability

The contractor shall establish preliminary maintainability design criteria to achieve short turn-around time, ease of refurbishment and maintenance, including unscheduled maintenance and replacement on the launch pad. Special emphasis shall be placed on accessibility, inspection techniques, replacement for minimum down time and the effect of launch site environment on maintainability of vehicle/system/equipment.

Whenever design trade-offs are performed, maintainability must receive consideration and any compromise of maintainability, shall be evaluated and documented.

4.1.11 Self-Ferry and Ground Handling

All vehicle stages shall be capable of self-ferry flights between airports and provisions for strap-on engines and/or auxiliary tankage for this purpose may be considered. The contractor shall insure that all aspects of self-ferry, including emergency landing, and ground handling both at airports and at the launch site are adquately considered during vehicle design. Consideration shall be given to the provision of structural hard points that are compatible with the vehicle as well as the ground handling system designs. The contractor shall assess the self-ferry and ground handling requirements necessary to support the design, development, test and operation of the proposed vehicle, including all anticipated payloads, as well as the booster and orbiter as separate stages and the safety problems involved in the recommended ground handling operations.

4.1.12 Ground and Flight Systems Optimization

The contractor will analyze all requirements which the vehicle imposes on ground systems to determine which functions can be handled totally on-board and what the trade-offs are between increased requirements on the vehicle versus increased complexity and cost of the ground operations.

4.1.13 Manufacturability

The contractor shall establish preliminary manufacturability criteria as a requirement for his system design. These shall be considered during the design effort and utilized in design/manufacturability trade studies. These analyses shall be documented.

4.1.14 Operations Site Evaluation

It is desired to have the launch, recovery and turn-around operations occur at a single site. The contractor shall conduct an evaluation to determine the relative merits of various operations sites such as KSC, Western Test Range and in-land sites. This evaluation shall consider the effect of the sites on the vehicle operating characteristics as well as the economics associated with the relative location of the manufacturing facilities, engine test facilities, ground test facilities hazards, and environmental pollution to the surrounding areas, including hazards associated with nuclear payloads.

4.2 Design Analyses

Design analyses of the vehicle structure and thermal protection system shall be performed by the contractor to support the configuration evaluation and optimization procedures outlined under the system analyses task.

Failure modes and effect analyses as appropriate to Phase B shall be generated, and single-point failures shall be identified and minimized as part of the analyses.

Layouts and drawings shall be made to define all the principal features of the overall design and structure. These preliminary design drawings shall be adequate to perform substantive weight and center-of-gravity estimates and to define all facets of the operational use of the space shuttle.

Accurate mass properties estimation, with detailed substantiation, is a major objective of this study. Mass properties control shall be in accordance with specifications found in SP 6004 (NASA) or MIL-M-38310A (USAF), as modified in Appendix E.

4.2.1 Structure

The structural system will be broken down into major structural assemblies, subassemblies and components where necessary, and the critical design conditions and materials requirements determined. The design criteria and natural environments criteria required for the Phase B studies will be furnished by NASA at the initiation of the Phase B contract.

The contractor will determine the space shuttle loads envelope (rigid body and dynamic loads) for the mission profile from prelaunch to earth landing. The rationale for selection of the primary structural assemblies subassemblies shall be presented, including such items as propellant tankage, thermal protection systems, thrust structures, wings, fins, landing gear, et cetera. Typical cross sections of the total vehicle structure at points of interest shall be shown with sufficient details describing assembly and manufacturing methods. Design wind profiles for prelaunch, launch, and flight will be utilized for load calculations. The effects of fatigue, low frequency structural dynamics, high frequency vibration, aeroelastic effects (including flutter, buffet and static aeroelasticity) and shock and corrosive environments on the structural design conditions and structural materials requirements shall be considered. These analyses shall show that the vehicle design provides a sufficient margin of safety to assure adequate strength (static and dynamic), rigidity and safety of personnel at all times.

The contractor shall conduct structural testing on a laboratory scale to substantiate the analyses where required and to provide a basis for weight estimates. In addition, a large scale structural demonstration will be developed as described in paragraphs 3.0 and 4.5.1.

The final report shall include a comprehensive and detailed loads section and strength section that provide methods, data assumptions and analyses and test results to the depth necessary to support preliminary design.

4.2.2 Materials

Candidate materials will be identified and evaluated on the basis of weight, reliability, temperature limitation and extended life, including considerations of technology status, material compatibility and safety (e.g., toxic, radioactive, etc.), manufacturing, availability, inspection and/or repair between flights, and cost. The determination of design allowables for the materials will be made on the basis of application, environment, manufacturing and testing and extended life. In specifying materials the contractor shall consider flammability, outgassing characteristics, and resistance to corrosion and stress corrosion. Advanced materials which require further developments in technology will not be considered as primary candidates where suitable alternatives exist, but will be evaluated to determine potential improvements to system design and performance and to define requirements for technology programs.

4.2.3 Thermal Protection System

An indepth thermal analysis shall be performed before definition is made of the thermal protection systems (TPS) for the configuration. The choice of transition criteria, rationale for onset of turbulent boundary layer flow (together with supporting specific test data, where practicable) and turbulent flow heating methods are of particular significance. A comparative analysis of candidate thermal protection concepts (active and passive), materials, and installation techniques shall be made in terms of weight, cost, technology status, fabrication, maintenance techniques, reusability, inspection and refurbishment requirements. Performance comparisons shall be made of the materials under consideration for use in the TPS. The performance comparisons shall establish the capability of candidate materials to withstand the ground environment, flight environment and abort techniques developed in para. 4.1.5 and 4.1.7. Cooling, insulation,

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and attachment techniques shall be defined. Application of the TPS for meteoroid, space debris and radiation protection shall be assessed. Analyses shall be made to determine the best locations for antenna placements or other critical surface discontinuities.

The TPS design and material selection shall be consistent with multi-mission thermal design criteria. Uniform or consistent interpretation of property degradation data obtained from cyclic exposures to representative environments will be required for the design and the development of maintenance inspection practices. Analyses shall be made of thermal control aspects of the TPS such as the protection of structure, tankage and cryogenic insulations for nominal and off-nominal conditions. Provision for purging during all appropriate phases of the mission shall be considered.

The contractor shall conduct a test program on selected thermal protection systems in a realistically simulated reentry environment to verify analyses and to provide a basis for substantive weight estimates. This may involve small specimen testing as well as the large scale demonstration described in paragraphs 3.0 and 4.5.1.

4.3 Subsystem Definition

The contractor shall define the subsystems to be used in the space shuttle configuration. This definition of the space shuttle subsystems will include description, performance specifications, interface requirements, weights, volumes, reliability, safety, installation requirements, and logistic support. Trade-off analyses will be conducted as necessary to optimize subsystem definition and to assure compatibility with mission requirements and systems characteristics and minimum ground and space station support requirements.

4.3.1 Propulsion Systems

The propulsion system shall include the following subsystems, as required, for both the booster and orbiter.

a. Main Propulsion System

b. Attitude Control Propulsion Syste

c. Orbit Maneuvering System

d. Air Breathing System

e. Cryogenic Tankage System

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The contractor shall determine the requirements for and define the propulsion subsystems for the space shuttle; however, portions or all of the propulsion systems hardware may be GFE.

4.3.1.1 Main Propulsion System

a. The main engines shall be of a high performance, high pressure, bell nozzle, hydrogen-oxygen propellant design as defined in CEI Engine Specifications, DCN 1-0-21-00001. Analyses of the propulsion systems shall include the examination of the effects of engine-out capability, pressurization, propellant management and usage, propellant handling, thermal control, and integration considerations. Such system effects as the operating percent of thrust range (overthrust and throttling); performance (specific impulse, Isp); engine length; gimballing restraints; center-of-gravity location will be considered in the study. This study shall also include a determination of the optimum expansion ratio, maintaining commonality of engines, for the booster and orbiter.

b. Engine-out capability and propellant jettison capability, including emergency dumping, shall be analyzed. The practicality of draining and purging main propellant tanks after landing and prior to reloading shall be evaluated.

c. The contractor shall define the propulsion system total environment, thermal control, and propellant boiloff, and losses over the mission duty cycle.

d. The contractor shall define the design and hardware criteria and operational and redundance requirements for the following:

(1) Propellant loading, feed and utilization: Consideration should be given to: structural and fluid dynamics, geysering, POGO suppression and engine start and cutoff transients, insulation and stratification, tank passivation and reentry heating effects, transfer and manifolding, disconnects and engine-out capabilities.

(2) Pneumatic: Consideration shall be given to: the storage volume, use rates and allowable leakages, control systems with operational limits for regulators, valves, switches, etc.

4.3.1.2 Attitude Control Propulsion System

The ACPS shall utilize the propellant combination oxygen/hydrogen in a gaseous state in the ACPS engines. The contractor shall determine the vehicle control requirements which must be satisfied by the ACPS for each of the various mission phases including: liftoff and boost, separation, orbit insertion and circularization, coast and transfer trajectories, rendezvous, docking, orbit maintenance, retrograde, reentry. The contractor shall consider the redundancy requirements specified in Appendix C "Desired System Characteristics" of this statement-of-work. The contractor shall translate the vehicle control requirements to at least the following ACPS type requirements:

a. Total thrust and torque per axis

b. Total impulse per axis

c. Duty cycle per axis

d. Minimum and maximum impulse bit per axis

e. Volume and weight limitations and vehicle sensitivities

f. Allowable thrust and specific impulse limitation per axis

g. Thrust application constraints such as "pure couples", "pure translation", thrust and minimum impulse bit repeatibility, etc.

The contractor shall conduct the necessary analysis, design and trade studies to configure conceptual system candidates to meet the above requirements. The contractor shall consider a low pressure ACPS which would utilize the boost tanks as an accumulator and heat exchanger, as well as higher pressure systems which may or may not be integrated with the main propulsion system. Maximum utilization of residuals and boiloff shall be considered for use in the ACPS. After the various options are examined the contractor shall select the ACPS concept and shall generate a detailed description of the selected system including performance specifications, interface requirements, weights, volume, etc.

4.3.1.3 Orbit Maneuvering System

The contractor shall determine the requirements for the orbit maneuvering system including the thrust levels, total impulse, number of starts, etc., for the orbiter vehicle. The propellant combinations shall be oxygen/hydrogen. Trade studies shall be performed to determine if the main propulsion and attitude control propulsion systems should perform on-orbit maneuver functions or if a separate system should be provided. This system could be separated from or integrated with the main propulsion system. Operational flexibility, safety, weight, and performance of the total propulsion system are of primary importance in defining this system. The contractor shall generate a detailed description of the selected system including performance specifications, interface requirements, weights, volumes, etc.

4.3.1.4 Air Breathing System

The contractor shall define the type and thrust level of the ferry, go-around or landing assist engines, as well as performance, location, tankage and fuel feed, deployment techniques (if applicable), pressurization, lubrication system, instrumentation, data display, and control requirements of the engines. The practical merits of using hydrogen as fuel for these engines shall be evaluated in depth and compared with the use of standard fuels such as JP. The contractor shall recommend the preferred fuel and its phase (gaseous or liquid), as derived from this evaluation. In addition, to understand the full implication of air breathing propulsion requirements for the orbiter and their impact on the booster, the contractor shall perform trade-off studies of: (1) the baseline requirement for go-around capability; (2) powered approach and (3) no air-breathing propulsion.

Analyses will be conducted to establish the practicality of using a common engine for both booster and orbiter. Determine modification to jet propulsion air breathing engines for hydrogen fuels, vehicle integration requirements, and review available engines for their acceptability.

4.3.1.5 Cryogenic Tankage System

The contractor shall define the Cryogenic Tankage Systems with particular emphasis on configurations, residuals, system thermodynamics, thermal protection (ground and all flight modes), pressurization requirements, fluid dynamics and liquid transfer, zero-g venting, quantity guaging, servicing, both ground and in-flight dumping, and compatible material selection. A study shall be conducted to establish feasibility of using common tankage for propulsion as well as fuel cells, if required, considering the ultra-pure reactant requirements for long life fuel cells. An effort shall be made to optimize the total cryogenic systems from a weight standpoint with consideration toward maximum tankage integration to facilitate residuals transfer and to minimize fluid losses through overboard venting.

4.3.1.6 Engines/Vehicle Integratioı

The contractor shall conduct those studies and analyses necessary to support the NASA engine development programs. To ensure proper and timely engine definition and vehicle integration the contractor shall make available data in accordance with Appendix F. The contractor shall evaluate the results of the engine parametric analysis as described in paragraph 4.1.4.1 of the Space Shuttle Main Engine Statement of Work as it affects the vehicle requirements and shall recommend the desired operating parameters, including any changes from the baseline engine size of 400,000 pounds sea level thrust. The booster and orbiter shall use a common engine except for differences peculiar to expansion ratio optimization.

4.3.2 Electro-Mechanical and Integrated Avionics

The contractor shall define the functions and requirement of the electro-mechanical and integrated avionics system. This system will include, but not be limited to, the following functions:

a. Guidance and Control

b. Navigation

c. Communications

d. Onboard checkout

e. Configuration and sequencing control

f. Displays

g. Data Management

h. Target tracking and sensors

i. Automatic landing system

j. Other functions which require computational capability or the exchange of data between systems

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The contractor shall determine the amount of onboard control and automation which is both desirable and feasible, taking into consideration overall subsystem and system concepts, requirements, and crew integration. Investigations and trade-off studies of crew size and skills, workload, system complexity, checkout and inflight status monitoring, and costs shall be included in determination of the amount of onboard control and automation. The contractor shall determine the optimum utilization of like components or systems on orbiter and booster. The space shuttle should be controlled routinely with onboard systems and should make minimum use of ground and navigational aids.

The contractor shall take into consideration electromagnetic interference and establish standards for its control. The contractor shall also specify verification testing for individual assemblies and the integrated system with particular regard to compatibility of low level signal requirements of the electronic systems.

The contractor will perform the following trade-off studies:

a. Centralization of functions: The contractor shall establish the desired degree of centralization. Applications where centralization is desirable (e.g., weight critical situations, similar data processing requirements) and applications where decentralization is desirable (e.g., safety-critical functions, high-sample rate operations, situations which are suitable to analog techniques) are to be considered. Emphasis shall be given to the definition of the onboard computer organization and hierarchy, and emphasis shall also be given to a comparative evaluation of the centralized computer concept versus other candidate concepts. The effect upon the avionics system design of the requirements for a high degree of onboard control and for a short turnaround time should be carefully considered. The level of system information necessary to implement flight crew fault and failure isolation and to satisfy ground service and turnaround requirements shall be established.

b. Digital interface techniques: The contractor shall consider both multiplexed data bus and nonmultiplexed data bus techniques. Logic complexity, software requirements, data rate, electromagnetic compatibility, reliability, flexibility, and so forth will be investigated.

c. Modular design: The desired extent of modularization for both avionics packaging and package installation in the space shuttle will be recommended by the contractor. The contractor shall also consider standard techniques for packaging, mounting, cooling, interconnections, circuit design, and parts selection. A study of modular checkout and maintenance approaches will be made.

d. Power condition: The contractor shall consider the centralization of power conversion versus the incorporation of power in systems for both an overload and a short-circuit protection approach. The power quality requirements (including the limits of ripple, transients, interruption, and conductor-interference effects) for power distribution shall be established.

e. Onboard checkout: The desirability and feasibility of incorporating built-in test and built-in self-test features in the system design should be determined. The desired test levels, the display and recording requirements, the extent of trend-data analysis and the extent of crewman participation in test initiation and stimulus generation shall be defined.

f. Configuration and sequencing control: The contractor shall recommend the criteria for the degree of crew participation. A comparison of alternate automatic/manual techniques shall be made and assessed in terms of cost and system complexity.

g. Redundancy techniques: The contractor shall recommend the redundancy techniques which are to be implemented for each application of the space shuttle. Inactive versus active redundancy shall be examined. The contractor shall consider circuit complexity, malfunction detection, performance degradation, and crew participation in determining redundancy techniques.

h. Integrated displays and controls: The crew decision and control requirements shall be established by the contractor. The human factors that are involved will be evaluated. Redundant multipurpose computer-operated displays shall be considered for providing both system status and flight-path information.

i. Sensors and actuators: The contractor shall determine how to best integrate sensors and actuators into the avionics system. Operating parameters (input and output signal characteristics, operating power, and control requirements) versus interfacing requirements of existing designs will be considered. An evaluation of the desirability of integrating flight safety items should be made. The contractor will recommend a preliminary avionics system point design. Subsystem configurations will be identified and described. Functional block diagrams and performance specifications for each subsystem will be prepared. Anticipated high-risk areas, critical problem areas, and the technology advances that are required for each subsystem will be identified.

j. The contractor will prepare cost, size, weight, power, and schedule estimates for the recommended avionics system configuration. The recommended integrated avionics system shall be compared to a conventional modular approach.

k. Shuttle-Ground Communication Interface: The contractor shall define the requirements for and the interfaces between the ground facilities, communication satellites and the shuttle for communications, data transmission and tracking. Data from the Space Station Program Definition studies shall be considered.

4.3.3 Landing System

The type and characteristics of the landing system shall be defined. Definition shall include dynamics and structural anslyses with weight, volume, stowage, location, and environmental control considerations. The contractor shall also trade-off the minimum acceptable landing-surface conditions and vehicle touchdown characteristics compatible with the recommended landing system. When feasible, standard aircraft landing system design practices should be followed. In addition, deceleration parachutes or devices (other than control surfaces) shall be defined, if applicable.

4.3.4 Docking System

The contractor shall perform analyses of an automatic approach and docking capability. The analyses will assess the operational aspects, including safety, of various docking options, i.e., shuttle docked with space station, space base or other orbiting vehicle; deployed payload module docked with space station, space base or other orbiting vehicle, etc. The number of pilot tasks necessary during the docking maneuver should not require more than one crewman. Once physical contact has occurred between the shuttle or its payload module and another orbiting vehicle, the docking system must be capable of limiting the relative motion of the two vehicles. Removal of the docking hardware in whole or in part should not be required in order to facilitate transfer through the docking port. The docking system must be reusable.

Trade-off studies shall be made to determine to what extent stabilization of the docked shuttle/space station or other orbiting vehicles will be a shared or complementary function and how this affects the docking mechanization These studies should consider the possible need for soft or flexible docking, possibly to alleviate structural loads on both the shuttle and space station. The amount of automation, degree of complexity, costs and other trade-offs shall be determined.

4.3.5 Environmental Control and Life Support System

The contractor shall perform analyses and define all elements involved in the environmental control, thermal control, water and waste management, and life support subsystems that are required on the space shuttle. These investigations shall include the environmental control, life support system (ECLS) requirements and interface requirements for the cargo compartment.

The environmental control and life support system must provide the following five functions:

a. Maintenance of a shirtsleeve environment-temperature, atmospheric pressure and composition

b. Supplying of water and oxygen

c. Revitalization of the atmosphere

d. Provision of facilities for waste management

e. Maintenance of the temperature of space shuttle equipment by dissipating heat and compensating for the varying thermal environment

4.3.6 Power System

The contractor shall analyze and recommend an integrated power system for both the booster and the orbit vehicles. Trade-off studies and analyses shall be conducted to establish detailed operating profiles and to recommend generation, distribution, conditioning, and control elements for all onboard power (including electrical, pneumatic, and hydraulic power).

4.3.7 Crew and Passenger Accommodations

The contractor shall perform trade-off studies with particular emphasis on human factors engineering to determine optimum crew habitation and working conditions. The design approach shall be one which achieves maximum work efficiency, minimum fatigue, adequate rest and diversion during non-duty periods, and maximum safety during all mission phases. Layouts of the crew compartment and instrument panels shall be prepared. These analyses shall include trade-off studies of optimum ways of accommodating twelve (12) passengers, including permanent seating in a cabin vs "palletized" accommodation in the cargo compartment. Since most missions require two (2) passengers for handling cargo (Appendix B) consideration will be given to providing permanent accommodations for a minimum of two passengers. An optimum tunnel configuration shall be provided for access between the crew and passenger/cargo compartment.

4.3.8 Launch System Interfaces

The contractor will define for all flight systems the requirements for interfaces with ground systems during prelaunch and launch operations. This will include identification of all physical connections for structural support and stabilization, power, communications, control, checkout, propellants, fluids and gasses.

4.3.9 Flight Control System

The flight control systems for booster and orbiter shall include both the attitude control propulsion system (para. 4.3.1.2) and the aerodynamic system. The contractor shall determine the requirements for and define the FCS subsystems and interfaces for the Space Shuttle system by analyses of system performance, stability, power requirements, duty cycle, fail safe features and static and dynamic structural loads.

The contractor shall conduct flight control system testing using a FCS simulator and mockup.

4.4 Configuration Preliminary Design

Sections 4.1, 4.2 and 4.3 have described space shuttle system analyses, design analyses and subsystem analyses to be performed by the contractor. The contractor shall utilize results of these analyses to provide an in-depth preliminary design definition of the space shuttle system. This definition shall include:

a. Design Drawings

b. Preliminary Part I CEI specifications for the space shuttle system, the booster, and the orbiter, and their subsystems and any other identifiable end item.

c. Preliminary Interface Control Drawings (ICD s) for the mechnical, electrical and functional interfaces of the space shuttle to the launch facility, the booster to orbiter, the booster airframe to booster engine and the orbiter airframe to orbiter engine. Once an ICD is approved and baselined by NASA, all future changes to that ICD will require NASA approval.

A baselined engine/airframe ICD and the design criteria and natural environments criteria required for Phase B space shuttle studies will be furnished by NASA at initiation of the Phase B contract.

The preliminary design task shall include but not be limited to the following elements:

a. Performance, stability and control and flight mechanics

b. Structure, thermal protection, and vehicle thermal control subsystems

c. All other space shuttle subsystems

d. Ground operations (including inspection, refurbishment and recertification) and flight operations

e. Facilities and ground support equipment

f. Logistics support

g. System safety

h. Manufacturing, reliability and quality assurance

i. Growth potential

Full-scale soft mockups of critical areas of the space shuttle configuration and scale models (1:96) shall be constructed for use as engineering aids. These critical areas shall be delineated in the proposal made by the contractor.

During fulfillment of this task, identification of new hardware, software, and modifications or additions that are made to existing flight hardware and to existing ground facilities and equipment shall be provided. Preliminary system designs for flight hardware should be developed to level 6 (assembly). Preliminary systems designs for new items of ground equipment should be developed to level 5 (subsystem).

In support of the preliminary design activities, structural, stress, thermal, dynamics and control, docking, aerodynamic, reliability, safety, maintenance, reusability, etc., characteristics for all mission phases shall be analyzed. The minimum amount of ground testing shall be performed which is necessary to assure that the recommended configuration can be developed without program delays. This includes wind tunnel tests on configuration models to establish characteristics such as aerodynamic stability, loads, heating, guidance and control characteristics, etc.; special testing on thermal protection system elements and unique structural elements, or other testing as required. Initial effort will be directed toward the identification of testing effort required to be conducted as a part of Phase B. A report thereof will be submitted as a part of the Phase B study plan and updated as required at subsequent formal reviews.

4.5 Configuration Preliminary Verification

The contractor shall, at the end of the Phase B study, provide to NASA the wind tunnel models of the preliminary design configuration used for the wind tunnel testing called for in paragraph 4.1.5. These models shall be used by NASA for evaluation of predicted aerothermal characteristics. Should NASA require additional wind tunnel test models, these requirements shall be the subject of separate negotiations.

4.5.1 Structural Test Program

In addition to the structure/TPS investigations called for in paragraph 4.2.1 and 4.2.3, the contractor shall propose, in accordance with the schedule given in Appendix F, a test program of major structural subassemblies. All test set-ups, facilities, fixtures and any other items needed to accomplish this shall be identified. These tests should be priority ordered such that supplemental NASA funding could be directed at the critical areas. The intent of this test program will be to provide data for design purposes and to verify the design concepts being proposed.

4.6 Supporting Research and Technology

During the course of the Phase B study work the contractor shall identify and define the technology which would further enhance his design, or decrease development risk. The contracto shall submit to NASA his need for technological data and indicate the specific range of data requirements needed to support the space shuttle design effort.

4.7 Program Acquisition Plan

The contractor shall prepare and provide NASA with a preliminary program plan for the space shuttle development and operations program. This plan shall reflect the result of analyses to identify cost drivers, trade-offs and innovations, both in technology and ways of doing buisness, to obtain a minimum cost program. The analyses of these trades will be used by the contractor to reduce cost of design and operational concepts throughout the Phase B study. The program plan shall place special emphasis on those areas of the program which are major cost drivers. This plan shall include, but not be limited to, the areas identified in paragraphs 4.7.1 to 4.7.7 of this section and Appendix D.

4.7.1 Program Management Plan

The program management plan shall depict the approach to management recommended by the contractor. The plan shall include the program management activities required to adequately conduct the program.

4.7.2 Engineering and Development Plan

The engineering and development plan will depict the approach to the design effort adopted by the contractor. Overall system performance, design verification, evaluation of the technical adequacy of interfaces, design and performance integration, and analysis and evaluation of development tests will be included in the plan.

4.7.3 Operations Plan

The operations plan shall contain recommendations made by the contractor regarding ground and flight operations. The plan will include a description of all ground operations from landing to launch and will identify all requirements for flight operations including communications, operating and control procedures (including automation) of the tracking and data acquisition network. A plan for using data relay satellites will also be included. The primary emphasis for this plan should be directed to the new operational aspects of the space shuttle and their effect on vehicle design. This plan shall include obtaining, utilizing, storing, and disseminating test and operational data generated during the program. The intent shall be to provide a method whereby data generated during the development and qualification programs can be utilized in establishing the operating regime and capabilities of the system and subsystems, as well as providing a source of data to be used in the determination of operational aspects of the program.

4.7.4 Facility Utilization and Manufacturing Plan

This plan shall be limited to the major manufacturing problems which will be involved in producing the space shuttle, and solutions to these problems will be proposed. In addition, new facilities requirements shall be identified and justified by analytical studies. The plan shall identify all major facilities required for the space shuttle development, test, manufacture, and operation.

4.7.5 Test Plan

The test plan shall describe an overall test program with the objective of achieving operational flight status for the space shuttle for substantially lower costs than in previous space programs. The test plan shall identify and evaluate test facility requirements. The test plans should delineate vendor test programs, the preinstallation test program, system buildup test programs, and integral vehicle test programs. The test plan should include the purpose, estimated time, and test equipment to be involved in the test program. Unmanned operations for early test flights shall be considered. Through a careful review of past programs (including high performance aircraft programs) and projected technology, the contractor proposed test and checkout plan should clearly show reduced costs compared to previous programs. Increased automation and standardization of test devices is desired, and the design of complex electronic, special-purpose ground support equipment should be avoided.

4.7.6 Logistics and Maintenance Plan

The contractor shall develop a plan for logistics and maintenance. This plan shall identify maintenance and logistics requirements necessary to support development, test, and operations of the space shuttle program. This evaluation shall be accomplished in sufficient depth to identify requirements which significantly affect feasibility and cost.

4.7.7 Program Cost and Schedule Estimates Plan

The contractor shall provide cost estimates for the space shuttle program at the levels and in the manner prescribed in Appendix D.

5.0 PHASE B STUDY MANAGEMENT

Phase B Study Management shall be in accordance with sections 5.1 to 5.7 of this document.

5.1 Participation of NASA and DOD

The scope of this definition task requires that several NASA centers, USAF, contractors, and other organizations be involved in the task implementation. The NASA will arrange for and coordinate all visits and interchange of information between the contractor and other organizations.

The NASA will participate in the program definition study at any time and to the extent deemed necessary to assure satisfactory direction, emphasis, and progress. Informal discussions and formal reviews will be arranged (as outlined in section 5.3 of this document) by NASA. The purpose of such meetings is to review the progress of the study, to provide the contractor with supplementary information, and to provide any guidance and redirection that may be required.

To fully accomplish the Phase B Study, NASA currently contemplates the award of up to three parallel contracts. The plan for administering the contracts is to place contractual responsibility for one or more total systems studies at the Manned Spacecraft Center (MSC) and one or more total systems studies at the Marshall Space Flight Center (MSFC). The choice of contract assignment will be at the Government's option only. The respective Centers will designate Contracting Officer Representatives to provide the technical surveillance and interface coordination which will be required during the contractor's performance. The contracts will be performed concurrently over the eleven-month period.

During the Phase B study effort both MSC and MSFC will be responsible for the technical direction of that part of the total system for which the Center will assume ultimate responsibility in later phases of the program. In this regard MSC will provide technical direction of the orbiter element, with MSFC providing technical direction of the booster element of each of the total systems contracts regardless of whether it (the Center) holds overall responsibility for that total systems contract. The

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Program Study Office located at each Center will contain an integration group that will be composed, in part, of personnel from the other Center. Elements of these integration groups will also work with an integration team reporting to the Office of Manned Space Flight, NASA Headquarters.

5.2 Contractor Management

The contractor shall assign a full-time study manager to the project. The study manager shall be delegated appropriate authority and shall be assigned the responsibility to accomplish the requirements specified in the contract. The study manager shall be assisted by a full-time staff. This staff shall be structured to have a clearly identifiable manager for each of the vehicles (orbiter and booster) so as to interface efficiently with the NASA technical management team. Appointment or reassignment of all key personnel will require NASA concurrence.

Before work on the project is begun, the contractor will meet with NASA for an orientation briefing to discuss details of the work to be accomplished and the method of approach adopted by the contractor. At this orientation, the contractor and the NASA will review the negotiated study plan which shows the functional and time phased flow of tasks and subtasks, the man hours planned for each task and subtask, proposed subcontracts, and suitable milestones. The key personnel who are to be assigned to the study will be present at this orientation meeting and will be expected to discuss detailed plans for their respective areas of responsibility.

5.3 Technical Performance, Review, and Evaluation

Throughout the duration of the contract, special working sessions, informal reviews, and special conferences will be held at times and places to be determined by NASA. Regular informal monthly reviews of technical progress will be scheduled.

The contractor will present formal reviews as required. These reviews will probably be required at the end of the third, sixth, eighth and eleventh month of the study.

5.4 Preparation and Release of Documentation and Software

A list of interim reports, final reports, and other deliverable documentation to be provided by the contractor is contained in Appendix D. All computer programs, program documentation, and instructions developed in connection with this study shall become the property of NASA and shall be prepared in accordance with written instructions from the NASA.

The contractor shall obtain approval from NASA prior to release of data, publication of articles, or release of any information resulting from this study.

In the area of documentation and procedures, the contractor shall review all applicable documents and directives and make recommendation for significant cost effective modifications in achieving the stated objectives of the documents as appropriate to the space shuttle program. Upon approval by the NASA the documents as modified shall be implemented.

5.5 Subcontracts and Supporting Contracts

The contractors shall cooperate and participate in the exchange and integration of information with other Government contractors performing supporting studies. This coordination and integration activity will be as specified by NASA and will include reports, presentations, conferences, and other special meetings.

5.6 Data Management Requirements

The contractor shall furnish all data items identified and described on the Data Requirement List (DRL), NASA Form 1106, Appendix D. The data items shall be prepared in accordance with the Data Requirement Description, NASA Form 9, Appendix D.

Wherever practical, the contractor's internal documents shall be used to meet the requirements specified in the applicable DRD. Unless otherwise specified, internal documents shall not be retyped or reprinted prior to submission or use.

5.7 Reports

The contractor shall submit a Phase B Final Report for the shuttle system prepared in accordance with Appendix D.

The contractor will submit monthly progress reports in accordance with Appendix D.

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APPENDIX A

STATEMENT OF WORK

SPACE SHUTTLE SYSTEM PROGRAM DEFINITION (PHASE B)

BASELINE SYSTEM REQUIREMENTS

APPENDIX A

BASELINE SYSTEM REQUIREMENTS

The following characteristics shall be considered as baseline system requirements. Variations from these baseline requirements should be identified by the contractor in the event improvements in mission capability and/or reductions in cost could be achieved.

	Systems Requirements	Vechicle (B-Booster (O-Orbiter
1.	Fully Reusable Two (2) Stage Vehicle	B, O
2.	Vertical Takeoff; Horizontal Landing	B, O
3.	No Propellant Cross Feed	B, O
4.	Aerodynamic Crossrange: Configuration (s) for low crossrange (approximately 200 n.mi.) and high crossrange (approximately 1500 n.mi.)	O
5.	Gross liftoff weight - 3.5 million pounds	B, O
6.	The cargo bay shall be sized to have a clear volume of 15' diameter X 60' length.	O
7.	A maximum payload capability shall be provided to the Space Station orbit and return. The vehicle must also be capable of flying up or down with lighter payloads.	O
8.	400,000 pound sea level thrust bell-type engines will be baselined in both the orbiter and booster stages as further defined in CEI Specifications, DCN 1-0-21-00001.	B, O
9.	Sequential Ignition	B, O
10.	Intact abort capability will be provided. This implies the capability of the booster and orbiter to separate and continue flight to a safe landing; the orbiter to land with a full payload.	B, O

Systems Requirements (continued)		Vehicle
11.	A Booster/Orbiter life of 100 missions will be provided with a cost effective level of refurbishment and maintenance.	B, O
12.	The weight of passengers and removable provisions for passengers is charged to the payload.	O
13.	All vehicle stages shall be capable of ferry flights between airports. Provisions for strap-on engines and/or auxiliary tankage may be considered.	B, O
14.	The Booster and Orbiter shall be baselined to have go-around capability.	B, O
15.	The Booster shall be capable of returning to the launch site.	B
16.	The Booster and Orbiter shall each have a two (2) man flight crew.	B, O
17.	Propellant shall provide 1500 fps in excess of the amount required to obtain the referenced injection orbit. The tanks shall be sized to provide for a 2000 fps delta V capability.	O
18.	The Orbiter crew and passenger environment shall be shirtsleeve.	O
19.	Systems sensitivity to loading of fluid consumables shall be minimized.	B, O

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APPENDIX B

STATEMENT OF WORK

SPACE SHUTTLE SYSTEM PROGRAM DEFINITION (PHASE B)

MISSION REQUIREMENTS

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APPENDIX B

MISSION REQUIREMENTS

The following mission requirements are presented to provide initial direction for the Phase B study. Continuous refinement of these requirements may be provided to the contractor by the NASA throughout the duration of the contract. Table B-1 contains a general description of the missions and mission requirements that have been identified as being of major interest in future space program planning.

The following nominal conditions have been selected, from the mission matrix discussed previously, as the shuttle baseline requirements:

1. Mission duration: At least 7 days of self-sustaining lifetime shall be provided for the mission duration. For missions in excess of 7 days the weight of the expendables shall be charged against the payload.

2. Design reference mission: The reference mission to be used in designing the space shuttle is a logistics resupply of a space station or space base.

3. Reference injection orbit: The reference injection orbit shall be 50 X 100 nautical miles.

4. Reference injection orbit ΔV: 1500 fps of usable ΔV capability in excess of the amount required to attain the reference injection orbit shall be provided.

5. Design reference orbit: The reference orbit to be used in designing the space shuttle shall be a 270-nautical-mile circular orbit, with a 55° inclination. For purposes of performance calculation the vehicle shall be considered to be launched from a lattitude of 28.5 degrees North.

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MISSION CHARACTERISTICS

MISSIONS / ORBITAL CHARACTERISTICS	SPACE STATION/ BASE LOGISTICS SUPPORT	PLACEMENT AND RETRIEVAL OF SATELLITES	DELIVERY OF PROPULSIVE STAGES & PAYLOAD	DELIVERY OF PROPELLANTS	SATELLITE SERVICE & MAINTENANCE	SHORT DURATION ORB. MISSION
ALTITUDE (N. MI.)	200 - 300	100 - 800	100 - 200	200 - 300	100 - 800	100 - 300
INCLINATION (DEG.)	28.5-90	28.5-SUN SYN.	28.5-55	28.5-55	28.5-SUN SYN.	28.5-90
ON-ORBIT ΔV (1000 FPS)	1 - 2	1 - 5	1 - 1.5	1 - 2	1 - 5	1 - 2
ON-ORBIT STAY TIME (DAYS)	7	7	7	7	7 - 15	7 - 30
CREW	2	2	2	2	2	2
PASSENGERS (MIN.)	ROTATE 50 MEN/QTR	2	2	2	4	12
DISCRETIONARY PAYLOAD						
WEIGHT (1000 LBS.)	*70/QTR	————	————	————	————	————
VOLUME (1000 FT.^{3})		5 - 10	10	10	5 - 10	4 - 6
CRITICAL DIMEN. DIA. (FT.)	10 - 15	15	15	15	15	15

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* INCLUDE PASSENGERS

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DESIRED SYSTEM CHARACTERISTICS

The desired system characteristics listed below are presented to provide initial direction for the Phase B study. The contractor shall evaluate these desired system characteristics and shall recommend revisions where improvements in cost and effectiveness would result. Continuous refinement of these characteristics will also be provided to the contractor throughout the duration of this contract. For convenience, the following tabulation of characteristics has been grouped under three headings: Progмam Characteristics, Vehicle Characteristics, and Operational Characteristics; however, it should be noted that each item applies to the total system.

Program Characteristics

1. Costs will be reported using the design reference mission and should not include payload costs. A communication satellite system is assumed to be available and shall not be costed in the program.

2. The calendar year 1972 will be used as the materials technological base.

3. IOC baseline is the second half of 1977.

4. Flexibility shall be maintained to incorporate technology advancement and alternate missions.

5. Launch rates will vary from a minimum of 25 to a maximum of 75 per year. Cost estimates shall be developed for two launch rates: 25 and 75/year.

Vehicle Characteristics

		Vehicle (B-Booster O-Orbiter
1.	The vehicle shall have a two-man flight crew and shall be flyable under emergency conditions by a single crewman.	B, O
2.	Provisions shall be made for deployment and boarding of a cylindrical payload of the size specified in Appendix A of this document.	O

APPENDIX C

STATEMENT OF WORK

SPACE SHUTTLE SYSTEM PROGRAM DEFINITION (PHASE B)

DESIRED SYSTEM CHARACTERISTICS

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3.	The crew environment shall be shirt-sleeve.	B, O
4.	The space shuttle shall have an internal, sealable tunnel with a standard interface between the crew compartment and unpressurized payload bay.	O
5.	The space shuttle crew/passenger compartment atmosphere and total pressure shall be compatible with the space station and space base.	O
6.	Systems shall be designed for a minimum of maintenance with ease of removal and replacement; maximum use of aircraft design practice will be used.	B, O
7.	In systems where redundancy is needed, the space shuttle systems shall be developed to provide redundant full mission capability and shall avoid minimum-requirement, minimum performance backup system concepts.	B, O
8.	The space shuttle system shall provide for safe mission termination in the event major malfunctions occur during prelaunch preparations and subsequent to lift-off. The desired safe-mission-termination capabilities should allow for crew and passenger egress prior to lift-off and for intact separation of orbiter from booster following lift-off.	B, O
9.	Multiple redundance system techniques that minimize or eliminate system transients caused by system component failures shall be adopted.	B, O
10.	All subsystems shall be designed to fail operational after the failure of the most critical component and to fail safe for crew survival after the second failure. Electronic systems shall be designed to fail operational after failure of the two most critical components and to fail safe for crew survival after the third failure.	B, O

Vehicle Characteristics (continued)		Vehicle
11.	Boost stages should be designed for manned operations, but capable of operating in an unmanned mode.	B
12.	Vehicle preflight and inflight checkout systems should be on-board, consistent with short turn-around and low cost operations.	B, O
13.	The vehicle shall be designed for maximum on-board control, using on-board and ground capabilities as appropriate to maximize operational flexibility and minimize ground mission operations consistent with low cost.	B, O
14.	Guidance and navigation functions shall be performed on-board, using ground and other navigation aids when appropriate. The guidance and navigation system shall be unrestricted in attitude.	B, O
15.	A three-axis translation system and a three-axis attitude control system is required. These systems shall be designed to minimize cross coupling which may result from normal operation and from potential failure modes.	B, O
16.	The space shuttle system shall be capable of remote or pilot-controlled landings. The automatic landing capability should permit landings under FAA category II conditions. Autopilot systems similar to systems used in commercial aircraft shall be included.	B, O
17.	The vehicle shall incorporate on-board provisions to quickly and easily place the space shuttle in a safe condition following landing.	B, O
18.	Survivability against hazards from radiation as specified in Joint DOD/NASA Survivability Characteristics document (S) dated 16 June 1969.	O
19.	Hydrogen will be baselined as fuel for the air breathing engines.	B, O

Operational Characteristics	Vehicle
1. Space shuttle launch sites may be located at KSC, Western Test Range or an in-land site.	B, O
2. All-azimuth launch capability	B, O
3. The vehicle trajectory load factors should be a 3g capability for passenger-carrying missions.	B, O
4. The launch pad, the primary landing site, and the servicing facility shall be in the same general location	B, O
5. The space shuttle shall have minimal assembly and checkout requirements at the launch pad.	B, O
6. Use of specialized facilities (i.e., clean room, altitude chambers, etc.) shall be minimized.	B, O
7. Cargo elements containing hazardous material shall have self-contained protective devices or provisions against all hazards.	O
8. A variety of self-sustaining payload types shall be included in the payloa integration. Prelaunch payload integration procedures similar to current air-cargo carrier operations are desired. In general, payloads should be loaded prior to moving to the launch pad.	O
9. Limited transfer of cargo shall be possible through the personnel transfer hatch.	O
10. The vehicle shall be docked to the space station or space base, and docking to accommodate personnel and cargo transfer should nominally be accomplished in a single operation.	O

		Vehicle
11.	Personnel and cargo transfer shall nominally be intravehicular activity.	O
12.	For logistics missions, personnel and cargo transfer will be by intravehicular activity. EVA capability should be provided at the expense of the allocated payload weight. The design of the vehicle should not preclude EVA capability.	B, O
13.	The space shuttle shall be designed to lift-off within a 60-second launch window for all launch azimuths.	B, O
14.	For the design reference mission, the space shuttle shall be capable of launch from a standby status within two hours and nominally would be launched at the next acceptable in-plane opportunity. The vehicle should be capable of staying in a launch status until the second in-plane launch opportunity. The system must be capable of accommodating the time between insertion and rendezvous for a worst case phasing situation. The orbit maneuver sequence should not be constrained by systems limitations.	B, O
15.	By using ground facilities and other aids when appropriate, the space shuttle shall be capable of accomplishing rendezvous with a passive target.	O
16.	Systems sensitivity to weather conditions during assembly, checkout, and launch shall be minimized.	B, O
17.	The opportunity to return to a pre-selected site shall be available at least once every 24 hours or at more frequent intervals for the high cross-range configuration. By using alternate sites, more frequent emergency returns will be possible.	O

Operational Characteristics (continued) | Vehicle

18.	Hypersonic lift-drag ratios will be referenced to conditions at a Mach number of 20 and at an altitude of 200,000 feet.	B, O
19.	The space shuttle elements shall have the capability to land horizontally on runways no longer than 10,000 feet.	B, O
20.	Landing characteristics and handling qualities shall not require skills more demanding than those required for operational land-based aircraft.	B, O
21.	Visibility from the cockpit during landing shall be comparable to high-performance aircraft standards.	B, O
22.	Total space shuttle turn-around time from landing to launch readiness should be less than two weeks. The removal and replacement time shall be minimized with on-board checkout and module accessibility.	B, O
23.	All-electronic displays and controls should be used, wherever practicable, to replace toggle switches and electromechanical gages and motors.	B, O
24.	The space shuttle shall be capable of operating within the cargo range from zero to maximum capability.	B, O
25.	Service lines at the launch pad should be minimal, preferably only for the main propulsion systems propellants.	B, O
26.	Maximum use of existing standards for the selection, design, packaging and integration of hardware should be employed, consistent with program operational requirements.	B, O
27.	Any peculiar GSE required to support a remote site landing should be packaged in a manner to be easily flown into the site.	B, O

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APPENDIX D

STATEMENT OF WORK

SPACE SHUTTLE SYSTEM PROGRAM DEFINITION (PHASE B)

DATA REQUIREMENTS

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APPENDIX D

SECTION 1. INTRODUCTION

This appendix specifies the contractual data requirements for the Space Shuttle System Definition Phase Contract. Data are scheduled for submittal to NASA in conjunction with and in response to applicable task requirements contained in the contractual statement of work. The contractor may suggest additions, deletions, or changes to the contract data requirements in response to the contract RFP and during performance of the contract. Upon contract award, the negotiated DRL shall be the governing document for the submittal of data to NASA.

The Data Requirement List (DRL) and supporting Data Requirement Descriptions (DRD s) provide NASA and its associated Contractor(s) with a program control system affording the necessary management visibility for effective Program Management. The system also provides an effective method for the identification, definition, acquisition and accounting of deliverable technical and management documentation. The Data Management System provides the means for procurement of only that data absolutely essential to accomplishing the program mission.

Short form instructions for completing the DRL form are shown in Figure 1. This information is provided to explain the coding system used on the DRL for identifying the type of data required (i.e., for approval, review, information only), inspection/acceptance requirements, frequency of submittal, etc. The cost information blocks (12 through 21) are not applicable unless so specified in the RFP.

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ATTACHMENT NUMBER a	DATA REQUIREMENTS LIST (DRL)	RESPONDENT f	RESPONDENT PREPARATION DATE j
EXHIBIT NUMBER b		PREPARATION DATE g	12 RESPDT USE % / 13 EST/ACT / 14 TOTAL COST
CONTRACT RFP NUMBER c	PROJECT/SYSTEM e	PAGE h	15 EST. NO SUBM/PGS PER SUBM / 18 PREP COST (ADMIN)
NUMBER d		REVISION i	16 EST NO. REV/PGS PER REV / 19 PREP COST (TECH)

1 LINE ITEM NO	2 DRD NUMBER	3 TITLE	4 OPR	5 TYPE	6 INSPECT/ACCEPT	7 FREQ OF SUBM	8 INITIAL SUBMITTAL	17 REPRO AND DELIV COST	20 DEVELOP COST
REMARKS							10 AS OF DATE / 11 COPIES / A TYPE / B NO.	21 REMARKS:	

For more explicit instructions in completing this form, see MSF DRL Preparation Standard, DM018-016-1

SHORT FORM INSTRUCTIONS FOR COMPLETING NASA FORM 1106

GENERAL

NASA Forms 1106 and 1106-1 contain two separate sections plus heading information common to entire DRL. The first section contains acquisition information, the second section contains cost information. When more than one page is required to complete DRL, continuation page (NASA Form 1106-1) shall be used. The numbers and letters below correspond to numbers and letters on sample form above.

HEADING INFORMATION

a. ATTACHMENT NUMBER—When form is an attachment to a Contract RFP, enter attachment number.

b. EXHIBIT NUMBER—Enter exhibit identification (numbers or letters) when form is an exhibit to a Contract RFP.

c. CONTRACT RFP NUMBER—Enter contract number or RFP number, if applicable. For inter NASA use, enter authority reference for DRL.

d. DRL NUMBER—Enter assigned DRL number. (Four alphanumeric character limit.)

e. PROJECT SYSTEM—Enter nomenclature descriptive of equipment/activity to which DRL pertains.

f. RESPONDENT—Enter respondent name. For use within NASA, enter NASA respondent organization.

g. PREPARATION DATE—Enter actual preparation date as follows: MONTH/DAY/YEAR.

h. PAGE—Enter page number.

i. REVISION—Enter DRL revision code and the revision date (MONTH/DAY/YEAR). The revision code may be the DRL revision letter or number as applicable or contract modification number. (Two character limit.)

j. RESPONDENT PREPARATION DATE—Enter MONTH/DAY/YEAR respondent completes Items 12 through 21.

ACQUISITION INFORMATION
(ITEMS NO. 1 THROUGH 11)

1. LINE ITEM NO.—Number line items sequentially 1 through 999 maximum.

2. DRD NUMBER—Enter identification number of DRD that is being used including source code letter and revision letter as applicable.

3. TITLE—Enter DRD title to be assigned to responding data item or an acceptable alternate.

4. OPR (OFFICE OF PRIMARY RESPONSIBILITY)—Enter office code of NASA organization levying data requirement and designated to exercise technical and/or administrative control.

5. TYPE—Enter type of data code as follows:

CODE	DESCRIPTION
1	Applicable to All MSF Organizations. Data requiring written approval by procuring activity prior to implementation into procurement or development program.
2	Applicable to All MSF Organizations Except MSC. Data submitted to procuring activity for review not later than three weeks prior to project implementation. Data shall be considered approved unless contractor has been notified of disapproval prior to project implementation. Applicable to MSC Only. Data submitted to procuring activity for coordination, surveillance, information, review and/or management control.
3	Applicable to All MSF Organizations ~~Except MSC~~. Data submitted to procuring activity for coordination, surveillance or information. ~~Applicable to MSC Only.~~ ~~Data retained by respondent to be made available to procuring activity upon request.~~
4	~~Applicable to All MSF Organizations Except MSC.~~ ~~Data retained by respondent to be made available to procuring activity upon request.~~ The respondent shall furnish a list to procuring activity upon request.
5	~~Applicable to All MSF Organizations Except MSC.~~ ~~Data to be retained by respondent and reviewed by NASA on request.~~

6. INSPECT/ACCEPT—Enter Inspection/Acceptance code as follows:

CODE	INSPECTION	ACCEPTANCE
1	Source	Source
2	Destination (OPR)	Destination (OPR)
3	Source	Destination (OPR)
4	Certificate of Conformance (Mandatory)	Not Applicable
5	Certificate of Conformance (Optional)	Not Applicable
6	No Inspection Required	No Acceptance Required

7. FREQ. OF SUBM.—Enter frequency of submittal code as follows:

CODE	DESCRIPTION	CODE	DESCRIPTION
AD	As Directed	BW	Biweekly (Every other week)
AN	Annually	DA	Daily
AR	As Required	DD	Deferred Delivery
BE	Biennially (Every other year)	MO	Monthly
BM	Bimonthly (Every other month)	OT	One Time

7. FREQ. OF SUBM.—(Continued)

CODE	DESCRIPTION	CODE	DESCRIPTION
PC	Per Contract	PV	Per Vehicle
PD	Per Failure	QU	Quarterly
PE	Per Event	RD	As Released
PF	Per Facility	RT	One Time and Revisions
PI	Per Equipment End Item	SA	Semiannually (Once every six months)
PJ	Per Project		
PL	Per Launch	TY	Three Per Year
PS	Per System	UR	Upon Request
PT	Per Test	WK	Weekly

8. INITIAL SUBMITTAL—Enter MONTH/DAY/YEAR of initial submittal. If calendar date is not scheduled, enter number of days preceding, or following event to which data requirement is related (e.g., 90 days prior to launch). Amplify in Remarks, Item 9, if necessary.

9. REMARKS—Enter in this space:
   a. When DRD provides options, limitations may be specified in this block. Other minor exceptions may also be specified.
   b. Reference to specific work statement paragraph as applicable to provide relationship of data line item to task.
   c. Additional submittal information, if necessary.
   d. Comments which explain an entry made in any block of the DRL.

10. AS OF DATE—If data is of a recurring nature, give as of date (cutoff date) and due date; e.g., 15/1 indicates input cutoff date on 15th and due date on 1st. Amplify in Remarks, Item 9, if necessary.

11. COPIES—General heading defining copy submittal requirements as follows:

A. TYPE—Enter code as follows:

CODE	DEFINITION	CODE	DEFINITION
PRINT	Printed Copies	MICRO	Microfilm Aperture Cards
REPRO	Reproducible Copy	OTHER	Explain in Remarks, Item 9

B. NO.—Enter number of copies required opposite each type of copy furnished.

COST INFORMATION
(ITEMS NO. 12 THROUGH 21)

~~ALL DATA IN THIS SECTION, INCLUDING HEADING (j), TO BE FILLED IN BY THE RE-~~SPONDENT. ALL COST DATA, WHETHER ESTIMATED OR ACTUAL, SHOULD REPRESENT TOTAL COST.

NOTE: The Data Item Cost Estimate (DICE) form or equivalent, may be used in lieu of completing Items 12 through 20. Consult MSF Data Cost Estimating and Analysis Standard, DM018-015-1 for DICE preparation instructions. Copies may be obtained from OFFICE OF MANNED SPACE FLIGHT, MSD, NASA, Washington, D.C. 20546.

THE SECTION ON COSTS IS NOT TO APPEAR ON COPY OF DRL PLACED ON CONTRACT.

12. RESPDT USE %—Enter percentage of data usage by respondent. If respondent does not use data whatsoever, enter 00 percent. If he makes total use of data, enter 100 percent. If DRL is being used for inter NASA data acquisition, substitute "NASA Respondent" for Contractor.

13. EST/ACT—Enter EST or ACT to indicate that total cost is estimated or actual.

14. TOTAL COST—Enter sum of Preparation Cost (Administrative), Preparation Cost (Technical), Reproduction and Delivery Cost, and Development Cost (Items 17, 18, 19 and 20).

15. EST. NO. SUBM/PGS PER SUBM.—Enter estimated number of times the data will be submitted during the period of performance. Following the slash (/) enter the estimated average number of pages per submittal.

16. EST. NO. REV/PGS PER REV.—Enter the estimated number of times data will be revised during period of performance. Following the slash (/) enter estimated average number of pages per revision.

17. REPRO AND DELIV. COST—Enter only cost of data reproduction, packaging, storage, and delivery.

18. PREP. COST (ADMIN)—Enter only those costs associated with typing, charting, proofing, layout, and purely administrative functions.

19. PREP. COST (TECH)—Enter only those costs associated with following technical functions: Writing, drafting, illustrating, coordinating, reviewing, editing, and other related functions, including travel. Although some engineering time could be involved in above functions, cost of engineering manhours should be included in Development Cost (Item 20).

20. DEVELOP. COST—This estimate shall include any engineering manhour costs that the respondent believes are properly chargeable to data. If a data processing system is used, the primary purpose being the production of data, include this cost. Entries in this field must be specifically identified by the respondent in Remarks, Item 21.

21. REMARKS—Enter any comments pertinent to the cost of the data requirements. If the DICE form or equivalent is used, state "see cost form attached."

Figure 1. DRL Form Instructions

Contractual Baseline Issue

DRL CONFIGURATION CHART

Amdt. No.	DRL Page Affected	DRL Page Change No.	Description of Change	Contractual Authority

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SECTION 2. GENERAL REQUIREMENTS

2.1 Preparation of Data. In response to the Phase B Definition Contract requirements, the Contractor shall deliver data to NASA in accordance with the Data Requirements List and supporting Data Requirements Descriptions specified in section 3 herein.

2.2 Subcontractor and Other Data Requirements. The prime Contractor shall state contractually to vendors and subcontractors that they make all requests to the prime contractor for data needed in the satisfactory accomplishment of their contracts. The Contractor shall validate and fulfill these requests, if appropriate, where the request concerns his or other Contractor data. When subcontractors are employed, the contractor shall also state contractually to his subcontractors the requirement that program data shall be furnished directly to the NASA Contracting Officer, when requested.

Reference to subcontractor data in the Contractor's responses are permissible, providing the references are adequate and include such identification elements as title, number revision, etc., and the referenced data is supplied with the response document.

When a document to be referenced would only be applicable to a minor or limited extent, the Contractor shall make every effort to include applicable requirements and avoid direct reference. All referenced documents shall be made readily available to the cognizant center agency upon request. Insofar as practicable, the Contractor's internal documents shall be utilized to meet the requirements specified on the DRL.

Any detail documentation generated within the normal course of the contracted work and not a part of the data required by the DRL shall be made available in accordance with the Data Requirements clause of the Basic Agreement applicable to the contract.

2.3 Data Identification. All data shall be organized into a series of numbered documents and shall reference the assigned contract number(s). All data delivered, except drawings, Engineering Change Proposal (ECP's) etc., shall be clearly marked with the following information:

(a) Contractor name and address, including organizational segment generating the data.
(b) Title of publication
(c) Date of publication
(d) Contract number
(e) DRL number and line item number.

Type 1 documents shall be clearly marked "Preliminary-NASA Approval Pending" or "Approved by NASA", as appropriate.

Sources of information contained in Type 1 and Type 3 documents shall be referenced by title, author or publisher and page or section.

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Documents that satisfy the requirements of more than one line item shall reflect all applicable line item numbers. Successive issues or revisions to data shall be identified in the same manner as the basic issue.

2.4 Maintenance of Data. Revisions to documentation may be accomplished either by individual page revision or a complete reissue of the document with the exception of drawings which shall be revised in accordance with minimum Configuration Management Requirements.

Individual page revisions shall be made as deemed necessary by the contractor or as directed by the Contracting Officer.

The document shall be completely reissued when in the opinion of the contractor and/or Government the document has been revised to the extent that is unusable in its present state, or when directed by the procuring Activity. When complete reissues are made, the entire contents of a document shall be brought up to date.

Changes of a minor nature such as typing errors, misspelled words, etc. shall only be made whenever a technical change is made, unless the accuracy of the document is affected.

All revised pages shall be identified by placing a revision symbol, and date in the upper right-hand corner of the page. Each document shall contain a log of revised pages that will identify the revisions status of each page with the revision symbol. The list shall follow the table of contents in each document. The line or lines revised on a given page shall be designated by the use of a vertical line in the margin of the page, and the change authority shall be indicated adjacent to the change.

In preparing Type 1 and Type 3 data that will require periodic revision, the Contractor shall prepare initial documents using refastening method so that pages may be deleted and/or inserted. When the original document is so prepared, the Contractor need not submit the entire document but shall submit revised, amended, or additional pages as appropriate. Accompanying these pages will be an instruction page detailing the exact means for effecting the revision or amendment.

The provisions of this paragraph do not apply to specifications in drawing format or end item drawings. These documents have an established procedure for the processing of amendments and revisions.

2.5 Printing Requirements. Printing of final reports and data in book format shall be in accordance with the following general specifications:

(a) Method of reproduction -- offset.
(b) Finished size -- 8½" X 11".
(c) Paper -- 60-pound opaque book.
(d) Cover -- litho cover stock.
(e) Pages will be printed on both sides, blank pages will be avoided when possible.
(f) Oversize pages will be avoided when possible, but if necessary will be folded to 8½" X 11".
(g) Additional color shall be used only upon approval by the COR.
(h) Binding shall be the most economical method commensurate with the size of the report and its intended use.

APPENDIX D

SECTION 3 - DATA REQUIREMENTS

3.1 Data Requirements List. NASA FORM 1106, DRL-M010 identifies data line item requirements having specific delivery schedules. However, additional submittals may be required to meet contract requirements; i.e., the Proposal Package contains numerous types of data which may be required by NASA to be submitted separately on an "As Required" basis as determined by the Contracting Officer.

3.2 Data Requirement Descriptions. NASA FORM 9, having specific identifying numbers (entered in block 2 of the DRD and the DRL) and describing in detail the data to be submitted, follow directly after the DRL.

ATTACHMENT NUMBER	DATA REQUIREMENTS LIST (DRL)	RESPONDENT
EXHIBIT NUMBER		PREPARATION DATE 12 February 1970
CONTRACT/RFP NUMBER 10-8423	PROJECT/SYSTEM Space Shuttle System Program Definition (Phase B)	PAGE 1 of 5
DRL NUMBER M010		REVISION 12 February 1970

1 LINE ITEM NO.	2 DRD NUMBER	3 TITLE	4 OPR	5 TYPE	6 INSPECT/ ACCEPT	7 FREQ OF SUBM	8 INITIAL SUBMITTAL
1	MA019M	Plan, Phase B Study	NASA	1		AR	AR
2	TM003M	Plan, Phase B Test	NASA	1		AR	AR
3	MA020M	Reports, Project Progress and Status	NASA	3		AR	AR
4	MA021M	Report - Monthly Status, Mass Properties	NASA	3		AR	

9 REMARKS / 10 AS OF DATE / 11 COPIES (A TYPE, B NO.)

Line 1 – Remarks:

Submit Phase B Study Plan for approval at the Orientation meeting prior to beginning work (10 copies).
Submit updated Phase B Study Plan when changes are made (10 copies).

Reference, Statement of Work, Paragraph 5.2.

Copies: PRINT 10

Line 2 – Remarks:

Submit as a part of the Phase B Study Plan at Orientation meeting for approval.
Submit summary and changes with Monthly Progress and Status Report.
Submit results accomplished in final reports*
Reference, Statement of Work, Paragraph 4.1, 4.4, 4.5

Copies: A *

Line 3 – Remarks:

Submit Monthly Progress Reports for each 30 day cutoff date within 15 days after cutoff date., i.e., initial submittal 45 days after contract go-ahead; monthly thereafter.

Copies: PRINT 50

Line 4 – Remarks:

Submit Monthly Progress Reports for each 30 day cutoff date within 15 days after cutoff date, i.e., initial submittal 45 days after contract go-ahead; monthly thereafter

Reference. Statement of Work, Appendix E.

Copies: PRINT 50

DATA REQUIREMENTS LIST (DRL)

(CONTINUATION SHEET)

DRL NUMBER:	REVISION:	PAGE
M010	12 February 1970	2 of 5

1	2	3	4	5	6	7	8
5	SE006M	Aerothermal Wind Tunnel Data	NASA			AR	

9: Submit data immediately upon acquisition and reduction to coefficient form.

Reference, Statement of Work, Paragraph 4.1.5.

10:
11 COPIES: PRINT 10

1	2	3	4	5	6	7	8
6	SE003M	Documentation, Propulsion Tradeoffs	NASA	3		AR	AR

9: Submit preliminary tradeoffs 90 DAC (20 copies).
Submit updated tradeoffs 180 DAC (20 copies).
Submit final tradeoffs 360 DAC.*
Reference, Statement of Work, Paragraph 4.3.

10:
11 COPIES: PRINT 200*, REPRO 2

1	2	3	4	5	6	7	8
7	TM004M	Proposal, Major Structural Tests	NASA			AR	AR

9: Submit within 90 DAC.

55

Reference, Statement of Work, Paragraph 4.5.

10:
11 COPIES: PRINT 20

322

1	2	3	4	5	6	7	8
8	MA022M	Report, Technology Requirements	NASA	3		AR	

9: Submit Quarterly Technology Requirements Reports by the 20th day of the final month of each calendar quarter.

Reference, Statement of Work, Paragraph 4.6.

10:
11 COPIES: PRINT 50, REPRO 2

1	2	3	4	5	6	7	8
9	CM009M	Documentation, Interface Control	NASA	3		AR	AR

9: Submit ICD's and changes as generated.
Submit preliminary ICD's 180 DAC (50 copies).
Submit final ICD's 360 DAC.*
Reference, Statement of Work, Paragraph 4.4.

10:
11 COPIES: PRINT 200*, REPRO 2

1	2	3	4	5	6	7	8
10	SE004M	Report, Design Data Book	NASA	3		AR	AR

Submit Design Data Book as requested (5 copies).
Submit Design Data Book 360 DAC.*

Reference, Statement of Work, Paragraph 4.1.

COPIES: PRINT 30*

1	2	3	4	5	6	7	8
11	MA018M	Report, Review and Status Meeting	NASA	3		AR	AR

Submit brochures and viewgraphs at time of meetings. (One set of viewgraphs and slides for interim meetings and 4 sets of viewgraphs and slides of final review.)
Submit minutes and action items 15 days after meeting (20 copies).
*Brochures
Reference, Statement of Work, Paragraphs 5.0 and 5.3.

COPIES: PRINT 100*

1	2	3	4	5	6	7	8
12	MA016M	Reports, Phase B Final	NASA	3		AR**	AR

Submit Preliminary Part 2 data 240 days after contract go-ahead (DAC) (100 copies).
56 Submit drafts of Part 1 330 DAC (20 copies) for approval.**
Final submittal 360 DAC.*
Print 500 Part 1 and 350 Part 2

COPIES: REPRO 2*

1	2	3	4	5	6	7	8
13	MA017M	Document, Program Management Plan	NASA	3		AR	AR

(Partial Final Report - Part 3)
Submit Program Management Plan 240 days after contract go-ahead (DAC) (100 copies).
Submit final document 360 DAC.*

Reference, Statement of Work 4.7.1

COPIES: REPRO 2* PRINT 350

1	2	3	4	5	6	7	8
14	SE001M	Document, Engineering & Development Plan	NASA	3		AR	AR

(Partial Final Report - Part 3)
Submit Engineering and Development Plan 240 days after contract go-ahead (DAC) (100 copies).
Submit final document 360 DAC.*

Reference, Statement of Work 4.7.2.

COPIES: REPRO 2* PRINT 350

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DATA REQUIREMENTS LIST (DRL) (CONTINUATION SHEET)	DRL NUMBER: M010	REVISION: 12 February 1970	PAGE 4 of 5

1	2	3	4	5	6	7	8
15	MP010M	Document, Operations Plan	NASA	3		AR	AR

(Partial Final Report - Part 3)
Submit Operations Plan 240 days after contract go-ahead (DAC) (100 copies).
Submit final document 360 DAC.*

Reference, Statement of Work 4.7.3.

COPIES: REPRO 2* PRINT 350

1	2	3	4	5	6	7	8
16	TM001M	Document, Facility Utilization & Manufacturing Plan	NASA	3		AR	AR

(Partial Final Report - Part 3)
Submit Facility Utilization & Manufacturing Plan 240 days after contract go-ahead (DAC) (100 copies).
Submit final document 360 DAC.*
Reference, Statement of Work, Paragraph 4.7.4.

COPIES: REPRO 2* PRINT 350

1	2	3	4	5	6	7	8
17	TM002M	Document, Preliminary Test Plan	NASA	3		AR	AR

(Partial Final Report - Part 3)
57 Submit Preliminary Test Plan 240 days after contract go-ahead (DAC) (100 copies).
Submit final document 360 DAC.*
Reference, Statement of Work, Paragraph 4.7.5.

COPIES: REPRO 2* PRINT 350

324

1	2	3	4	5	6	7	8
18	LS001M	Document, Logistics and Maintenance Plan	NASA	3		AR	AR

(Partial Final Report - Part 3)
Submit Logistics and Maintenance Plan 240 days after contract go-ahead (DAC) (100 copies)
Submit final document 360 DAC.*
Reference, Statement of Work, Paragraph 4.7.6.

COPIES: REPRO 2* PRINT 350

1	2	3	4	5	6	7	8
19	MF003M	Document, Program Cost and Schedule Estimates Plan	NASA	3		AR	AR

(Partial Final Report - Part 3)
Submit Program Cost and Schedule Estimates Plan 240 days after contract go-ahead (DAC) (100 copies).
Submit final document 360 DAC.*
Reference, Statement of Work, Paragraph 4.7.7.

COPIES: REPRO 2* PRINT 350

DATA REQUIREMENTS LIST (DRL) *(CONTINUATION SHEET)*	DRL NUMBER: M010	REVISION: 12 February 1970	PAGE 5 of 5

1	2	3	4	5	6	7	8
20	SE002M	Drawings, Lists, Form 1 and Microfilm	NASA	3		AR	AR
21	CM007M	Specification, CEI Part I	NASA	1		PY	AR
22	CM008M	Specifications, Non CEI	NASA	1		AR	AR
23	SE005M	Report - Detail Mass Properties	NASA	3		AR	

Item	9	11 Copies
20	Submit preliminary drawings as required for technical review by COR. Submit preliminary drawings 240 DAC (50 copies). Submit final drawings 360 DAC.* Reference, Statement of Work, Paragraph 4.4.	MICRO 10 REPRO 2* PRINT 200
21	Submit separate specifications for the booster, orbiter, and all other identifiable end items. Submit preliminary specifications 240 DAC (50 copies). Submit final specifications 360 DAC.* Reference, Statement of Wor, Paragraph 4.4.	PRINT 200*
22	*Submit separate specification for the Space Shuttle Systems and all other identifiable non-CEI items. Submit preliminary specifications 240 DAC (50 copies). Submit final specifications 360 DAC.* Reference, Statement of Work, Paragraph 4.4.	PRINT 200*
23	Submit report 240 days after contract go-ahead (DAC) (50 copies). Final submittal 360 DAC.* Reference, Statement of Work, Appendix E.	PRINT 350* REPRO 2

APPENDIX D

DATA REQUIREMENT DESCRIPTIONS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE	2. NUMBER
Plan, Phase B Study	MA019M
3. USE To define the contractor's planned method of accomplishing the tasks set forth in the Statement of Work. The contractually Approved Plan will be the primary technical guideline as well as NASA's program control document for study task definition.	4. DATE Feb. 10, 1970 5. ORGANIZATION NASA
7. INTERRELATIONSHIP Statement of Work, Para. 5	6. REFERENCES NHB 2330.1

8. PREPARATION INFORMATION

8.1 SCOPE: This Data Requirements Description establishes the preparation requirements for a detailed study implementation plan covering the Phase B definition study requirements specified in the RFP Statement of Work. The plan will be an updated version of the contractor's proposed study plan modified to reflect NASA guidance at contract negotiations.

8.2 CONTENT: The plan shall include as a minimum the following information: A description of planned activities for each identifiable requirement. The plan shall utilize flow diagrams, work breakdown structures, logic networks, matrices and other similar means to reduce the amount of verbal descriptive material. The plan shall be logically structured to include all the program management requirements specified in the statement of work. Included shall be the following:

X A. Subcontract Plan

As applicable to Phase B, the contractor shall prepare a subcontract plan which includes: A listing of the make or buy items, selected vendors, the method of procurement, procurement schedules, and procedures by which control will be exercised over the subcontract effort. The subcontract plan shall be included in the Project Management Plan.

X B. Organization Requirements

The contractor shall designate his program organization and the key personnel assigned to perform/supervise the contract task specified in this statement of work.

NASA FORM 9 FEB 67 REPLACES NASA FORM 1107, EXISTING STOCKS OF WHICH ARE TO BE DESTROYED.

lan, Phase B Study (continued)

X C. Logic Network

The contractor shall include in the Project Management Plan a logic network of activities and events in direct relation to the Work Breakdown Structure developed, and in sufficient density to depict his planning, implementation, and other major milestones type information that will provide NASA a clear understanding of the contractor's plan for accomplishing the requirements of Phase B work statement. A description of each logic network event and activity shall be included to clearly define the work involved in the accomplishment of the event.

D. Statement of Work (Redundant with para. E incl. 2 to RFP)

The contractor shall define the method of accomplishing the tasks and subtask required by the RFP Statement of Work. The contractor's definition of accomplishment should include a detailed description of each task, the responsible contractor's organizational element, and planned manpower and/or hours required for each task shall be presented. Additionally, expenditure of resource (manhours, materials, etc.) shall be projected and kept current in the monthly progress reports.

X E. Work Breakdown Structure

The contractor shall develop the Work Breakdown Structure (WBS) and shall ensure the integration of all technical and management activities within the frame work establishe by the WBS. The contractor shall develop and delineate the WBS to a level recommended as a manageable unit for planning and control.

3.3 FORMAT:

A. Cover - The cover shall contain the contractor's name and address, title of document, date of publication, contract number, DRL number and DRL line item number.

B. Title Page - Same information as cover page plus signature block for cognizant authority's signature.

C. Table of Contents - Shall list major divisions and subdivisions of the plan. Each entry shall include page number reference.

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Plan, Phase B Study (continued)

D. Introduction - Shall be a concise summarization of the plan and shall be self-explanatory, presenting such information as the objectives, scope, technical considerations, accomplishments constraints, etc.

E. Main Body of the Document - Shall present as a minimum the information required as outlined in content paragraph of this DRD plus additional data as determined necessary by the contractor.

F. References - If required, a list of references shall be included showing author, title, sources, etc.

G. Appendices - Shall be used when necessary to present supplemental or incidental information, detailed tabulations or derivations or graphic representations.

8.4 MAINTENANCE

This plan will be modified to reflect NASA guidance at negotiations and at the orientation meeting immediately following contract award, and maintained current with NASA approved changes through the Phase B contract.

8.5 DELIVERY

Submittal requirements for this data shall be as specified on the Data Requirements List (DRL).

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

TITLE Plan, Phase B Test	2 NUMBER TM003M
USE To provide NASA with Phase B test planning for better coordination and avoidance of any duplication of test.	4 DATE 16 January 1970 5. ORGANIZATION NASA
INTERRELATIONSHIP Major Structural Test Proposal Paragraph 4.4 and 4.5 of the Statement of Work	6. REFERENCES

PREPARATION INFORMATION

8.1 SCOPE: This Data Requirements Description (DRD) establishes the preparations requirements for a Phase B Test Plan for all space shuttle system/subsystem tests.

8.2 CONTENT/FORMAT: The Phase B Test Plan shall be a summary schedule of all test planned, during Phase B, with a supporting concise definitio of the test, requirements, funding, and current status of each test plan (Reference Paragraph 4.4 and 4.5)

8.3 MAINTENANCE: The summary schedule plus changes and supporting information shall be submitted as a part of the Monthly Progress Report.

8.4 DELIVERY: The submitted requirements shall be as specified in the Data Requirements List (DRL) and 8.3 above.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1 TITLE	2 NUMBER
Report, Project Progress and Status	MA020M
3. USE	4 DATE 16 January 1970
To provide customer visibility of significant events occurring during the reporting period and status of contract schedule milestones and other significant areas within technical and administrative disciplines.	5. ORGANIZATION NASA
7. INTERRELATIONSHIP	6. REFERENCES

8. PREPARATION INFORMATION

8.1 SCOPE: This Data Requirement Description (DRD) establishes the requirements for the preparation of a Monthly Progress Report covering a description of technical and administrative progress and status in major and significant activities, leading to the accomplishment of contractual objectives and correction of problem areas.

8.2 CONTENT: The report shall include as a minimum the following information:

A. Reporting against master development schedules as they occur covering a comparison of planned work and milestones for the past month vs actual accomplishments. Deviations from the planned work shall be given in sufficient detail to enable NASA Project Manager to have clear visibility as to the cause and corrective action.

B. Include listing and description of the planned effort for the next two months.

C. List the 5 to 10 most significant problems (technical or management) in order of importance and give a description of the problem and corrective action being taken.

8.3 FORMAT: The format and arrangement of the report may be as determined by the contractor. Illustrations and photographs shall be held to a minimum consistent with the information being provided. The report shall not exceed 15-20 pages.

8.4 DELIVERY: The reproduction, distribution, and frequency of submittal of this report shall be as specified on NASA Form 1106, Data Requirements List (DRL).

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE	2. NUMBER
REPORT - Monthly Status, Mass Properties	MA021M

3. USE	4. DATE / 5. ORGANIZATION
Provides visibility of mass properties required to conduct the program.	4. DATE: 16 January 1970 5. ORGANIZATION: NASA

7. INTERRELATIONSHIP	6. REFERENCES
Statement of Work, Appendix E	SP-6004 (NASA)

8. PREPARATION INFORMATION

This report shall present the results of utilizing the mass property control procedures outlined in MIL-M-38310-A and Appendix E.

The monthly status report shall consist of the report elements identified in table 1, column 4, of MIL-M-38310-A with the exception that the reporting forms identified in the paragraphs discussing each report element shall be replaced by the reporting forms 1 thru 5 attached or an approved equivalent.

Form 1 - Design Data Statement - Minimum acceptable information

Form 2 - Summary Weight Statement - Minimum acceptable information

Form 3 - Detail Weight Statement - Not required monthly

Form 4 - Sequence Mass Properties Statement - Equivalent computer output acceptable with prior approval

Form 5 - Summary Mass Properties Statement - Equivalent computer output acceptable with prior approval

This report will provide the above data consistent with the phase of the program.

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NASA FORM 9 FEB 67 REPLACES NASA FORM 1107, EXISTING STOCKS OF WHICH ARE TO BE DESTROYED.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1 TITLE	2 NUMBER
Aerothermal Wind Tunnel Data.	SE006M
3. USE	4 DATE February 10, 1970
To provide NASA with a guide for structuring its program for study and evaluation of contractor data and results.	5. ORGANIZATION NASA
7. INTERRELATIONSHIP	6. REFERENCES
Paragraph 4.1.5 of Statement of Work	

8. PREPARATION INFORMATION

8.1 SCOPE: This Data Requirements Description establishes the preparation requirements of aerothermal wind tunnel data.

8.2 CONTENT: These data shall encompass all wind tunnel aerothermal studies on the space shuttle candidate vehicles (orbiter, booster and combination) including force and moment, heating, pressure distribution, oil flow and other flow visualization studies.

Immediately upon acquisition and reduction of the data to coefficient form it shall be submitted to NASA as follows:

A. All force and moment, pressure distribution and heating data obtained at discrete points (such as by use of thermo-couples) shall be submitted on magnetic tape through a data bank system. such as SAD SACK.

B. Reproducible copies of all other aerothermal data (e.g.. oil flow, schlieren, phase change paint heating, etc.).

8.3 FORMAT: Standardized formats and procedures for submitting data will be established by NASA and given to the contractor prior to initiation of the Phase B study.

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NASA FORM 9 FEB 67 REPLACES NASA FORM 1107, EXISTING STOCKS OF WHICH ARE TO BE DESTROYED.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1 TITLE Proposal, Major Structural Test	2 NUMBER TM004M
3. USE To provide NASA Major Structural Test proposal for major structural demonstration test plans for potential NASA supplemental funding.	4 DATE 16 January 1970 5. ORGANIZATION NASA
7. INTERRELATIONSHIP Paragraphs 4.4 and 4.5 of the Statement of Work Phase B Test Plan Appendix F	6. REFERENCES

8. PREPARATION INFORMATION

8.1 SCOPE: This Data Requirements Description establishes the preparation requirements for a major structural demonstration test proposal during Phase B.

8.2 CONTENT/FORMAT: The Major Structural Test Proposal shall be prepared in response to Paragraph 4.5 and Appendix F of the Statement of Work.

8.3 DELIVERY: The submittal requirements shall be as specified in the Data Requirements List (DRL).

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NASA FORM 9 FEB 67 REPLACES NASA FORM 1107, EXISTING STOCKS OF WHICH ARE TO BE DESTROYED.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1 TITLE Document, Propulsion Tradeoff	2 NUMBER SE003M
3. USE To provide vehicle/engines tradeoff data to NASA for main, auxiliary and airbreathing engines definition by NASA and engines contractors.	4 DATE January 1970 5. ORGANIZATION NASA
7. INTERRELATIONSHIP Appendix F	6. REFERENCES

8. PREPARATION INFORMATION

8.1 SCOPE:

This Data Requirements Description (DRD) establishes the preparation requirements for Propulsion Tradeoff Data.

8.2 CONTENTS/FORMAT:

The Propulsion Tradeoff Data shall be prepared in accordance with requirements of Paragraph 4.3.1 of the Statement of Work and Appendix F. thereof.

8.3 MAINTENANCE:

Substantial changes in data, after initial submission, shall be submitted to NASA with any supporting information.

8.4 DELIVERY:

The submittal requirements shall be as specified on the Data Requirements List (DRL) and 8.3 above.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1 TITLE Reports, Technology Requirements	2 NUMBER MA022M
3 USE To provide NASA with timely exposition of technology requirements for space shuttle configurations under investigation, to serve as guidance in conducting the Space Shuttle Technology Program.	4 DATE February 10, 1970 5. ORGANIZATION NASA
7. INTERRELATIONSHIP Paragraph 4.6 of Statement of Work	6. REFERENCES

8. PREPARATION INFORMATION

8.1 SCOPE: This Data Requirement Description establishes the requirements for the preparation of periodic reports covering requisite supporting research and technology for the space shuttle configurations under investigation.

8.2 CONTENT: The report shall contain as a minimum:

A. Identification and definition of those items of technology which are critical or pacing to a particular design, would further enhance the design, or would decrease the development risk involved with the design.

B. Statement of the need for technology data, indicating the specific range of data needed to support the space shuttle design effort and the desired schedule of technology input to the contractor.

8.3 FORMAT: The format and arrangement of the report may be as determined by the contractor. The report shall be concise, presenting only that information necessary to define the needed technology, establish its importance to the design, and support the desired schedule for data feedback.

8.4 DELIVERY: Submittal requirements for this report shall be as specified on the Data Requirements List.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1 TITLE Documentation, Interface Control	2 NUMBER CM009M
3 USE Provides control of hardware interface areas.	4 DATE August 28, 1969 5. ORGANIZATION NASA
7. INTERRELATIONSHIP Statement of Work, Paragraph 4.4	6. REFERENCES

8. PREPARATION INFORMATION

8.1 SCOPE: This Data Requirement Description (DRD) establishes the requirements for the preparation of documentation covering physical, functional, procedural requirements interface control.

8.2 CONTENTS:

8.2.1 Physical ICD - This documentation shall pictorially and dimensionally define and document the physical configuration of two or more Contract End Items at Interface locations. Only those items where a change on either side of the interfacing elements may require a change of the matching item or configuration shall be clearly depicted and made subject to interface control.

8.2.2 Functional ICD - This narrative documentation shall define the requirements common to two or more CEI's at a physical interface required to assure functional compatibility of CEI's. Functional ICD's shall be used to correlate functional requirements definitions of the applicable CEI specifications and to maintain effective change control of the interfaces. The subject of structural loads, environment (natural and induced), electrical, fluid, and pneumatic criteria when specified applicable by NASA shall be documented as related to the physical interface.

8.2.3 Procedural ICD - This narrative documentation shall contain procedural and human factors requirements, common to two or more CEI's, which are pertinent to the design and/or change control of interfacing hardware. When specified by NASA this documentation shall include identification of environmental conditions required to protect and support life within and without the applicable interface area, such as temperature and air control, protective clothing, emergency procedures and safety equipment.

NASA FORM 9 FEB 67 REPLACES NASA FORM 1107, EXISTING STOCKS OF WHICH ARE TO BE DESTROYED.

8.3 FORMAT: The documents shall be written in general accordance with the initial release and its revision.

8.4 MAINTENANCE: Revisions to ICD's shall be made with Interface Revision Notices (IRN).

8.5 DELIVERY: The reproduction, distribution and frequency of submittal shall be as specified on the DRL.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE	2. NUMBER
Report, Design Data Book	SE004M
3. USE 1. To provide a current compilation of design criteria, assumptions, guidelines, analytical methods, experimental method and theories (equations) used for design. 2. To provide an orderly method and record of any changes approved by NASA.	4. DATE 16 January 1970 5. ORGANIZATION NASA
7. INTERRELATIONSHIP Appendices A, B, C & E Design Criteria Natural Environments Criteria	6. REFERENCES

8. PREPARATION INFORMATION

8.1 SCOPE: This Data Requirements Description (DRD) establishes the requirements for compilation of current design data used to perform the contracteral effort.

8.2 CONTENT/FORMAT: The Design Data Book shall contain all design criteria, natural environments criteria, assumption, guidelines, analytical methods, experimental methods, and theories (equations) used to design the Space Shuttle System and its subsystems. One section of this report shall show the origin of each item and changes if any made subsequent to contract go-ahead.

8.3 MAINTENANCE: This report shall be kept current and shall reflect the then present design practices. Changes shall be made only with NASA notification and approval. Preparation shall be according to the contractors practices (format, typing, binding, etc.).

8.4 DELIVERY: A then current draft upon request of NASA. And distribution, reproduction, and frequency of submittal shall be specified on the DRL.

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NASA FORM 9 FEB 67 REPLACES NASA FORM 1107, EXISTING STOCKS OF WHICH ARE TO BE DESTROYED.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1 TITLE Report, Review and Status Meeting	2. NUMBER MA018M
3 USE To provide NASA with contract review material used in oral presentations	4 DATE December 19, 1969 5. ORGANIZATION NASA
7 INTERRELATIONSHIP Reference, Statement of Work, Paragraphs 5.0 and 5.3	6. REFERENCES

8 PREPARATION INFORMATION

8.1 SCOPE: This Data Requirements Description establishes the preparation requirements of review presentation material.

8.2 CONTENT: Review reports will be provided as required on significant results, problem areas, and future plans for the study effort. Included in the report package will be:

A. Briefing brochure.

B. Copies of all vu-graphs, slides, film, or other presentation material.

C. Minutes of the meeting.

D. Recording of action items resulting from the meeting.

8.3 DELIVERY: The distribution, reproduction, and frequency of submittal of this package shall be as specified on the Data Requirements List (DRL).

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NASA FORM 9 FEB 67 REPLACES NASA FORM 1107, EXISTING STOCKS OF WHICH ARE TO BE DESTROYED.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE	2. NUMBER
Report, Phase B Final	MA016M
3. USE	4. DATE
To provide a comprehensive report of the complete study effort accomplished during Phase B Definition.	16 January 1970
	5. ORGANIZATION
	NASA
7. INTERRELATIONSHIP	6. REFERENCES

8. PREPARATION INFORMATION

8.1 SCOPE

This Data Requirement Description establishes the preparation of requirements for a final report which provides pertinent results of the study effort.

8.2 CONTENT/FORMAT

The final report shall be presented in three (3) parts or volumes and contain the following descriptive information:

A. Part 1. Executive Summary: This part of the final report shall be separately bound and provide comprehensive and concise descriptive information of results of the study effort and definitive configuration data for the selected design (i.e., inboard and outboard profile schematics, photographs, etc.). This summary shall also provide overall schedules and costs for development and operational phases of the program.

B. Part 2. Technical Summary: This part of the final report shall be separately bound and consist of the following:

(1) Design and functional descriptions of selected configuration

(2) Systems engineering documentation

(3) Trade-off study conclusions

(4) All technical considerations pertinent to selection of the contractor's proposed configuration/design.

(5) Salient description of the proposed phase C/D program plans, sub-plans and other related documentation including program controls.

NASA FORM 9 FEB 67 REPLACES NASA FORM 1107, EXISTING STOCKS OF WHICH ARE TO BE DESTROYED.

:reparation Information (Continued)

(6) All other technical data determined necessary to summarize the design approach.

(7) This report shall be formatted with a direct correlation to the work statement by section (4.1, 4.2, etc.) and subsection. In addition, such overlapping items as cost analysis and trade-off data, engineering cost estimates, schedules and milestones, and mass properties analyses shall be reported separately.

C. Part 3. Program Acquisition Plans: This volume shall contain specific requirements/plans for the design and development/ operation (phases C and D) of the program, applicable schedules, and a description of the contractors approach to meeting these requirements and schedules. This volume shall be structured in a manner that will allow separation of booster specific and orbiter specific requirements/plans, e.g., test plans would, or could be covered in 3 sections as follows:

Section I - Overall Space Shuttle
Section II - Booster
Section III - Orbiter

This report shall be formatted with a direct correlation to sections of paragraph 4.7 of the statement of work, as a minimum.

1.3 FORMAT: Each volume or section shall contain as a minimum the following:

A. Cover - The cover shall contain the contractor's name and address, title of document, date of publication, contract number, DRL number, and DRL line item number.

B. Title Page - Same information as cover page plus signature block for NASA approval.

C. Table of Contents - List major divisions and subdivisions of plans. Each entry shall have a page number reference.

D. Introduction - Brief narrative of scope and purpose of plan.

E. Main Body of Plan - Complete descriptive material on the subject to be covered.

F. Appendices - Provide as necessary to present supplemental information (i.e., trade study results, applicable documents, etc.).

3.4 DELIVERY: The report shall be submitted in accordance with the Data Requirements List (DRL).

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE	2. NUMBER
Document, Program Management Plan	MA017M
3. USE To provide the program management activities required for adequate conduct of the program.	4. DATE 16 January 1970 5. ORGANIZATION NASA
7. INTERRELATIONSHIP Reference, Statement of Work 4.7.1	6. REFERENCES

8. PREPARATION INFORMATION

8.1 SCOPE

This Data Requirement Description establishes the preparation requirements for a Program Management Requirements Document.

8.2 CONTENT

This document shall contain the program management activities required to adequately conduct the program. The following areas of management shall be defined, as a minimum.

A. Results of analysis and trade studies to identify improvements in manage ment practices and new methods of doing business wherein significant reductions in cost might be accomplished.

B. Requirements for program management organization and internal interfaces, including all program control functions such as scheduling, financial management, etc.

✓C. Relationships required between the contractor's and NASA's project management organization.

✓D. The subcontract requirements which includes: the method of procurement, procurement schedules, and procedures by which control should be exercised over the subcontract effort.

✓ E. A logic network of activities and events in direct relations to the Work Breakdown Structure depicting major milestones that will provide NASA a clear understanding of what is required to accomplish the program.

✓ F. A Work Breakdown Structure shall be developed to a level recommended as a manageable unit for planning and control.

G. Schedules and milestones directly related to the design, development and production of program hardware and facilities shall be included.

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8.3 <u>DELIVERY</u>

The delivery requirements for the document shall be specified on the Data Requirements List (DRL).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1 TITLE	2 NUMBER
Document, Engineering and Development Plan	SE001M
3 USE To provide the overall engineering and development requirements.	4 DATE 16 January 1970 5. ORGANIZATION NASA
7. INTERRELATIONSHIP Reference, Statement of Work 4.7.2	6. REFERENCES

8. PREPARATION INFORMATION

8.1 SCOPE: This Data Requirement Description establishes the preparation requirements for an Engineering and Development Requirements Document.

8.2 CONTENT:

8.2.1 This document shall define the scope of the total engineering effort required. Major test articles shall be described and hardware development and qualification testing shall be identified. A discussion of the anticipated problems in the engineering area and their resolution approached.

8.2.2 The required approach to design of the end item and related support equipment shall be described. Included shall be the overall system performance criteria, system design requirements based upon the mission constraints, system task analysis, design verification, analysis and interface requirements, design and performance integration, systems engineering and integration and analysis and evaluation of development tests.

The document shall describe the requirements for developing the necessary breadboard models, engineering prototypes or mockups, and testing of critical items for design verification.

8.3 DELIVERY: The delivery requirements for this document shall be as specified on the Data Requirement List (DRL).

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE Document, Operations Plan	2. NUMBER MP010M
3. USE To provide the operations plan for satisfying the mission operation portions of the basic objectives of the program.	4. DATE 16 January 1970 5. ORGANIZATION NASA
7. INTERRELATIONSHIP Reference, Statement of Work 4.7.3	6. REFERENCES

8. PREPARATION INFORMATION

8.1 SCOPE: This Data Requirement Description establishes the preparation requirements for a document which identifies the operations requirements for the program.

8.2 CONTENT:

8.2.1 This document shall describe operation activity/requirements and the constraints, limits, and goals required to satisfy the mission operations portions of the basic program objective.

8.2.2 This document shall include requirements for all ground operations from landing to launch and will include any major equipment items.

8.2.3 This document shall include a description of all flight operations including communications, operating and control procedures of the tracking and data acquisition network.

8.2.4 Include requirements for utilization of data relay satellites and requirements for operation of experiments and interfaces with scientific community.

8.3 DELIVERY: The reproduction, distribution, and frequency of delivery shall be as specified on the Data Requirements List (DRL).

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1 TITLE	2 NUMBER
Document. Facility Utilization and Manufacturing Plan	TM001M
3 USE	4 DATE
To provide NASA with the requirements for all major new facilities and major Government owned facilities. Also, to identify to NASA the major manufacturing problems and proposed solutions.	February 12, 1970 5. ORGANIZATION NASA
7. INTERRELATIONSHIP	6. REFERENCES
Reference, Statement of Work, Para. 4.7.4	

8. PREPARATION INFORMATION

8.1 SCOPE: This Data Requirement Description establishes the preparations requirements for a Facility Utilization and Manufacturing Plan document.

8.2 CONTENT:

8.2.1 This document shall identify the requirements for all major new facilities and major Government owned facilities for the Space Shuttle development, test, manufacture and operations. This identification shall include such items as environmental data, special facilities and equipment (i.e., vibration equipment, test stands, etc., floor space, power, utilities and services, and special handling capability, desired location) and a statement of acceptability of joint-use and work around situations to meet facility man-loading factors. A summary of the analytical studies justifying the need for new major facilities shall be included.

8.2.2 This document shall identify the major manufacturing problems which will be involved in producing the Space Shuttle. Solutions to these problems shall be presented. Discuss the related manufacturing technology and processes, identify present state-of-the-art techniques and the new technology required. Items causing substantial program impact shall be identified.

8.2.3 Use of GFE will be defined including a list of major machine tools and other fabrication tools.

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Document, Facility Utilization and Manufacturing Plan (continued)

Preparation Information (continued)

8.2.4 Also included shall be requirements for special major test equipment to be furnished by the Government. This shall include the item description, its use, estimated cost and proposed location. Identify and describe those specific major items of GSE necessary for handling, maintenance, refurbishment, checkout, and ground test operations.

8.2.5 Requirements for procurement of Long Lead Time Facility/ Equipment Items shall be included.

8.3 DELIVERY: The document shall be submitted as specified on the Data Requirements List (DRL).

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE Document, Preliminary Test Plan	2. NUMBER TM002M
3. USE This DRD establishes the requirement for a Phase B document which identifies the Test Program requirements for Phase C & D; presents the philosophy, rationale, and justification to support these requirements, and presents the identifiable milestones in a program plan.	4. DATE November 21, 1969 5. ORGANIZATION NASA
7. INTERRELATIONSHIP Prelim. Reliability Program Requirements/Plan (RA-145A); Prelim. Quality Program Requirements/Plan (RA-146A); Prelim. Manufacturing Requirements/Plan (TM-144A).	6. REFERENCES NHB 8080.1 NHB 8080.3

8. PREPARATION INFORMATION

8.1 SCOPE: This document identifies the Test Program Requirements for Phases C and D, presents the philosophy, rationale, and justification to support these requirements and presents the identified milestones, schedules, and costs in a preliminary plan.

8.2 CONTENT:

8.2.1 This document shall identify the Phase C and D test program requirements, using NHB 8080.1 and NHB 8080.3 as guidelines where applicable, and present the philisophy, rationale, and justification to support these requirements.

8.2.2 This document shall describe the activities, tasks, and approaches required to assure operational flight status. Included shall be the results of tradeoff studies for determining tests requirements, and approaches in terms of performance, cost, and schedule effectiveness. Such requirements shall be based on System Engineering definitions of design/performance requirements, mission objectives, and program plans developed during preliminary analysis, and early definition efforts of program planning. Participation by Reliability and Quality Engineering in testing, evaluation, and assessment shall be described. Methods of implementing logistics, reliability and quality assurance shall be described.

8.2.3 This document shall describe the key milestones, schedules, methods, procedures, resources, facilities, equipments, etc., required to accomplish the test program. Also the description and number of test articles, objectives of tests, the requirements for ground support equipment for data acquisition and evaluation, and the test documentation

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Preparation Information (Continued)

requirements shall be included. All categories of testing (i.e., development, qualification, reliability, manufacturing, acceptance, flight, etc.) shall be included. Items causing substantial program impact shall be identified.

8.3 DELIVERY: The reproduction, distribution, and frequency of submittal shall be as specified on the Data Requirement Lists (DRL).

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE Document, Logistics and Maintenance Plan	2. NUMBER LS001M
3. USE To provide the logistics support requirements necessary to support the specified program goals and objectives.	4. DATE November 5, 1969 5. ORGANIZATION NASA
7. INTERRELATIONSHIP Reference, Statement of Work, Para. 4.7.6	6. REFERENCES

8. PREPARATION INFORMATION

8.1 SCOPE: This Data Requirement Description establishes the preparation requirements for a document which identifies the requirements for logistics support for the program.

8.2 CONTENT:

8.2.1 This document shall describe the logistics requirements necessary to support development, test, and operation of the proposed program.

8.2.2 The logistics support philosophy in assuring compliance with the requirements of the contract shall be described.

8.2.3 Requirements for all functions of logistics support such as the following shall be described:

A. Maintenance
B. Maintainability
C. Control of Support and Test equipment
D. Field service support
E. Transportation
F. Propellants, pressurants, and coolants requirements
G. Supply support and spares
H. Training
I. Support Documentation
J. Packaging and handling

8.3 DELIVERY: The reproduction, distribution and frequency of submittal shall be as specified on the Data Requirements List (DRL).

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1. TITLE Document, Program Cost and Schedule Estimates Plan	2. NUMBER MF003M
3. USE To provide NASA with estimated costs and planning data for new designs and/or modifications to existing designs for use in planning future space programs resulting from Phases A and B activities.	4. DATE 16 January 1970 5. ORGANIZATION NASA
7. INTERRELATIONSHIP NONE	6. REFERENCES NHB 7121.2 (AUGUST 1968) NHB 9501.2 (MARCH 1967) AFSCM 173-1 (28 NOV 67)

8. PREPARATION INFORMATION

A. PURPOSE - This document will provide the NASA with information to permit an effective and comprehensive evaluation of costs for new programs. It will (1) assure that all elements of cost are considered in any NASA in-house or contracted study, (2) provide an effective base for comparing competing designs, (3) insure that contractor cost data will be compatible with Office of Manned Space Flight (OMSF) techniques, and (4) provide detailed costs for Phase C/D planning.

B. BACKGROUND INFORMATION - This document is prepared to direct contractor costing activities for the program Phases A and/or B (the Preliminary Analysis Phase and the Definition Phase of Phased Project Planning). The information resulting from these activities will provide a framework for cost, budget, and program planning estimates for the balance of the program, i.e., from definition to completion.

C. DEFINITIONS

1. Non-Recurring Cost (DDT&E): Refer to pages 4-4 and 4-5 of the NHB 9501.2 for the definition of non-recurring cost.

2. Recurring Costs (Production): Are defined as those costs associated with producing flight hardware up through acceptance of hardware by the Government, which include all costs associated with: (1) The fabrication and assembly of flight hardware, (2) ground test and factory checkout of flight hardware, (3) spares to support airborne hardware during flight operations, (4) maintenance of GSE and spares for GSE, (5) maintenance of tooling and special test equipment, and (6) sustaining engineering in support of hardware production.

3. Recurring Costs (Operations): Are defined as the costs associated with those activities occurring subsequent to Government acceptance of the flight hardware, and are further identified as:

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a. Launch Operations: The costs of receiving the flight hardware, static firings, refurbishments of static test stand, assembly of the vehicle, checkout, prelaunch test and checkout, servicing, launching, and refurbishment of the launch pad.

b. Flight Operations: The cost of mission control; mission planning, flight crew training, and simulation and aids required for crew training (not to include the costs of those identified as test articles).

c. Refurbishment Costs: The costs of those activities required to restore a previously flown reusable system to a flight readiness condition.

4. Cost Estimate: A judgement of the amount of U.S. dollars at the current value which are required to accomplish a new development or major modification.

5. Elements of Cost (EOC): The most basic cost collection dimension (e.g., engineering labor). Refer to pages 4-2 and 4-3 of NHB 9501.2 for a definition of EOC.

6. Subdivisions of Work (SOW): The accumulations of elements of cost into functional categories, which explain the type of activity toward which the EOC is expended, e.g., tooling (which may contain tooling labor, engineering labor, and manufacturing labor), production, test, etc.

7. Work Breakdown Structure (WBS): A hierarchy of levels illustrating the logical separation of a program into hardware elements.

8. Technical Characteristics List (TCL): A collection of technical, physical, and mission characteristics describing each WBS item.

D. CONTENTS

1. General

The details presented in the following pages may be summarized by 7 concise groundrules, which, if followed by the contractor, will fully satisfy all NASA requirements for cost information for Phase A and Phase B studies. These are:

a. All information will be presented according to a hardware-oriented work breakdown structure (WBS). The WBS will be developed jointly by the contractor and the NASA subsequent to contract award, and will be finalized within 30-60 days after contract award.

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b. The NASA Agency-wide system for establishing WBS levels shall be employed. Figure 1 pictorially illustrates the levels of this system.

c. Cost information shall be broken into non-recurring (RDT&E), recurring (production), and recurring (operations).

d. For Phase B studies only, cost information shall further be broken into Elements of Cost and Subdivisions of Work as specified by the contract manager.

e. Cost information shall be time-phased AT THE LEVEL AT WHICH IT IS ESTIMATED, and accumulated to each higher WBS level. The contract manager will establish a threshold level (e.g., 5% of the program) below which cost estimation will not be required.

f. All WBS items should be coded in accordance with the guidelines enclosed. Numbers may be arbitrarily assigned, as long as duplications are avoided.

g. Supporting analyses, historical costs, CER's and other pertinent information used in the preparation of cost estimates shall be presented.

If the above 7 criteria are followed, this specification will be satisfied.

2. Specific

The response document will be divided into four major sections as follows:

+ Section 1 - Total Program Cost Estimate Data by Work Breakdown Structure (WBS) Items. (Data Form A)

+ Section 2 - Detailed Cost Information by Elements of Cost and Subdivisions of Work. (Data Form B)

+ Section 3 - Technical Characteristics Data. (Data Form C)

+ Section 4 - Total Program Funding Schedules. (Data Form D)

a. Section 1 - Cost Estimate by WBS Items: This section of the response document will display cost estimates for specified WBS items, the time-phasing recommended to spread the costs for funding purposes, and a method to derive unit costs for recurring items. This information will be presented on the Cost Estimate Data Form A, Figure 2.

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When the Contractor requires access to costs of items existing in NASA's inventory in order to accomplish his costing activity, he will request such data from the NASA Contracting Officer and the costs of those program elements will be provided to the extent such information is available and/or appropriate.

Each item of cost presented on the Cost Estimate Data Form A will be identified by its occurrence in the WBS. Separate cost estimates will be presented for the non-recurring (DDT&E) activities, recurring (production) activity, and the recurring (operations) activity. These shall be identified by appropriate indication at the top of each form. All data necessary to produce the Funding Schedule Report will be displayed on the Cost Estimate Data Form A. A description of the contents of each column of the form follows:

(1) Identification Number: The appropriate WBS code corresponding to the item of cost (13 digits, XX-XXX-XX-XX-XX-XX).

(2) WBS Identification: The alphanumeric nomenclature of the item from the WBS (not limited in length).

(3) WBS Item Cost: The cost estimate for the WBS item. For production and operations items, the WBS item cost will be the total cumulative cost for the number of units quantified in Column D.

(4) Number of Units: The quantity of units for each WBS item used in the production and operations phases of the program. A value will not appear in this column for the non-recurring category.

(5) Reference Unit: The production sequence number of the first unit that is used in the recurring phase of the program. A value will not appear in this column for the non-recurring category.

(6) Learning Index: A numerical index of a learning rate related to the recurring cost in Column C, which, in conjunction with the data in Columns D and E, will provide a method of obtaining unit costs.

(7) T_d: The time (months) to design and develop or produce a a WBS item. For non-recurring category, T_d is the cost duration of the DDT&E activity. For the production and operations activities, T_d is the cost duration of only the reference unit in Column E.

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(8) T_s: The lead time (months) measured from the start of cost accrual for the item to the launch milestone. For the production and operations activities, T_s will be given for the reference unit in Column E.

(9) Spread Function: An index number representing a cost distribution curve which the estimator recommends for the time phasing of Column C costs over the Column G interval T_d.

Figure 6 contains five different curves from which one ma be selected for use. Cost distribution curves different from those in Figure 6 may also be used. Any such curves must be identified in this column, and elsewhere describe in either tabular or mathematical form.

(10) Launch Milestone Date: Is the date used in conjunction with T_s.

b. Section 2 - Detailed Cost Information by Elements of Cost and Subdivisions of Work - This section of the response document will display detailed cost information for individual WBS item The total cost shown in Column C, Form A, for levels 2, 3, 4, when required, level 5 WBS items will be divided across specif Elements of Cost and Subdivisions of Work. Cost Estimate Form B, Figure 3, will be used for this presentation. To minimize arbitrary allocations of cost in this section, specific elements of cost and subdivisions of work have not been identified on Data Form B. The contractor will propose Elements of Cost and Subdivisions of Work, along with comprehensive definitions of each, and submit these to the NASA contract manager subsequent to contract award and prior to finalization of the WBS. This will allow the contractor to align the data requirements of this section with those data contained in his cost data base. Both recurring and non-recurring cost categories will be displayed. The direct costs will be computed in total hours and total dollars by the elements of cost as applicable. Indirect costs will be computed in total dollars. This section will not be a requirement for Phase A studies.

c. Section 3 - Technical Characteristics Data (TCD): This section of the response document will present the technical, physical, and mission characteristics which may have a significant effect on the cost of an item. This data shall be presented on the Technical Characteristics Data Form, Figure 4.

A guideline in selecting technical characteristics, the TCD form should contain parameters that describe the item in each of the four following areas:

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Sizing Parameters: e.g., total impulse, weight, KWH, volume, etc.

Performance Parameters: e.g., minimum attitude change rate, position location, actual Isp/ideal Isp, etc.

Complexity Parameters: e.g., number of restarts of the engine, throttling ratio of the engines, etc.

Reliability Parameters: e.g., mission duration, maximum operating distance from Earth, etc. NOTE: Reliability numbers are not to be used.

A description of each column of the form follows:

(1) Identification Number: The appropriate WBS code corresponding to the item.

(2) WBS Identification: The alphanumeric nomenclature of the item from the WBS (not limited in length).

(3) Quantity or Value: The numerical quantity or value of the characteristic under consideration.

(4) Units of Measure: The identification of the units of measure associated with the characteristic under consideration.

(5) Characteristic: The identification of the technical property under consideration.

(6) Notes: Any brief comments or explanations which will increase the clarity of the information presented.

Since the TCD is used for cost parameter purposes, it is not necessary that the sum of lower level individual characteristics, such as weight or volume, equal the total weight or volume of the higher level WBS item.

d. Section 4 - Total Program Funding Schedules: This section of the response document will present an estimate of the resources required to accomplish subsequent phases of the program.

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Ordinarily these schedules will represent the summarization of cost estimates at the lowest required level of the WBS into the Project Level unless otherwise specified. To accomplish this, the WBS low level cost estimate must be time-phased by Fiscal Year against the proposed development or production plan -- by using the appropriate spreading function -- and the results summarized to produce the Funding Schedules. Funding schedules for major program items will be presented separately for the non-recurring (DDT&E), recurring (production), and recurring (operations) costs. Figure 5 will be used to display this information in the response document.

E. FORMAT

The response document shall contain the front and back matter as detailed below and arranged accordingly.

1. Cover - The cover shall contain the contractor or agency name and address, title of document, date of publication, contract number, applicable DRL number, and DRL line item number.

2. Title Page - Same information as cover page plus signature block for cognizant authority's signature.

3. Table of Contents - Shall list major divisions and subdivisions of the report. Each entry shall include page number reference.

4. Main Body of the Report - Shall present the cost and schedule plans in a sectionalized manner as outlined in Paragraph D2 of this DRD.

5. Appendices - Shall be used when necessary to present supplemental or incidental information, detailed tabulation or derivations, graphic representations, or special cost and schedule summarizations.

   NOTE: If the primary document is classified or company proprietary, a separate unclassified or non-proprietary summary will be provided.

6. Distribution List - Shall provide the names, addresses and copy requirements of all recipients of the report as approved by the NASA Contracting Officer or study manager.

PUBLICATION REQUIREMENTS

The response document shall be published in the most economical manner, taking into consideration the available facilities and the quantity to be printed.

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FRAMEWORK

FOR

WORK BREAKDOWN STRUCTURES

STRUCTURE	LEVEL	EXAMPLE	IDENTIFICATION NUMBER
PROGRAM	2	TO BE DETERMINED	XX
PROJECT	3	SPACE SHUTTLE	XXX
SYSTEM/MODULE	4	ORBITER	XX
(SUBSYSTEM GROUP)	(NONE)	AVIONICS	(NONE)
*SUBSYSTEM	5	G&N	XX
ASSEMBLY	6	IMU	XX
COMPONENT	7	GYRO	XX

*LEVEL 5 IS THE KEYSTONE LEVEL, AND SHOULD ALWAYS BE RESERVED FOR SUBSYSTEMS. OTHER LEVELS ARE ESTABLISHED BY THEIR RELATIONSHIP TO THE LEVEL 5 ITEMS.

FIGURE 1

_____ RECURRING (PRODUCTION)

_____ RECURRING (OPERATIONS)

WBS IDENT. NUMBER a	WBS ITEM NAME b	WBS ITEM COST c	NUMBER OF UNITS d	REFER. UNIT e	LEARN. INDEX f	T_d g	T_s h	SPREAD FUNC. i	MILES DATE j

FIGURE 2

WBS Ident. No. ____________
WBS Identification ____________

____ Non-Recurring (DDT&E)
____ Recurring (Production)
____ Recurring (Operations

Date ____________
Page ______ of ____

ELEMENTS OF COST	SUBDIVISIONS OF WORK							TOT

FIGURE 3

TECHNICAL CHARACTERISTICS DATA FORM C

WBS IDENTIFICATION NUMBER	WBS IDENTIFICATION	QUALITY OR VALUE	UNITS OF MEASURE	CHARACTERISTICS	NOTES

FIGURE 4

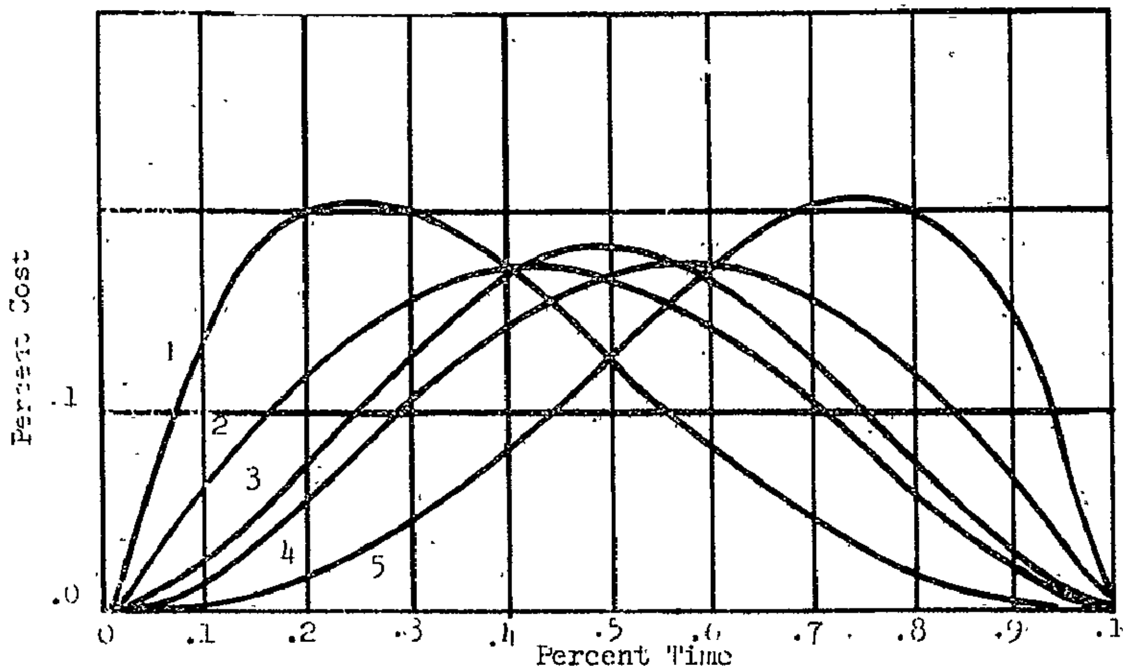
COST ESTIMATE DATA FORM D

___ NON-RECURRING (DDT&E)
___ RECURRING (PRODUCTION)
___ RECURRING (OPERATIONS)

PROJECT WBS ITEMS	FY ___	FY ___	FY ___	FY ___	FY ___	FY ___	FY

IDEALIZED COST DISTRIBUTION CURVES

Cost Rate Curves



IDEALIZED CURVES	Beta Function Coefficients A	B
1) 50% time at 80% cost	.96	.04
2) 50% time at 60% cost	.32	.68
3) 50% time at 50% cost	.00	1.00
4) 50% time at 40% cost	.00	.68
5) 50% time at 20% cost	.00	.04

General Expression:

$$F(s) = As^2\,(10+s((15-4s)s-20)) + Bs^3\,(10+s(6s-15)) + (1-(A+B))s^4\,(5-4s)$$

where s is the fraction of time elapsed and F(s) is the fraction of cost consumed. The values of A and B select respectively the first, second and third Beta functions separately and an average of the first and third Since F(s) represents the accumulation of costs, successive intervals mus be differenced to obtain the cost rates as presented above and tabulated in Table 6.

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FIGURE 6

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DATA REQUIREMENT DESCRIPTION

1. TITLE

Drawings, Lists, Form 1 and Microfilm

2. NUMBER

SE-002M

3. USE

1. To document engineering data developed in areas of design, procurement, manufacturing, testing, operation and verification of equipment of facilities.

2. To depict the use of microfilm as applicable to provide an inexpensive, effective method of maintaining a drawing and specification record.

4. DATE

February 10, 19

5. ORGANIZATION

NASA

7. INTERRELATIONSHIP

Interrelated applicable to engineering specifications and configuration management plan.

6. REFERENCES

Mil-D-1000 N.
Mil-I-8500
NHB 1440.4A
NASA Form 128
MIL-STD 100A

8. PREPARATION INFORMATION

8.1 This Data Requirements Description (DRD) establishes the requirement for the preparation of engineering drawings of Class II engineering data developed as a result of the contract effort. Drawings shall be prepare in accordance with Specification MIL-D-1000 and contractual deviations thereto. The options permitted in Specification MIL-D-1000 shall be exercised at the discretion of the contractor unless otherwise specified in the contract.

8.2 Existing engineering data to be furnished to the government shall not be redrawn to meet MIL-D-1000 requirements provided the data contains engineering definition adequate to meet the purpose for which the data are required and meets the "Delineation on Engineering Drawings" and "Item identification and part numbering" requirements of MIL-D-1000 and defines the symbols and abbreviations conforming to applicable company standards.

8.3 Engineering drawings for component parts, which are furnished to the government, shall be marked to indicate the approved interchangeability or replaceability status. The engineering drawings to be marked shall be limited to those parts required by Specification MIL-I-8500 to be listed in the interchangeability and replaceability working list. New part numbers shall be assigned to identify parts which change status, i.e., configuration of item is improved to higher degree of replaceability or from replaceable to interchangeable. Paragraphs 2-101.4.2, 2-101.4.3 and 2-101.4.4 of MIL-STD-100A apply.

8.4 Unless otherwise specified, this description does not include vendor data considered of a proprietary nature. When data of this nature is unobtainable due to excessive costs, the contractor should advise the NASA Contracting Officer or his representative to seek guidance.

NASA FORM 9 FEB 67 REPLACES NASA FORM 1107, EXISTING STOCKS OF WHICH ARE TO BE DESTROYED.

Drawings, Lists, Form 1 and Microfilm

8.5 All original drawings for the program deliverable end-items shall be equivalent to or better than the material requirements of Specification MIL-D-1000.

8.6 Updating shall be accomplished in accordance with the contractor's configuration requirements management plan.

8.7 The reproduction, distribution, and frequency of submittal of drawings shall be as specified on NASA Form 1106, Data Requirement List (DRL).

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DATA REQUIREMENT DESCRIPTION

1. TITLE Specification, CEI, Part I	2. NUMBER CM007M
3. USE To provide requirements peculiar to the design, development, test and qualification of the contract end item (prime equipment).	4. DATE November 10, 1969 5. ORGANIZATION NASA
7. INTERRELATIONSHIP Reference, Statement of Work, Para. 4.4	6. REFERENCES MIL STD-490 Appendix II

8. PREPARATION INFORMATION

8.1 SCOPE: This Data Requirement Description establishes the preparation requirements for a Part I CEI Specification for prime equipment items.

8.2 CONTENT/FORMAT: The CEI Specification shall be prepared in accordance with MIL STD-490 Appendix II. The specification shall provide complete design, performance, test/verification requirements for the end item.

8.3 MAINTENANCE: The specification shall be maintained current with changes in program requirements.

8.4 DELIVERY: The submittal requirements for the specifications shall be as specified on the Data Requirements List (DRL).

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NASA FORM 9 FEB 67 REPLACES NASA FORM 1107, EXISTING STOCKS OF WHICH ARE TO BE DESTROYED.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

ITLE ecification, Non-CEI	2. NUMBER CM008M
USE provide mission requirements definition, system performance requirements, performance budgets for primary and secondary functional areas, standard requirement r design, development, and operations for a program, oject, or system (Non-CEI).	4. DATE February 10, 1970 5. ORGANIZATION NASA
NTERRELATIONSHIP	6. REFERENCES MIL-STD-490 Appendix I

PREPARATION INFORMATION

1 SCOPE: This Data Requirement Description (DRD) establishes the preparatio requirements for a program, project, or system non-CEI Specification.

2 CONTENT-FORMAT: The program, project, or system non-CEI specification shall be prepared in accordance with MIL-STD-490. The contractor shall insure that the specification contains a specification tree showing specification relationships to level 6 in accordance with the Work Breakdown Structure for the program.

3 MAINTENANCE: The specification shall be maintained current with changes in program requirements.

4 DELIVERY: The submittal requirements for the specification shall be as specified on the Data Requirements List (DRL).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

DATA REQUIREMENT DESCRIPTION

1 TITLE REPORT - Detail Mass Properties	2 NUMBER SE005M
3 USE Provides visibility for mass properties for next phase of the program.	4 DATE 16 January 1970 5. ORGANIZATION NASA
7 INTERRELATIONSHIP	6 REFERENCES SP 6004 (NASA) or MIL Spec M-38310-A (USAF)

8 PREPARATION INFORMATION

This report shall present the results of utilizing the mass property control procedures outlined in MIL M-38310-A and Appendix E.

The detail mass property report shall consist of the report elements identified in Table 1, column 3 of MIL M-38310-A with the exception that the reporting forms identified in the paragraphs discussing each report element shall be replaced by the reporting forms 1 thru 5 attached or an approved equivalent.

Form 1 - Design Data Statement - Minimum acceptable

Form 2 - Summary Weight Statement - Minimum acceptable information

Form 3 - Detail Weight Statement - Equivalent computer output acceptable with prior approval

Form 4 - Sequence Mass Properties Statement - Equivalent computer output acceptable with prior approval

Form 5 - Summary Mass Properties Statement - Equivalent computer output acceptable with prior approval

The detail weight and mass property information presented on form 3 or its equivalent shall be consistent with the MIL M-38310-A Functional breakdown modified in a manner compatible with the modifications utilized in the phase A study and updated with concerned parties.

This report will provide the above data consistent with the phase of the program.

NASA FORM 9 FEB 67 REPLACES NASA FORM 1107, EXISTING STOCKS OF WHICH ARE TO BE DESTROYED.

APPENDIX E

STATEMENT OF WORK

SPACE SHUTTLE SYSTEM PROGRAM DEFINITION (PHASE B)

MASS PROPERTIES

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APPENDIX E

MASS PROPERTIES

The contractor shall develop and maintain data for weights and mass characteristics for all mission phases. Weight reporting will be required at all major contract reporting milestones with complete detail submission at contract midterm and completion (Ref. document MIL-M-38310A (USAF) July 15, 1966, for mass properties formating). Summary status data will be reported monthly.

Allowances for contingencies, uncertainties, and growth are to be clearly identified for each configuration. Usable capacities use rates, residuals, etc., will be identified for each consumable (including personnel) on-board. Mass properties constraint (i.e., center of gravity tolerance, maximum inertia, displacement of principal axes, etc.) are to be identified with source.

Weight sensitivities shall be developed and maintained to reflec effects of selected subsystem or system parameters on critical shuttle elements and performance.

The final report will include, in addition to the basic mass properties data consisting of configuration drawings, design data, summary and detail data, a section providing, but not limited to, the following information: mass substantiating data, mass dependent design information, mass sensitivity as related to design features, critical mass uncertainties, mass limits, inventory capacity information for fluids/propellants, and mass histories/projected weight and density growth patterns.

The attached forms (forms 1 through 5) or equivalents shall be utilized in reporting the data to comply with the documentation requirements as outlined in Appendix D and table 1, colums 3 and 4 of MIL-M-38310A (USAF) July 15, 1966.

SPACECRAFT SUMMARY MASS PROPERTIES STATEMENT

Page of

Configuration | By | Date

CODE	SYSTEM	WEIGHT LBS.	CENTER OF GRAVITY FEET			MOMENT OF INERTIA SLUG FT^2X10-			PRODUCT OF INERTIA SLUG FT^2X10-		
			X	Y	Z	I_{x-x}	I_{y-y}	I_{z-z}	I_{xy}	I_{xz}	I_{yz}
1.0	AERODYNAMIC SURFACES										
2.0	BODY STRUCTURE										
3.0	INDUCED ENVIR. PROT.										
4.0	LNCH, RECOVERY AND DOCKING										
5.0	MAIN PROPULSION										
6.0	ORIENT CONTROL, SEP. & ULL.										
7.0	PRIME POWER SOURCE										
8.0	POWER CONVERSION AND DISTR.										
9.0	GUIDANCE AND NAVIGATION										
10.0	INSTRUMENTATION										
11.0	COMMUNICATION										
12.0	ENVIRONMENTAL CONTROL										
13.0											
14.0	PERSONNEL PROVISIONS										
15.0	CREW STA. CONTROL & PANEL										
16.0	RANGE SAFETY & ABORT										
SUBTOTALS (DRY WEIGHT)											
17.0	PERSONNEL										
18.0	CARGO										
19.0	ORDNANCE										
20.0	BALLAST										
21.0	RESID. PROP. & SERV. ITEMS										
SUBTOTALS (INERT WEIGHT)											
22.0	RES. PROP. & SERV. ITEMS										
23.0	INFLIGHT LOSSES										
24.0	THRUST DECAY PROPELLANT										
25.0	FULL THRUST PROPELLANT										
26.0	THRUST PROP. BUILDUP										
27.0	PRE-IGNITION LOSSES										
TOTALS (GROSS WEIGHT)											

NOTES:

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Ref. MIL M-38310A or SP-6004

SPACECRAFT SEQUENCE MASS PROPERTIES STATEMENT		Page of
Configuration	By	Date

No.	Mission Event	Weight Lb.	Center of Gravity Feet			Moment of Inertia Slug Ft^2X10-			Product of Inertia Slug Ft^2X10-		
			X	Y	Z	I_{x-x}	I_{y-y}	I_{z-z}	I_{xy}	I_{xz}	I_{yz}

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Ref. MIL-M-38310A or SP-6004

SPACECRAFT DESIGN DATA STATEMENT

CONFIGURATION	BY	DATE

REFERENCE MIL-M-38310A, SP-6004, AN-9103-D

SYSTEM/AIRFRAME DESIGN

1.0 AERODYNAMIC SURFACES	WING	H. TAIL	V. TAIL
VOLUME (WETTED, OUTER MOLD LINE, FT3)			
SURFACE AREA OF ABOVE VOLUME (FT2)			
GROSS AREA (FT2)			
SPAN (FT)			
MEAN AERODYNAMIC CHORD LENGTH (FT)			
THEORETICAL ROOT CHORD, LENGTH (IN)			
, MAX THICKNESS (IN)			
THEORETICAL TIP CHORD, LENGTH (IN)			
, MAX THICKNESS (IN)			

2.0 BODY STRUCTURE (ALSO NAC & PYL)	CABIN	CARGO	REMAIN	NAC&PYL
VOLUME (WETTED MOLD LINE, FT3)				
PRESSURIZED VOLUME (FT3)				
SURFACE AREA (WETTED, FT2)				
MAXIMUM LENGTH (FT)				
MAXIMUM DEPTH (FT)				
MAXIMUM WIDTH (FT)				

TOTAL WETTED OUTER MOLD LINE VOLUME (FT3)	
TOTAL WETTED OUTER MOLD LINE SURFACE AREA (FT2)	

3.0 INDUCED ENVIR. PROT.	WING	H. TAIL	V. TAIL	BODY	NAC&PYL
VOLUME DELTA WITHIN 1.0 & 2.0 (FT3)					
SURFACE AREA DELTA WITHIN 1.0 & 2.0 (FT2)					
WINDWARD UNIT WT. (LB/FT2)					
LEEWARD UNIT WT. (LB/FT2)					

4.0 LAUNCH RECOVERY AND DOCKING	MAIN	NOSE	OTHER
LANDING GEAR (MAX. VERT. LOAD/GEAR, LB)			
LENGTH, OLEO EXTENDED (INCHES)*			
OLEO TRAVEL (INCHES)**			

STRUCTURAL	STRESS G. W.	ULT.L.F.
FLIGHT		
LANDING		
LIMIT LANDING SINKING SPEED (FT/SEC)	@ ____ G. W.	
PRESSURIZED CABIN ULT. DSN. PRESS. DIFF., FLT. (PSI)		
AIRFRAME WEIGHT (AS DEFINED IN AN-W-11) (LBS)		

SYSTEM DESIGN

5.0 MAIN PROPULSION	LIFT-OFF	LANDING
NUMBER OF ENGINES		
MAX SL STATIC THRUST PER ENG (LB)		
TOTAL PROPELLANT TANKAGE VOLUME (FT3)		
TOTAL JP FUEL TANKAGE VOLUME (FT3)		
6.0 THROUGH 16.0		
MAXIMUM ELECTRICAL POWER (KW)		
PRESSURIZED SURFACE AREA (FT2)		
MAXIMUM MISSION DURATION (DAYS)		
NUMBER OF CREW		
17.0 THROUGH 21.0		
MAXIMUM NUMBER OF PERSONNEL INCL. CREW		
MAXIMUM CARGO (LB)		
MAXIMUM CARGO DENSITY (LB/FT3)		
22.0 THROUGH 27.0		
CAPACITY PROPELLANT WEIGHT (LB)		
CAPACITY JP FUEL WEIGHT (LB)		

GENERAL/MISSION DESIGN

MAXIMUM DESIGN GROSS WEIGHT (LB)		
MAXIMUM BOOST LOAD FACTOR ____ g AT		G. W.
MAXIMUM BOOST DYNAMIC PRESSURE (LB/FT2)		
MAIN ENGINE SPECIFIC IMPULSE (LB SEC/LB)		
DELTA VELOCITY AVAILABLE (FT/SEC)		
ENTRY VELOCITY (FT/SEC)		
ENTRY WEIGHT (LB)		
BALLISTIC COEFFICIENT (W/C_DA, LB/FT2)		
MAXIMUM HEATING RATE (BTU/FT2 SEC)		
FACTORS OF SAFETY (DEFINE)		
MARGINS (DEFINE)		
CONTINGENCY (DEFINE)		
WEIGHT GROWTH (DEFINE)		

*℄ AXLE TO ℄ TRUNNION **FULLY EXTENDED TO FULLY COLLAPSED

SEPT. 1969

SPACECRAFT DETAIL WEIGHT STATEMENT

PAGE ______ OF ______

CONFIGURATION	BY	DATE

Reference MIL-M-38310A or SP-6004

FOR CODE

FOR SYSTEM

FOR ITEM OR MODULE

		UNITS								TOTALS		
						LOCATION EACH ORBIT REF. SYSTEM				WEIGHT CODE GENERATION		
CODE	DESCRIPTION	CLASS (E, C, A)	VOLUME FT^3 EACH	POWER WATTS EACH	WEIGHT LB EACH	X	Y	Z	QUANTITY	FIRST	SECOND	THIRD

NOTES:

	FIRST	SECOND	THIRD
PAGE TOTALS			
TOTALS FROM PAGE ______			
SUBTOTALS			

SPACECRAFT SUMMARY WEIGHT STATEMENT

CONFIGURATION	BY	DATE

CODE	SYSTEM	ITEM OR MODULE A	B	C	D	E	F	SPACECRAFT M	U
1.0	AERODYNAMIC SURFACES								
2.0	BODY STRUCTURE								
3.0	INDUCED ENVIR PROT								
4.0	LNCH RECOV & DKG								
5.0	MAIN PROPULSION								
6.0	ORIENT CONTROL SEP & ULL								
7.0	PRIME POWER SOURCE								
8.0	POWER CONV & DISTR								
9.0	GUIDANCE & NAVIGATION								
10.0	INSTRUMENTATION								
11.0	COMMUNICATION								
12.0	ENVIRONMENTAL CONTROL								
13.0	(RESERVED)								
14.0	PERSONNEL PROVISIONS								
15.0	CREW STA CONTRL & PAN								
16.0	RANGE SAFETY & ABORT								
SUBTOTALS (DRY WEIGHT)									
17.0	PERSONNEL								
18.0	CARGO								
19.0	ORDNANCE								
20.0	BALLAST								
21.0	RESID PROP & SERV ITEMS								
SUBTOTALS (INERT WEIGHT)									
22.0	RES PROP & SERV ITEMS								
23.0	INFLIGHT LOSSES								
24.0	THRUST DECAY PROPELLANT								
25.0	FULL THRUST PROPELLANT								
26.0	THRUST PROP BUILDUP								
27.0	PRE-IGNITION LOSSES								
TOTALS (GROSS WEIGHT) (LB)									
DESIGN ENVELOPE VOLUME (FT^3)									
PRESSURIZED VOLUME (FT^3)									
DESIGN ENVEL SURF AREA (FT^2)									
PRESSURIZED SURF AREA (FT^2)									
DESIGN q, MAX (LB/FT^2)									
DESIGN g, MAX									
DESIGN POWER, MAX (KW)									
DESIGN NO. MEN-DAYS									

DESIGNATIONS:

CODE, SYSTEM: REF. MIL-M-38310A OR SP-6004

ITEM OR MODULE

A

B

C

D

E

F

SPACECRAFT

M MANNED LAUNCH

U UNMANNED LAUNCH

NOTES & SKETCHES:

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MSC Form 1523 (Jul 69)

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APPENDIX F

STATEMENT OF WORK

SPACE SHUTTLE SYSTEM PROGRAM DEFINITION (PHASE B)

STUDY SUBMITTAL SCHEDULE

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APPENDIX F

STATEMENT OF WORK

SCHEDULE FOR SUBMITTAL OF ENGINE/VEHICLE INTEGRATION STUDIES, WIND TUNNEL MODELS AND STRUCTURAL TEST PROGRAM PROPOSAL

	Completion Date from Start Phase B
I. ENGINE/VEHICLE INTEGRATION STUDIES	
A. MAIN PROPULSION SYSTEM	
o Thrust Level Optimization	3 Months
o Expansion Ratio Optimization	3 Months
o Emergency Power Level Optimization	3 Months
o Throttle Requirements (consider use of other systems on-board as source of thrust for orbital maneuvers)	3 Months
o Gimbal Angle and Rate Optimization	3 Months
o Propellant Tank Pressurization Requirements	3 Months
o Gimbal System Type and Location	3 Months
o PU System Requirements	3 Months
o Engine Controller Functional Requirements and Location	3 Months
B. APS	
o APS vs Main Propulsion for Orbital Maneuvers	3 Months
o Establishment of Requirements and Duty Cycle (consider also power generation and hydraulic system requirements)	6 Months
C. AIRBREATHING ENGINE	
o Establishment of Requirements and Duty Cycle	6 Months

APPENDIX F (continued)

	Completion Date from Start Phase B
II. WIND TUNNEL MODELS	
o Wind Tunnel Models	11 Months
III. STRUCTURAL TEST PROGRAM	
o To be determined based on contractors structural test program to be proposed early in the study but not later than 3 months after the start of the Phase B study.	
IV. INTERIM DESIGN SUBMISSION	8 Months

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APPENDIX G

STATEMENT OF WORK

APPLICABLE DOCUMENTS

1.* Final Reports, Integral Launch and Reentry Studies - Contract No. NAS9-9204, NAS9-9205, NAS9-9206, NAS9-9207

2.* Space Shuttle Main Engine Statement of Work including Exhibit A, Engine CEI Specification (Preliminary), and Exhibit B, Data Requirements

3.* OMSF Safety Program Directive No. 1, System Safety Requirements for Manned Space Flight, December 1969

4.* SP-6004, Mass Properties Standard, 1965, or MIL-M-38310-A (USAF) 1966

5.** Joint DOD/NASA Survivability Characteristics (U) June 16, 1969 (SECRET)

6.** Final Reports (USAF) Space Transportation System Studies (U) Contract No. FO 4701-69-C-0379,0380, 0381, 0382 (CONF)

* Documentation will be available for pickup at NASA Headquarters, Federal Office Building 10B (FOB 10B), 600 Independence Avenue, S. W., Washington, D. C. Contact Mr. Philip H. Sload, Code KD-5, Telephone - AC 202-962-0570

** Classified documentation will be made available (subject to security clearance) only to contractors who provide NASA with written notification of their intent to submit a proposal (as provided in paragraph 13 of the RFP letter) Specific direction for obtaining these documents will be provided by Maj. P. B. Crotty, Code SMAOR, Space and Missile Systems Organization, Los Angeles AFB, Los Angeles California 90045 - Telephone AC 213-643-2026.

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ENCLOSURE NO. 5

CERTIFICATIONS

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CERTIFICATIONS

This form is to be completed, signed and returned with the bid or proposal.

BIDDER OR OFFEROR REPRESENTS: (Check as appropriate)

1. That he is a ( ) MANUFACTURER, ( ) REGULAR DEALER, ( ) CONSTRUCTOR CONTRACTOR, ( ) SERVICE CONTRACTOR, as defined in the NASA Procurement Regulation 12.603-1, 12.603-2, 1.204 and 1.229, respectively.

2. (a) That he ( ) has ( ) has not employed or retained any company or person (other than a full-time bona fide employee working solely for the bidder or offeror) to solicit or secure this contract, and (b) that he ( ) has ( ) has not paid or agreed to pay any company or person (other than a full-time bona fide employee working solely for the bidder or offeror) any fee, commission, percentage or brokerage fee, contingent upon or resulting from the award of this contract; and agrees to furnish information relating to (a) and (b) above as requested by the Contracting Officer. (For interpretation of the representation, including the term "bona fide employee", see Code of Federal Regulations, Title 44, Part 150.) (January 1964)

NOTE: If the bidder or offeror, by checking the appropriate box provided therefor in his bid or proposal, has represented that he has employed or retained a company or person (other than a full-time employee) to solicit or secure this contract, he may be requested by the Contracting Officer to furnish with his bid or proposal a completed Standard Form No. 119 (Contractor's Statement of Contingent or Other Fees for Soliciting or Securing Contract). If the bidder or offeror has previously furnished a completed Standard Form No. 119 to the office issuing this invitation for bids or request for proposals, he may accompany his bid or proposal with a signed statement, in lieu of Standard Form No. 119, (a) indicating when such completed Form was previously furnished, (b) identifying by number the previous invitation, request for proposals, or contract in connection with which such Form was submitted, and (c) representing that the statements in such previously furnished Form are applicable to this bid or proposal. (February 1962)

3. That he operates as ( ) AN INDIVIDUAL, ( ) A PARTNERSHIP, ( ) A CORPORATION, incorporated in the State of ________________.

4. (a) That he ( ) is ( ) is not a small business concern. A small business concern is a concern that is independently owned and operated, is not dominant in the field of operation in which it is bidding on Government contracts, and, with its affiliates, can further qualify under the criteria as prescribed by the Small Business Administration.

See Code of Federal Regulations, Title 13, Part 121, as amended which contains detailed industry definitions and related procedures.

(b) If he is a small business concern and is not the manufacturer of the supplies offered, he also represents that all supplies to be furnished hereunder ( ) will ( ) will not be manufactured or produced by a small business concern in the United States, its territories, its possessions, or the Commonwealth of Puerto Rico, states has ( ) has not ( ) been refused a Certificate of Competency by the Small Business Administration.

5. That he ( ) has ( ) has not participated in a previous contract or subcontract subject to either the Equal Opportunity clause herein or the clause originally contained in Section 301 of Executive Order 10925; that he ( ) has, ( ) has not, filed all required compliance reports; and that representations indicating submissions of required compliance reports, signed by proposed subcontractors, will be obtained prior to subcontract awards. (The above representation need not be submitted in connection with contracts or subcontracts which are exempt from the clause.) (July 1968)

6. That each end product, except the end products excluded below, is a domestic source end product (as defined in the contract clause entitled BUY AMERICAN ACT); and that components of unknown origin have been considered to have been mined, produced, or manufactured outside the United States.

EXCLUDED ITEMS: ______________________________

CERTIFICATE OF INDEPENDENT PRICE DETERMINATION (JUNE 1964)

(a) By submission of this bid or proposal, each bidder or offeror certifies, and in the case of a joint bid or proposal, each party thereto certifies as to its own organization, that in connection with this procurement:

(1) the prices in this bid or proposal have been arrived at independently, without consultation, communication, or agreement, for the purpose of restricting competition, as to any matter relating to such prices with any other bidder or offeror or with any competitor;

(2) unless otherwise required by law, the prices which have been quoted in this bid or proposal have not been knowingly disclosed by the bidder or offeror and will not knowingly be disclosed by the bidder or offeror prior to opening in the case of a bid, or prior to award, in the case of a proposal, directly or indirectly to any other bidder or offeror or to any competitor; and

(3) no attempt has been made or will be made by the bidder or offeror to induce any other person or firm to submit or not to submit a bid or proposal for the purpose of restricting competition.

(b) Each person signing this bid or proposal certifies that:

(1) he is the person in the bidder's or offeror's organization esponsible within that organization for the decision as to the prices eing bid or offered herein and that he has not participated, and will ot participate, in any action contrary to (a)(1) through (a)(3) above; r

(2) (a) he is not the person in the bidder's or offeror's organization responsible within that organization for the decision as to the rices being bid or offered herein but that he has been authorized in riting to act as agent for the persons responsible for such decision n certifying that such persons have not participated, and will not articipate, in any action contrary to (a)(1) through (a)(3) above, nd as their agent, does hereby so certify; and (b) he has not articipated, and will not participate, in any action contrary to a)(1) through (a)(3) above.

c) This certification is not applicable to a foreign bidder or offeror ubmitting a bid or proposal for a contract which requires performance or elivery outside the United States, its possessions, and Puerto Rico.

d) A bid or proposal will not be considered for award where (a)(1), a)(3), or (b) above has been deleted or modified. Where (a)(2) above as been deleted or modified, the bid or proposal will not be considered or award unless the bidder or offeror furnishes with the bid or proposal signed statement which sets forth in detail the circumstances of the disclosure nd the Administrator, or his designee, determines that such disclosure was ot made for the purpose of restricting competition.

____
Organization

By ____________________________
Signature

____
Typed Name

____
Title

____
Date

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IFB/RFP No. ________________

ENCLOSURE NO. 6

CERTIFICATION OF NONSEGREGATED FACILITIES

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CERTIFICATION OF NONSEGREGATED FACILITIES (MAY 1968)

(Applicable to contracts, subcontracts, and agreements with applicants who are themselves performing federally assisted construction contracts, exceeding $10,000 which are not exempt from the provisions of the Equal Opportunity clause.) By signing this form, the bidder, offeror, applicant, or subcontractor certifies that he does not maintain or provide for his employees any segregated facilities at any of his establishments, and that he does not permit his employees to perform their services at any location, under his control, where segregated facilities are maintained. He certifies further that he will not maintain or provide for his employees any segregated facilities at any of his establishments, and that he will not permit his employees to perform their services at any location, under his control, where segregated facilities are maintained. The bidder, offeror, applicant, or subcontractor agrees that a breach of this certification is a violation of the Equal Opportunity clause in this contract. As used in the certification, the term "segregated facilities" means any waiting rooms, work areas, rest rooms and wash rooms, restaurants and other eating areas, time clocks, locker rooms and other storage or dressing areas, parking lots, drinking fountains, recreation or entertainment areas, transportation, and housing facilities provided for employees which are segregated by explicit directive or are in fact segregated on the basis of race, creed, color, or national origin, because of habit, local custom or otherwise. He further agrees that (except where he has obtained identical certification from proposed subcontractors for specific time periods) he will obtain identical certifications from proposed subcontractors prior to the award of subcontracts exceeding $10,000 which are not exempt from the provisions of Equal Opportunity clause; that he will retain such certifications in his files; and that he will forward the following notice to such proposed subcontractors (except where the proposed subcontractors have submitted identical certifications for specific time periods):

NOTICE OF PROSPECTIVE SUBCONTRACTORS OF REQUIREMENT FOR CERTIFICATION OF NONSEGREGATED FACILITIES

A Certification of Nonsegregated Facilities, as required by the May 9, 1967, order on Elimination of Segregated Facilities, by the Secretary of Labor (32 Fed. Reg. 7439, May 19, 1967), must be submitted prior to the award of a subcontract exceeding $10,000 which is not exempt from the provisions of the Equal Opportunity clause. The certification may be submitted either for each subcontract or for all subcontracts during a period (i.e., quarterly, semiannually, or annually). (Note: The penalty for making false statements in offers is prescribed in 18 U.S.C. 1001.)

Firm ____________________

Name ____________________

Title ____________________

Date: ________________

APPENDIX 4

UNSOLICITED PROPOSAL EVALUATION AND DISPOSITION
A DESCRIPTIVE MODEL OF THE DECISION PROCESS

UNSOLICITED PROPOSAL EVALUATION AND DISPOSITION
A
DESCRIPTIVE MODEL
OF
THE DECISION PROCESS

Prepared for
Professor Richard Reid
and
Professor Charles S. Telly
Business Administration 552

Prepared by
Robert Battey and Larry Damewood
March 13, 1979

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TABLE OF CONTENTS

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LIST OF FIGURES

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PREFACE

The purpose of this paper is to present a descriptive model of a real world decision process, to analyze the model with the objective of identifying modifications that would, if incorporated, make the model more normative, and to draw conclusions regarding the effectiveness of the decision process.

The decision process selected for the project is of sufficient complexity and magnitude to require expertise in more than one discipline to even begin to approach the quality for which the paper strives. The authors have actual experience as both observers and participants in the decision process of the system described in this paper. This experience brings a desirable knowledge base into the project and hopefully results in a more factual paper. Mr. Battey is associated with the technical decision making process. Thus he appropriately assumed responsibility for technical considerations. Mr. Damewood has experience in the business oriented aspects providing background for the non-technical portion of the model. To achieve the best utilization of resources and to devote appropriate emphasis to the most significant areas, a dual model approach is followed. First, the entire decision process is described via the medium of a macro model. This is intended to provide perspective on the total process with sufficient emphasis on the more crucial aspects. Then, a second model which is more micro-oriented, deals exclusively with the most important single part of the decision spectrum, the technical decision process.

The organization of the material is as follows: The Introduction, which lays the foundation for the paper, includes a description of the decision process, the system in which it functions, the scope and limitations of the study, the environments, applicable literature and the research methodology. Next, the models are presented in diagrammatic form and described. Part III provides an analysis of the models oriented to normative improvements, and finally Part IV summarizes and draws conclusions as to the effectiveness of the models.

PART I

INTRODUCTION

Part I introduces the subject and provides sufficient background information to facilitate an understanding of the authors' work.

System: The organization within which the decision making process functions is a major research and development activity within a federal agency, the National Aeronautics and Space Administration (NASA). The specific system described in this paper is the Manned Spacecraft Center (MSC), Houston, Texas. MSC is a field activity with responsibility for research and development of spacecraft for manned spaceflight. About 50 percent of NASA's 34,000 employees work under the Office of Manned Space Flight (MSF), which includes three field centers, and a headquarters staff in Washington, D. C. MSC, one of the three OMSF field centers, was established about 10 years ago with a cadre of 35 people and has grown to a major installation whose programs at peak periods involve as many as 200,000[1] people. The center developed the spacecraft and trained flight crews for the Mercury, Gemini and Apollo Programs and is currently engaged in advance programs such as the Space Station and Reuseable Shuttle. Organization charts for NASA (Figure 1)[2] and MSC (Figure 2)[3] show

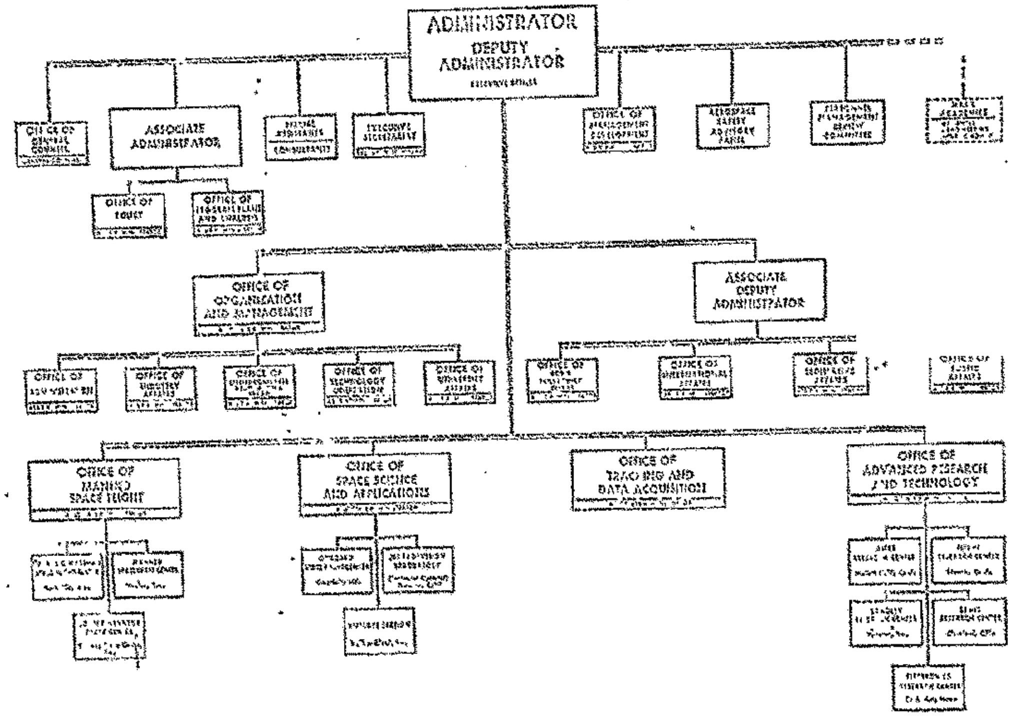
[1] Wesley L. Kjornevik, Issues in Public Science Policy and Administration (Albuquerque: Univ. of New Mexico, 1969), Ch. IV.

[2] United States Government Organization Manual, 1969-70 (Office of the Federal Register, Nat'l Archives and Records Service, General Services Administration), p. 623.

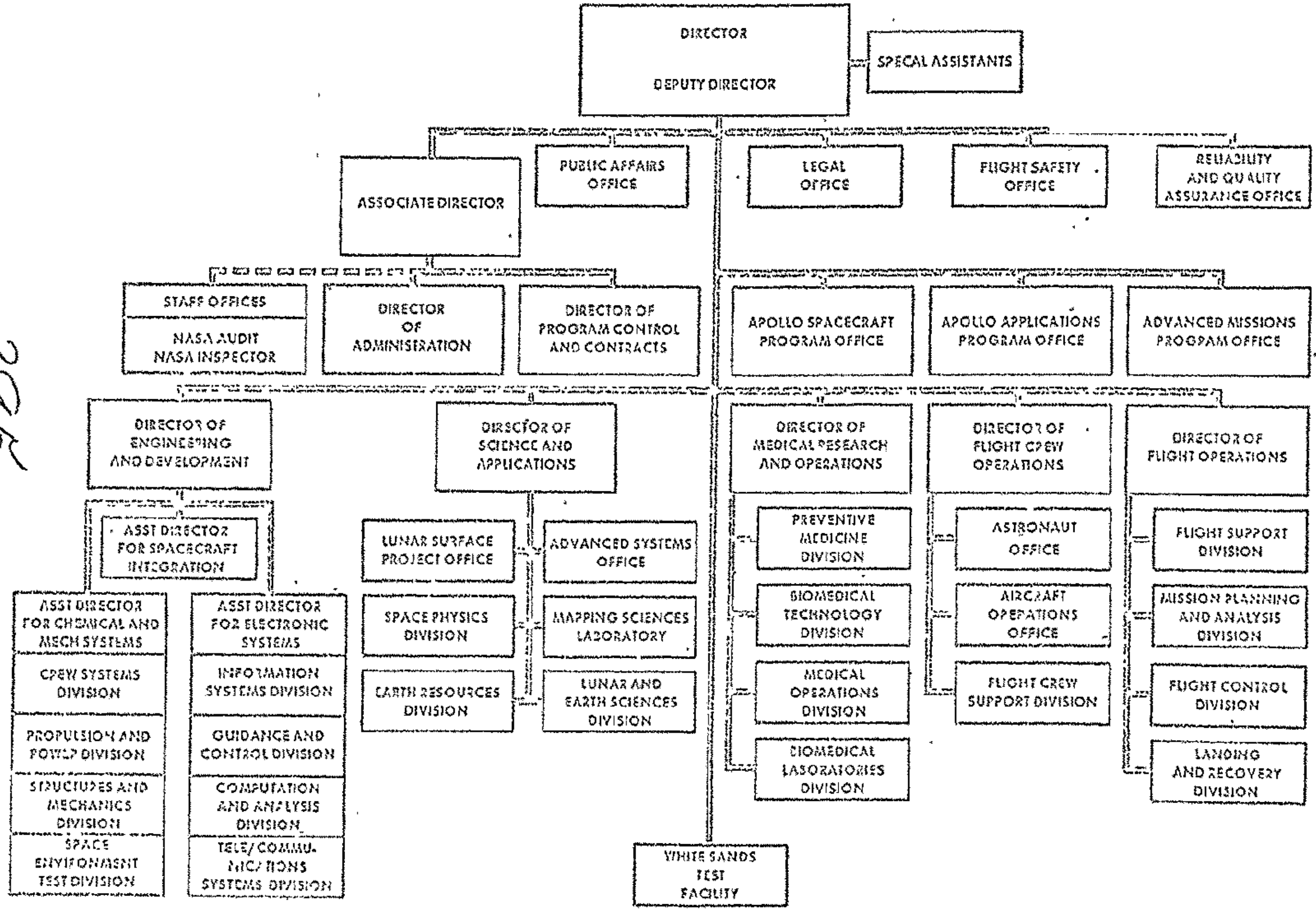
[3] National Aeronautics and Space Administration, Manned Spacecraft

Figure

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS



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the organizational context of the decision system.

Decision process: The system, is the recipient of a steady stream of unsolicited proposals. These proposals come from various sources desirous of financial support to pursue ideas in areas related to space exploration.[4] The management of the system is constantly in search of new and better ways to carry out the objectives; it is therefore advantageous to carefully consider all proposals. Many worthwhile ideas come to the surface via the unsolicited proposal vehicle. On the other hand, many of the proposals have little merit. For this reason, the decision process culminating in "rejected and accepted" proposals must be geared to identifying the good potentials early and thoroughly investigating them while culling the proposals with little or no merit. Such a process involves all organizational elements in an interrelated, complex operation. Decisions are made at all points in the process and by different levels of management depending on such factors as estimated cost and technical merit. Every proposal competes with the on-going programs and every other proposal for support. With funding constraints always a problem, the system must assure that only those proposals with high technical merit are selected for implementation.

The decision process modeled in this paper commences at the point of initiation of an unsolicited proposal and continues through the entire process of review, selection or rejection, contract negotiation, performance and finally ends with the decisions that determine if the initiator has performed as obligated under the

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Center, Annual Procurement Report, Fiscal Year 1969 (Houston, Texas, 1969), p. 20.

[4]The term "unsolicited" is the commonly accepted term to differentiate a proposal submitted on the originator's own initiative from those submitted in response to a request from the system.

contract. Emphasis is placed in the areas of most significance to an understanding of the process.

The model and associated work is directed to a description of the "functions" of the decision process as opposed to an organizational description. Each function may involve several organizational elements. Although decisions are made at various levels within the system, the process is essentially the same throughout the management hierarchy.

Environment: The entire decision process is surrounded by a continuous interaction between the decision maker and his environment. All decisions are in a real sense a culmination and integration of a multitude of internal and external factors. It is not appropriate to discuss the decision process described in this paper in terms of "the" environment. There are multiple environments depending upon the point in the process as well as the management level at which the decision is made. For example, at the top management level the environment consists of factors external to the system such as the proposal initiator, the initiator's competitors, the scientific community, political factions, other federal organizations including NASA field centers, Headquarters, local interest groups, and universities. The degree and type of influence depends upon prestige, relationship of the environmental factor to the system, and a host of other such factors. Headquarters, for example, is in a position to dictate and is always a powerful influence. Decisions made by top management must recognize not only the technical merits of a particular proposal, but must also integrate these environmental factors.

At lower levels within the system the environment consists primarily of the system's own management hierarchy. The decision makers must always consider the views of their respective manager recognizing that different values are at play.[5]

In both instances the degree of influence on the decision maker is largely a factor of the power and prestige of the environmental factor as well as the power and prestige of the decision maker.

Limitations and Scope: The objective of this presentation is to bring the decision making process into focus in such a manner so as to provide an overall perspective on the total process. A detail analysis of every facet of the process is not feasible and in fact would jeopardize the ability to communicate the main thoughts. Therefore, there is an intentional "highlighting" treatment of many areas that an in-depth study would cover more thoroughly. Also, the study does not investigate the decision making process of the initiator nor the Headquarters activity. The model is based entirely upon the authors' subjective observations, interpretation of official literature and consultation with selected individuals within the system. Recognizing the authors' own values,[6] there is no intent to imply that other researchers would necessarily view the process as presented herein.

Literature: Considerable literature was reviewed for familiarizatio[n] and ideas on model building.[7] However the survey revealed no directly

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[5] C. West Churchman, Prediction and Optimal Decision (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1961), Ch. 7.

[6] Irwin D. J. Bross, Design for Decision (New York: The MacMillan Company, 1953), pp. 65-91.

[7] R. H. Cramer and B. E. Smith, "Decision Models for the Selection of Research Projects," The Engrg. Economist, Vol. 9:2 (Jan-Feb. 1964),

applicable work. The only literature with direct applicability are the official regulations governing NASA procurement.[8] These regulations provided much of the descriptive information regarding the processing of unsolicited proposals.

Research Methodology: The authors' objective is to develop and present a descriptive model of what actually occurs in the decisi making process. Using Hyneman's terminology, the methodology is primarily descriptive, providing "an account of what actually exists and occurs."[9] Techniques employed included personal observation and participation in the process, a study of literature and consultation with selected NASA officials.

pp. 1-20; R. G. Brandenberg, "Project Selection in Industrial R&D Problems and Decision Processes" in M. C. Yovits, et. al. (eds.) Research Program Effectiveness (New York: Gordon and Breach, Publishers, 1966), pp. 13-40.

[8] NASA Procurement Regulation, January 1964 (NPC-400), as amended through Rev. 14, Oct. 1969.

[9] Charles S. Hyneman, The Study of Politics (Urbana: University of Illinois Press, 1959), p. 116.

PART II

DESCRIPTIVE MODELS

Part II provides a verbal model[10] of the diagrammatic model in Figure 1 to more clearly describe the decision making process. Although the total decision making and implementation process is described, the main thrust is directed to the "Key Decision" sub-process areas. For convenience and ease of presentation, the variables, constraints and other decision making considerations are discussed as a part of the description of each major step. Consideration was given to establishing separate categories for these factors; however, the authors believe such an approach would be unduly cumbersome. The decision making steps discussed below are identified by the same numbers shown on Figure 1:

Step 1 - Initiate - Most unsolicited proposals received by the system are initiated by the industrial sector. However, unsolicited proposals are also initiated by various other parties such as universities, other non-profit institutions and individuals. Proposals can and do cover the spectrum from basic research in narrow fields to full scale spacecraft systems. Specific instructions are provided by the system to assist prospective initiators. The following information is required, hopefully with the initial submission to facilitate decisions regarding acceptability of their proposal:

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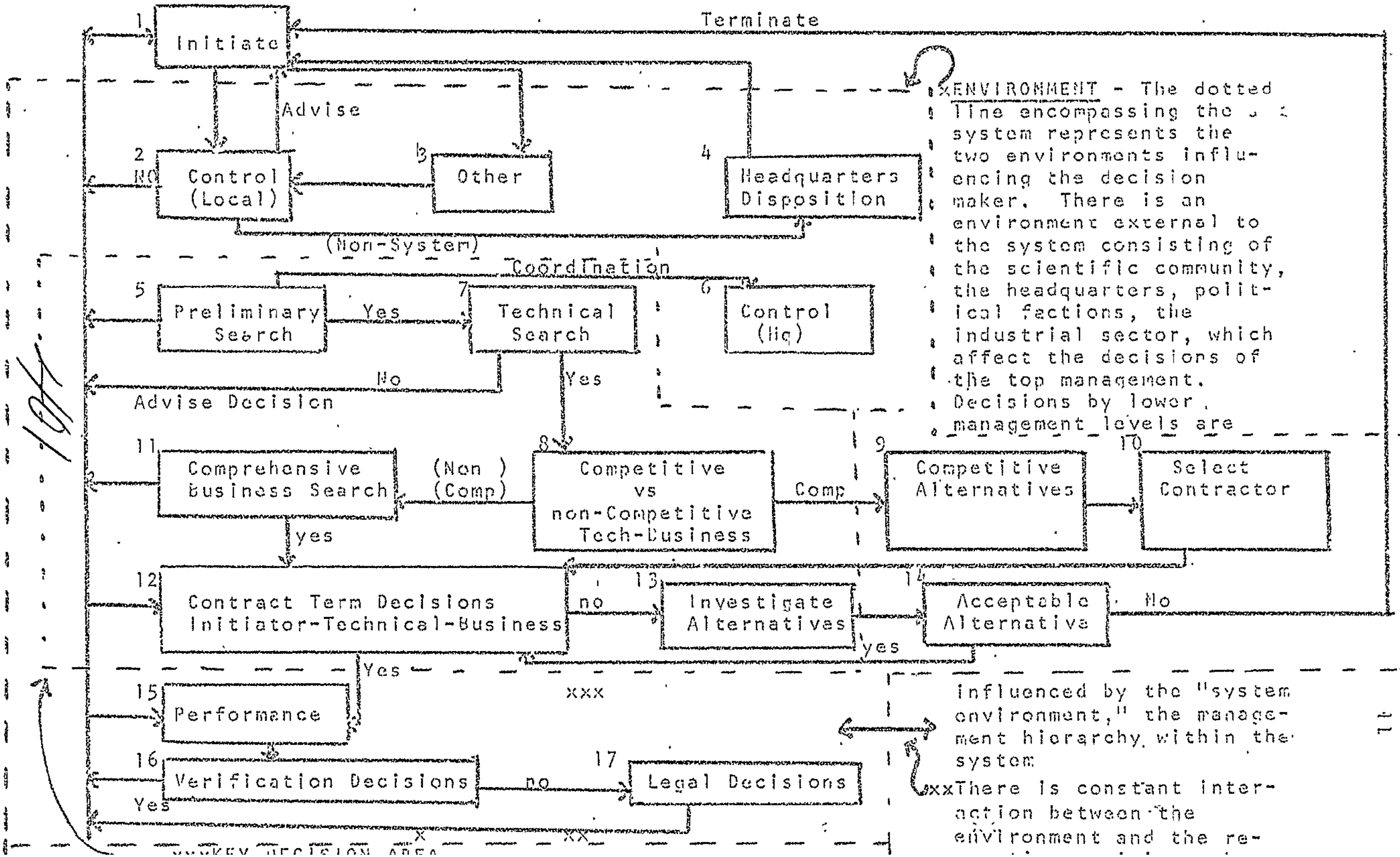
[10] Bross, p. 164.

Figure 3

UNSOLICITED PROPOSAL
EVALUATION-DISPOSITION
(Descriptive-Functional Model)



(i) Name and address of the organization submitting the proposal;
(ii) Date of preparation or submission;
(iii) Type of organization (profit, non-profit, educational, other);
(iv) Concise title and abstract of the proposed effort or activity for which support is being sought;
(v) An outline and discussion of the purpose of the proposed effort or activity, the method of attack upon the problem, and the nature and extent of the anticipated results;
(vi) Names of the key personnel to be involved (name of principal investigator, if applicable), brief biographical information, including principal publications and relevant experience;
(vii) Proposed starting and completion dates;
(viii) Equipment, facility and personnel requirements;
(ix) Proposed budget, including separate cost estimates for salaries and wages, equipment, expendable supplies, services, travel, subcontracts, other direct costs, and overhead;
(x) Names of any other Federal agencies receiving the proposal and/or funding the proposed effort or activity;
(xi) Brief description of the proposer's facilities, particularly those which would be used in the proposed effort or activity;
(xii) Brief outline of the proposer's previous work and experience in the field;
(xiii) If available, a descriptive brochure and a current financial statement;
(xiv) If proposed effort or activity requires or may generate classified security information, the security status of the organization and the major investigators, and identification of the cognizant security office;
(xv) Period for which proposal is valid;
(xvi) Names and telephone numbers of proposer's primary business and technical personnel whom NASA may contact during evaluation and/or negotiation;
(xvii) Each proposal containing technical data, which the submitter intends to be used by NASA for evaluation purposes only, may be marked on the cover sheet with the legend prescribed in 1.304-2(c)(1);
(xviii) Signature of a responsible official of the proposing organization--

Most proposals are initially received at the control point discussed in Step 2 below. However, this is not always the case. Unsolicited proposals are sometimes received at various points throughout the system. When this occurs, the first decision associated with the proposal (after receipt) must be made - what is the disposition. This becomes a problem only in event of ignorance of prescribed procedures, or intentional deviation.

Deviation for either reason is eventually discovered and the proposal delivered to control (Step 2). Step #3 on the diagram represents all points within the system at which a proposal may be received other than the designated control.

Step 2 - Control (local) - Control functions as a central receipt and distribution point for all unsolicited proposals. This is a point for two decisions. First control must determine if the proposal can be evaluated by MSC (the system) or must it be forwarded to Headquarters. This is an objective decision based on the following ground rules: Retain all unsolicited proposals for system evaluation with exception of "proposals from educational and non-profit scientific institutions:"[11]

If the proposal requires Headquarters review, the proposal is forwarded to the Headquarters with simultaneous notification to the initiator.[12] If the proposal meets the criteria for evaluation by MSC, control takes appropriate record keeping actions, then forwards the proposal to the next decision point.

Step 5 - Preliminary Search - Many proposals do not merit expenditure of the resources required to perform a comprehensive evaluation. These proposals can often be identified by a preliminary review focused on basic essentials that would have to be met under all circumstances. This is primarily a business oriented review of such factors as: (1) does the proposal contain the basic cost and technica data, (2) has the proposal been approved by a responsible official.

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[11] NASA Procurement Regulation, p. 424.

[12] Headquarters disposition (step #4) follows essentially the same pattern as that described by the model from point of receipt forward.

of the initiating organization, and (3) does it offer more than standard services or "off-the-shelf" type articles.[13] If the proposal fails to meet these minimum requirements it is treated as regular correspondence or advertising material.[14] The decision as to whether the proposal is considered worthy of comprehensive evaluation or simply a piece of correspondence is reflected in a reply to the initiator indicating the course of action. If the decision is to proceed with a comprehensive evaluation, the proposal is forwarded to the appropriate technical organization within the system. At the same time action is taken to coordinate the decision with the Headquarters Control (Step 6). This assures an agency-wide perspective and provides a communication link for feedback and guidance. The Headquarters control function also provides participative support in technical evaluation activities when there is higher level interest.

Step 7 - Technical Search - The technical evaluation and decision process is the single most important part of the decision making process. Proposals that do not survive this facet of the process receive no further consideration. When a "rejection" decision is made, the responsible technical organization advises the control function, which in turn communicates the decision to the initiator. Proposals that are determined to be technically acceptable proceed to Step 8. Because of the importance and complexity of the technical evaluation, a separate model is provided along with analysis and comment regarding a normative view of the process. (pages 25-32)

Step 8 - Competitive vs. non-competitive decision - A proposal that

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[13] NASA Procurement Regulation, p. 424.

[14] *Ibid.*, p. 425.

has survived to this point has high probability for full contractual implementation. However, Step 6 is an extremely sensitive and critical decision point. This is the point at which the decision is made as to whether a contract will be negotiated with the initiator without providing an opportunity to other potential contractors, OR whether other contractors will be given an opportunity to participate. If the latter course is selected the initiator stands a risk of not receiving the contract ultimately awarded. The initiator of the unsolicited proposal would normally be disappointed and unhappy if his competitors are brought into the picture and may use various tactics to attempt to change the decision. However, the system decision makers are responsible for assuring that only those justifiable cases are treated as non-competitive or single source procurements. Information developed in Step 7 (technical search) becomes the primary basis for this important decision. The following illustrates the type of criteria upon which the decision is based:

(i) The procurement is to provide support to an educational institution for the development or improvement of that institution's capability to contribute to the national aeronautical and space program; and the proposal was selected on the basis of its overall merit, cost and potential contribution to NASA program objectives, after a thorough evaluation and comparison with other proposals for similar support;

(ii) The procurement is for basic scientific or engineering research; and the proposal was selected on the basis of its overall merit, cost and contribution to NASA program objectives, after a thorough evaluation and comparison with other proposals in the same or related fields; or

(iii) The procurement is for services other than basic research (e.g., development, feasibility studies, etc.); the proposal contains technical data or offers unique capabilities that are not available from another source; and it is not feasible or practical to define the Government's requirement in such a way as to avoid the necessity of using the technical data contained in the proposal.[15]

After the decision is made the initiator of the unsolicited proposal is immediately informed to avoid long periods of uncertainty. In the event the decision is to conduct a competitive procurement the decision process now takes the path of a standard competitive procurement action. In other words, the "unsolicited proposal" aspect is no longer a factor in future activities. Assuming the decision to be that (i) the system desires to proceed with contractural implementation, (ii) the work which is to be contracted is suitable for competition, and (iii) necessary coordination, reviews and approvals within and external to the system have been accomplished; the next step in the sequence is #9.

Step 9 - Competitive Alternatives - Early planning and preparation for a competitive procurement is one of the most crucial phases of the entire cycle. The activities involve a multitude of individual decisions including: selection of specific technical objectives, operating and contract schedules, procurement method, type of contract to be utilized, companies to be solicited, proposal evaluation plan and criteria for selection of contractor, and terms for the contractual arrangement. One of the more important considerations involves the estimates of the cost of the work to be contracted and provision for funding. This is often one of the more difficult problems because of the extreme competition for resources. Even when the project has strong support from the interested technical organizations it must compete in the priority

[15] NASA Procurement Regulation, p. 426.

assessment along with other proposals. The magnitude of the problem is often directly related to the cost of the project. As the cost estimates increase, so do the difficulties associated with budget approval. Application to the system's objectives becomes a prime factor in the final decision. Flexibility is generally available within the system to cover the smaller proposals but the larger projects may require extensive budget activity, particularly if the work will be of long duration. Contracts extending over fiscal years must be considered in future budget requests and are of course subject to pruning at higher levels.[16] The criticality of the decisions cannot easily be overemphasized because this is often an area of great difficulty for prospective projects. The earlier the budget planning the better, but early planning is difficult because cost estimates are generally not reliable until later phase

In essence, once an unsolicited proposal is determined to be an appropriate matter for competitive processing, the thrust of the activity becomes the same as it would be for a procurement which was initiated within the system.[17]

Two important decisions at this point involve the method of procurement and the proposal evaluation planning. Their importance warrants special discussion. Method of procuremen Decisions must be made first, as to whether the proposed procurement is appropriate for advertising, or negotiation. Since advertising

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[16]The factors and decision process in this Step 9 and Step 11 are the same.

[17]Depending upon the value (dollar) the decisions are made at varying levels within and external to the system (Headquarters). However, the same basic criteria applies regardless of the decision point.

is the fundamental rule for all government purchasing,[18] it must be the first alternative considered. Negotiation in any form is authorized only as an exception to the statutory requirements for advertising.[19] Careful review and consideration must always be given to each procurement before deciding that it will be negotiated in lieu of advertising. The factors that may justify negotiation without competition are:

> National emergency, public exigency, purchases not in excess of $2,500, personal or professional services, services of educational institutions, purchases outside the United States, medicines or medical supplies, perishable or nonperishable subsistence supplies and supplies or services for which it is impracticable to secure competition by formal advertising.[20]

Advertising requires use of a firm fixed price type of contract which means firm specifications, schedules, and contract terms must be established prior to advertising. Few requirements of the system to which this model is related will meet these criteria. Therefore it is not a frequently selected method. If the decision is that formal advertising is not feasible, consideration may shift to a modified version of advertising called "Two-step advertising." This procedure permits a solicitation of technical proposals even though the system's description of the requirement may be vague or ill defined. The technical proposal is evaluated, and if determined to be acceptable becomes the basis for a price competition. Each company having an acceptable technical proposal would then submit a fixed price bid to

[18] Clarence H. Danhof, Government Contracting and Technological Change (Washington, D. C.: The Brookings Institution, 1968), Chapter IV

[19] NASA Procurement Regulation, Part 3, pp. 301-314.

[20] Ibid.

implement its proposal.[21] This procedure is not often utilized because it adds substantially to the time cycle for the procurement. In addition, few procurements of an R&D nature (the system's business) are compatible with fixed price contract arrangements.

If neither the formal advertising or the two-step procedure is selected as a method of procurement, the decision process shift to the negotiation method.

Negotiation provides flexibility to establish the type of contract most appropriate for the circumstances, to negotiate term such as price, schedules, work requirements and a multitude of other factors to the mutual satisfaction of the parties. It is the method most often utilized in R&D contracting.

Another crucial decision in Step 9 involves the proposal evaluation plan and selection criteria. This activity normally involves many people, especially in high dollar value situations. The various disciplines are brought into focus as a team, generally formal committee or board. Official regulations require use of formal boards in procurements of certain dollar value (million and above).[22] There are a multitude of factors upon which decisions must be made in order to evaluate and rank proposals; however, they are generally detail aspects of the following basic criteria:

-Technical consideration:
-Experience of proposer
-Cost considerations
-Management capability
-Financial and other business considerations

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[21] NASA Procurement Regulation, Part 2, pp. 245-247.

[22] Source Evaluation Board Manual, NPC 402, (National Aeronautics and Space Administration, 1964).

After having decided the method of procurement, terms, type of contract and evaluation plan, the Request for Proposal or Invitation for Bid is prepared and forwarded to prospective contractors. At a specified time and place proposals or bids are delivered to the system and the evaluation process begins.

Step 10 - Select contractor - If the procurement has been advertised the contractor selection process is essentially an objective determinati The lowest price bid that meets all requirements of the Invitation for Bid submitted by a responsible contractor is accepted. That is, the lowest responsive, responsible bidder receives the contract. If, as is normally the case, the procurement is negotiated, selection becomes almost entirely a subjective decision process involving Business and Technical considerations. The committee or board evaluates proposals based on the previously established criteria and the individuals rank the proposals, compiles the findings, and submits to the appropriate decision making official for final selection. The decision level varies depending on the value of the procurement, but the process is essentially the same insofar as fundamental factors are concerned. In a negotiated procurement the activities of evaluation are directed to identifying the contractors who have offered proposals which have the greatest promise of success, and are within the "competitive range" for purposes of negotiation. The difficulty of deciding just what the "competitive range" means, is illustrated by Paul Darron's comment on the matter.

Within a Competitive Range;

> The statute itself offers nothing to clarify. The legislative history has little more and the persons involved in the legislative history discussions were conspicuously and knowingly vague and did not attempt

any precise definition. At several points in the legislative history, the term "representative number" or some equivalent expression appear. Reading the "statutory" history as a whole, proposals with the following characteristics reasonably could be considered as not falling within a competitive range:

(1) Proposals which are substantially and conspicucusly nonresponsive to a major or an unreasonable extent.

(2) Proposals which, though superficially responsive, are technically deficient to a major or unreasonable extent.

(3) Proposals which are substantially deficient on business and management aspects to a major or unreasonable extent, e.g., they indicate either a lack of interest or lack of business or management acumen reasonably necessary for the task.

Additionally, the size of the procurement, the time available for the selection process, and the cost to be incurred in the selection process all bear reasonably on the number of contractors to be selected for the evaluation and negotiation process. Also, a significant breakpoint in the rankings may suggest the contractors within a proper zone of competitive consideration.[23]

Upon selection of the contractor or contractors for negotiation, the next step is to establish firm contractual agreements. (Step 11) From this point forward the process is the same for both the competitive and the non-competitive situation. So, we will now pick up again with the unsolicited proposal path assuming a decision in Step #8 that the circumstances warrant contracting non-corpetitively with the initiator.

Step 11 - Comprehensive Business Search - Proposals surviving the Step 8, Competitive vs. non-competitive decision as single source procurements have met the most severe requirement and are now approaching the final tests prior to contract definitization, a

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[23]Paul A. Barron, "Government Selection of Contractors for Research and Development," Unpublished paper, pp-27-28. Mr. Barron is Deputy Director of Procurement for the National Aeronautics and Space Administration, Washington, D. C.

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comprehensive business evaluation. This is an evaluation of the substance of the proposal from the standpoint of legal considerations, pricing arrangements, contract terms including schedules, data provisions and work description. This decision requires subjective judgment as to the adequacy of the content of the proposal - does it contain adequate detail support in such areas as cost to facilitate evaluation. If the decision is no, a feedback to the initiator is immediately implemented to obtain the necessary information. If the decision is yes meaning the data is adequate, or upon receipt of any necessary additional data, an in-depth analysis is conducted to establish a price comparable to the work to be performed. The necessary contract terms desired by the system are also established in preparation for the formal confrontation with the initiator, the negotiation process. As in Step 9, a most important aspect of Step 11 decision process is the determination regarding funding and the level of support. Whether the procurement is a competitive or non-competitive situation makes no difference, the project must stand the test of competition with other proposals in the battle for support. If the proposal does not win this struggle, the decision process ends with a "termination" notification to the initiator. If, on the other hand the decision is to support the proposal but not in the amount requested by the initiator there are at least two alternatives. The scope of the work may be reduced, or the initiator can be requested to share the cost. Assuming that satisfactory funding is arranged, and that all other considerations are still "go," the system is now in position to conduct formal negotiations, Step 12 in the decision phase.

<u>Step 12 - Contract terms</u> - Step 12 is a focalizing point where all appropriate participants within the system and the initiator of the unsolicited proposal come together for the purpose of developing mutually acceptable contract terms. If the informal coordination and feedback system has worked properly there will be few surprises at this point. The parties will have explored the problem areas sufficiently to know what to expect. This is not to suggest that problems do not arise. To the contrary, when a proposal reaches this point an initiator sometimes feels confident and begins to become less flexible. Every aspect of the prospective contract is explored thoroughly with the objective of mutual agreement. If the objective is achieved the process moves to Step 15, contract performance. If, on the other hand agreement is not reached, activity shifts to Step 13, an investigation of alternatives.

<u>Step 13 - Investigate alternatives</u> - Because both parties, the system and the initiator are desirous of implementing the proposal, there is a high probability that acceptable alternatives to the problems identified in Step 12 will be discovered. If it is a matter of inadequate funding the work requirement may be changed. If it is a contract term there is usually a compromise solution. If the normal case prevails and acceptable alternatives are found, the decision process moves back into the sequence and Step 15, contract performance. However, if the parties are unable to agree on an alternative to the problems there is a termination situation. The parties must agree before a contract can be established. Therefore, there are only two paths leading from Step 14, one is to a contract, the other to a termination.

<u>Step 15 - Performance</u> - This is the fruit of all preceding labor. The decisions during this phase are largely those of the initiator, deciding how the multitude of requirements of the contract will be carried out. The decisions made by the system are limited to those involved in monitoring and maintaining surveillance over the contractor' work. This is normally conducted by specifically designated representatives who maintain a day-to-day surveillance over the progress of the work. Decisions include such matters as acceptability of products, reports and other items delivered to the system. The decisions are directly dependent upon the terms of the contract. They vary from relatively minor, non-demanding matters to extremely complex, continuous decision making requirements.

<u>Step 16 - Verification decisions</u> - This is hopefully the last phase of the entire process that started with submission of an unsolicited proposal and ends with payment for services rendered. The decisions in this step are a matter of determining if the initiator has compli with the requirements of the contract. If the decisions are positive the financial obligations of the system are met and the file is retired.[24] If, however, the decision is that the contractua obligations have not been met a new and often serious problem exists. The objective of the system must be to obtain the services due, or to make appropriate adjustments in the financial arrangements and other appropriate provisions. The decision process at this point becomes a highly specialized function involving legal specialists as well as the other participants. The issues may be resolved by mutual agreement between the initiator and representatives

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[24]Subject to post audit.

of the system, or it may eventually require formal ligation proceedings involving third parties.

TECHNICAL ASSESSMENT MODEL

Descriptive Model

The present technique for determining whether or not a given proposal should be pursued is a highly subjective process involving many individuals and groups at every level in the organization. Specific variables in the process are presented later. At this point it is only necessary to recognize that subjectivity enters each block of the decision model to some degree. Another important concept affecting the outcome of each step in the process is the strength of the evaluator's opinion. Whether he is strongly in favor, strongly opposed or relatively neutral on a given proposal has a significant effect on the evaluation, particularly if his opinion is highly regarded. Except for one example (the block showing source of the proposals) this factor is not included explicitly in the model because it makes the model so cumbersome it destroys its utility.

The following is a block by block description of the technical decision model shown in Figure 4.[25]

1. The principle decision maker for the proposals being considered is the Director for Engineering. Every member of the evaluation team is a decision maker in the sense that he tends to slant his evaluation, select data that enforces his opinion and of course prepares his recommendation to include these biases (intentional or not).

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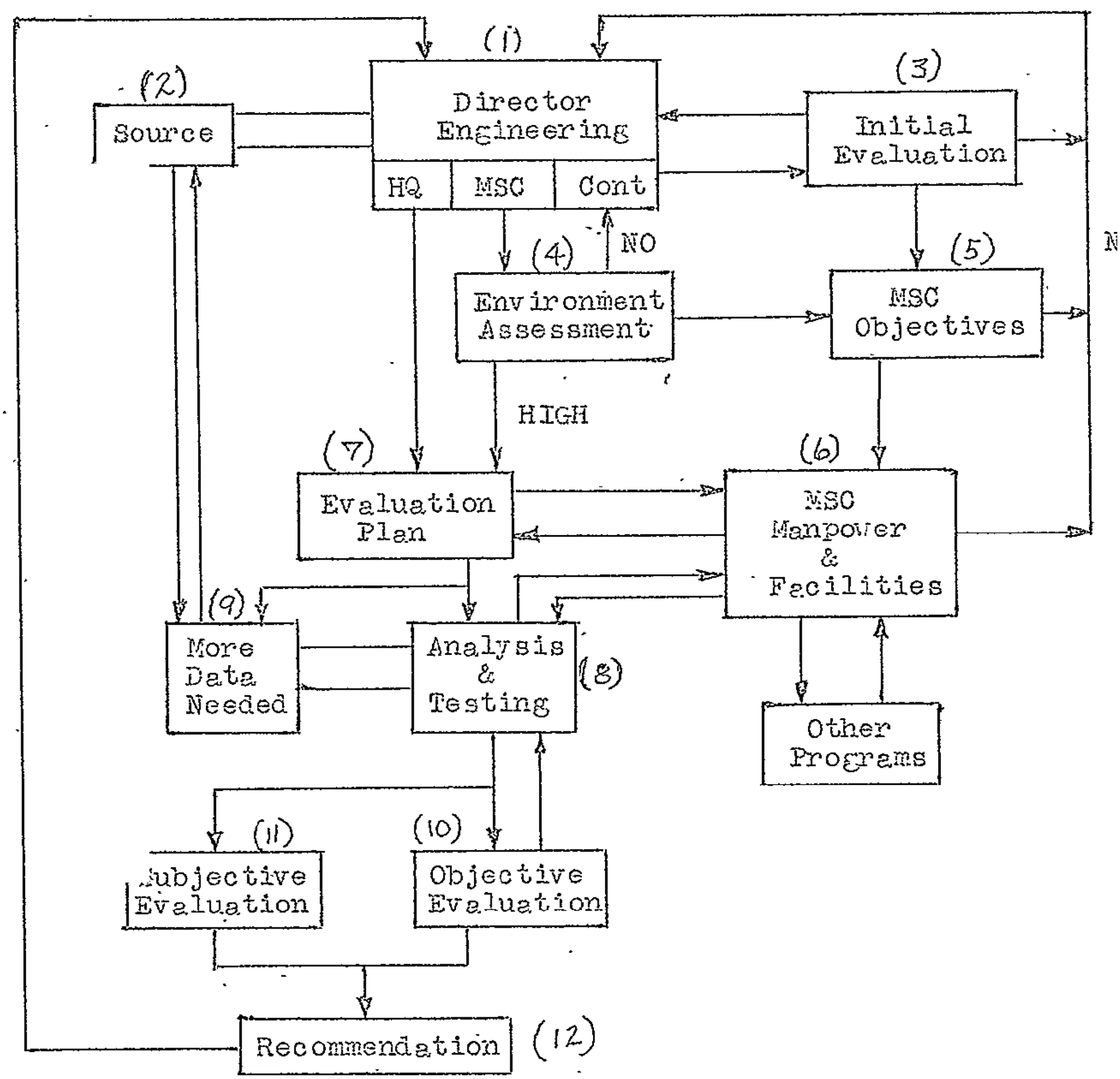
[25] This process is the result of the authors' observations augmented by discussions with several engineering managers at MSC.

Figure 4
TECHNICAL EVALUATION MODEL



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However, the Engineering Director is the only one in this model that can explicitly and unilaterally kill a proposal from the technical point of view. He can of course be over ridden by higher authority.

2. In Block 2, "Source" refers to any one of several places. For example, it might be the Centers Business Office, a proposing contractor, an individual within the center or NASA headquarters. It represents the function from which the Director for Engineering receives a proposal as well as the place the evaluators go for more information.

Proposals from Headquarters are assumed to be direct orders. Therefore, an implementation plan is begun immediately upon receipt of the "proposal."

Proposals from within the system are assumed to have had adequate preliminary evaluation prior to arriving at the Director for Engineering's office to eliminate the need for a formal initial evaluation (block 3).

3. Proposals from contractors (or individuals not employed by NASA) have frequently received no previous technical screening; therefore they are given a cursory review to screen those that are obviously of little or no technical value to the center.

4. One of the steps in the determination of whether or not a proposal has merit is to assess its impact on the environment in which the system must operate. Key variables, in addition to financial considerations which are covered in the business model, are the overall NASA plan, Congressional attitudes, public opinion, the general trend of the economy and world events. If the need is obvious and urgent an evaluation plan will be begun and the necessary

system resources will be made available without additional consideration.

5. Even if the environment will support implementation of a proposal, there is a question as to whether or not it is in an area of interest to the system. If not, it will probably be referred to the NASA center or other government agency having particular cognizance and authority in that area.

6. A final check before proceeding with the preparation of a formal evaluation plan is whether or not MSC has the resources to evaluate the proposal and then to assure adequate implementation support if the proposal is accepted. It is also compared to other proposals to determine if the resources available should be reallocated.

7. The first block in which the entire center gets involved is the selection of a project engineer and the subsequent preparation of an evaluation plan. An evaluation plan contains the technical areas to be evaluated, the extent, or depth of evaluation required, areas requiring special emphasis, naming evaluation team members, assigning responsibilities and defining the evaluation schedule.

8. Each technical team then proceeds to conduct its respective analysis and to perform any tests desired to assure that the analysis and claims contained in the proposal are valid or at least feasible. This evaluation is the most objective block in the process and even it is frequently biased by the values of the evaluator. The team approach is a useful mechanism for identifying individual biases.

9. Additional data is frequently required to clarify specific points. Two common reasons for this are attempts by the proposer to "gloss-over" difficult technical problems and simply omitting the

individual steps in a particular analysis to hold the bulk of the proposal to a minimum. It is, therefore, very important to determine the reason for omissions, especially on critical technical points.

10. Evaluation of the proposal after all desired testing and analysis has been completed is not conveniently divided into objective and subjective blocks as shown in the model. They were shown as separate blocks to emphasize the importance of the subjective factors.

Objective evaluation variables include whether or not the proposal:

a) is a feasible solution to a technical need
b) includes evidence that all required aspects were considered
c) contains applications of new technology or advanced state-of-the-art which are obviously optimistic
d) compares favorably technically with other proposals in the same area.

11. Subjective variables that affect the recommendation include

a) the evaluator's knowledge of the subject
b) the evaluator's opinion of the subject
c) the evaluator's knowledge of the proposer
d) the evaluator's opinion of the proposer
e) the confidence other members of the team have in the evaluator
f) the evaluator's perception of the NASA's needs
g) the evaluator's perception of the MSC needs
h) the evaluator's perception of the desires of his boss
i) the evaluator's perception of reasonable cost.

These values and opinions might or might not be mentioned in the technical evaluation report. Those factors recognized as explicit, important factors in the recommendations are usually documented. However, many of these factors are not recognized as assumptions or unique values, therefore are not likely to be mentioned.[26] A graphic representation of how these values are

[26] Many engineers and engineering managers would object to the suggestion that their opinions have a subjective element. However, the authors' observation that the subjective or qualitative aspects of a given decision are frequently as important as the

ed and integrated is shown on Figure 5. If the decision maker to explicitly quantitize and weigh the recommendation of each son having an influence on the recommendation vis a vis the posal, each person's assessment could be represented by a vector shown. Therefore, the decision maker's total impression would be the same of all of the individual vectors.

12. On a large proposal involving a substantial evaluation task force, many hierarchial steps and many iterations are required before a recommendation is prepared. Subgroup members discuss their ideas among themselves, with their group leader and with subgroups with which the function they are evaluating has an interface. Next the subgroup leaders discuss their recommendations with their respective group leaders and the evaluation team leader both individually and collectively. For some proposals, communication between groups and subgroups is specifically prohibited to prevent the attitudes of one group from influencing the next.

A summary of the evaluation results is usually presented to the Director of Engineering by the evaluation team leader. Then each group leader discusses his own team's recommendations in greater detail. Again, frequently only one group leader at a time is allowed in the presentation room to prevent a snow-balling of attitudes from starting. On large proposals, the evaluation team's recommendations are presented to a board composed of high level managers and experts from all areas of the center having an interest in the

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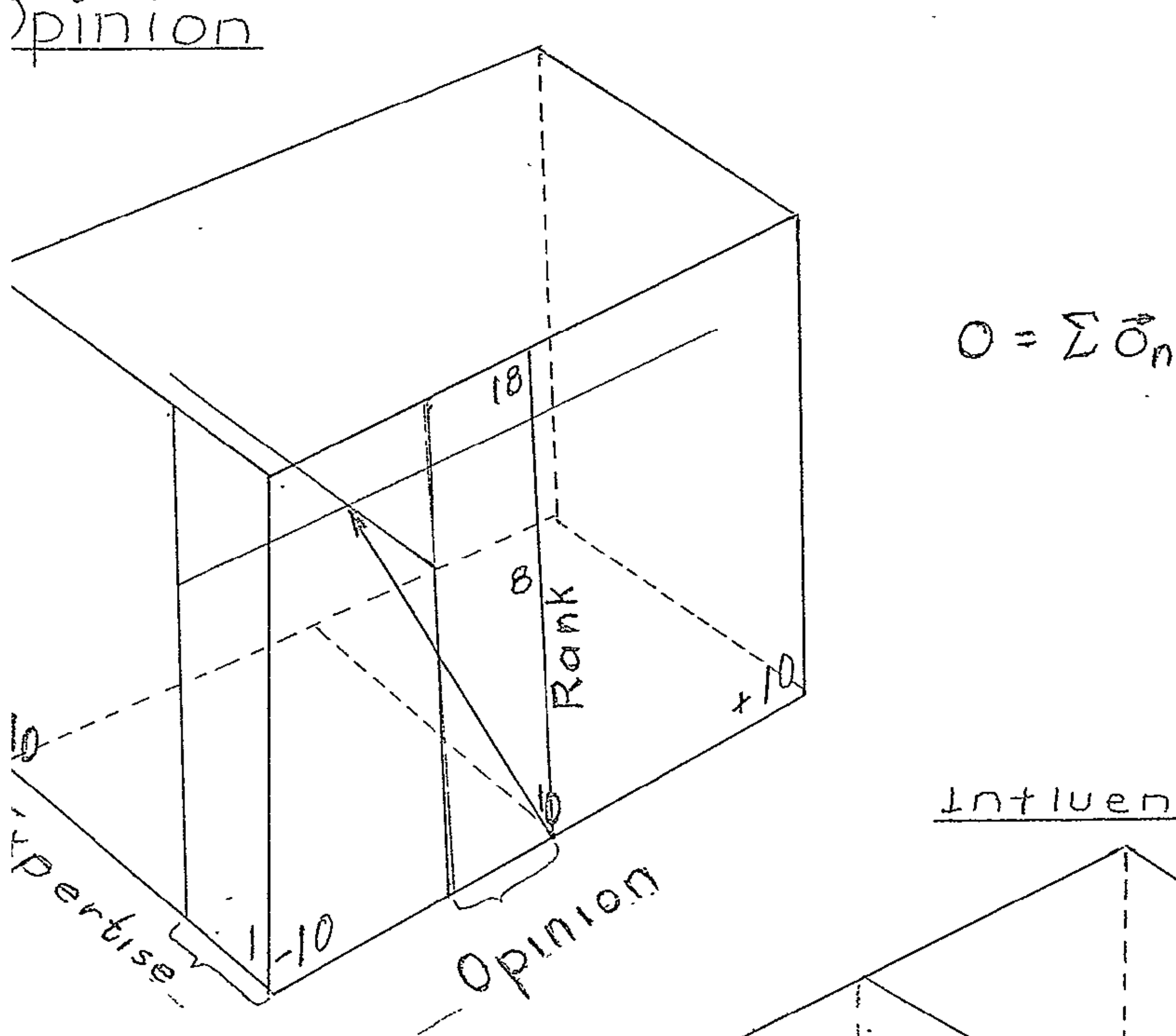
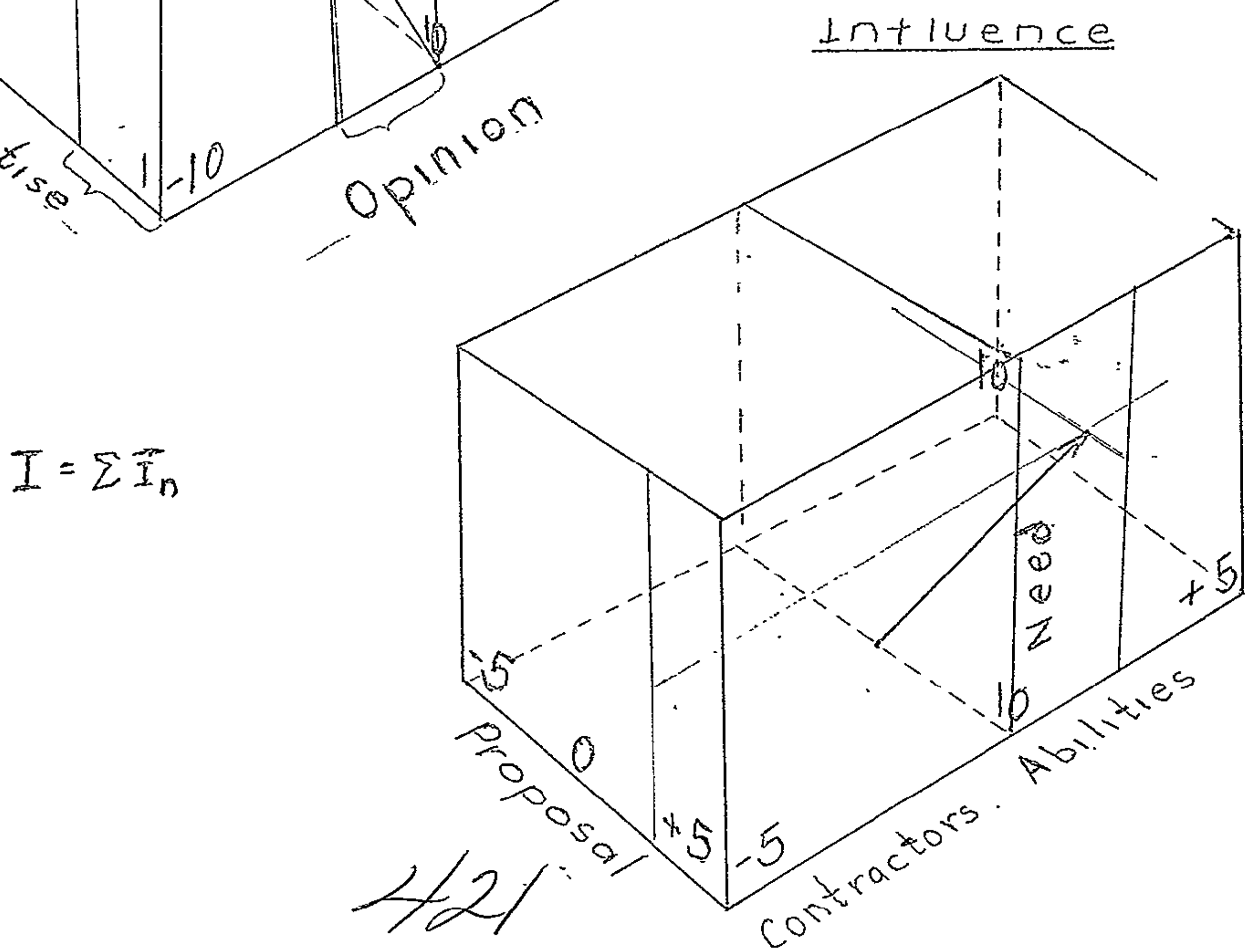
quantitative data; even when quantitative data is available, has recently been substantiated by a study conducted by the Harvard Business School. Greiner, L. E., D. Paul Leitch and Louis B. Barnes, "Putting Judgment Back into Decisions" in Harvard Business Review, March-April 1970, pp. 59-67.

Figure 5
RECOMMENDATION ASSESSMENT MECHANISM





proposal. The chairman of the board depends on the proposal. However, for our model we are assuming it to always be the Director of Engineering.

Evaluation Boards are good in that some of the best minds in the Center can evaluate the whole proposal in context as well as from each member's particular area of interest. Boards are also a hazard in that its members frequently have even stronger values and prejudices than the evaluators in addition to the power of thei authority of hierarchy and/or expertise. It is not uncommon for a single board member who has strong feelings on some point to force a significant change in the overall recommendation.

Another possible outcome is for the board to request the evaluation team to go back and consider some other aspect of the problem or to reconsider its recommendation in light of information provided by the board members.

This process continues until the board chairman is satisfied; then the recommendation is forwarded to the business office for their consideration prior to presentation to the Director of the Center for a final decision.

Interrelation between Variables

Many of the variables listed in the previous section are interdependent. However, the degree of interdependence varies with individuals and with groups as well as with time. Therefore, an attempt to correlate the variables is not considered to be profitable.

PART III

ANALYSIS

A careful analysis of the "descriptive-functional" model (Fig. 3) reveals its highly normative character. However, this is not totally unexpected since the model is a reflection of policies and practices that have evolved over the years in various government agencies. One would normally expect that the regulatory guides and procedures would approach a normative state, at least from a theoretical standpoint. This is the situation in the present case. The prescribed method and actual practices approach a normative situation. Deviations from the model are the exception rather than the norm. So, we have in the authors' opinion, a descriptive model which could be changed only in minor ways insofar as constructive improvement is concerned. This is not to suggest that the actual decision making process is always carried out in precisely the manner prescribed by the model. People are in the loop, and experience indicates that as long as people and subjective judgments are involved "perfection" is not likely. We do believe however, that in this case human error or deviation is not a significant problem. The system works in a fash that encourages compliance, making deviation a temporary situation. For example, occasionally an individaul or organization will elect to handle an unsolicited proposal as if their decisions, uncoordinated and out of channels, are all that is necessary. However, it soon becomes obvious that this approach will not work and the proposal is brought back into the appropriate decision cycle.

Due to the minor nature of the modifications which would be incorporated into a "normative model," it is not considered necessary or even desirable to diagram the normative. Instead, using the descriptive model as a baseline, we will discuss the changes in a step by step manner making it possible for the reader to easily visualize the adjustemnts.

Steps 1 through 4 - In this area the descriptive model is considered to be as close to normative as could reasonably be expected. The function of "local control" is essential due to the involvement of numerous organizations and initiation sources. Ideally, it would be better if proposals could somehow be automatically directed to the control point avoiding the occasional problem of inappropriate involvement; however, we can think of no way to improve the present procedure.

Step 5 - A reduction in time and effort required to process proposals is possible by a consolidation and parallel review approach to the "preliminary reviews" independently conducted in Steps 5 and 7. A mechanism could be established whereby the preliminary technical review could be performed in parallel with the business review. Possible alternatives include assignment of appropriate technical skill to the Step 5 function or simply forwarding a copy of the proposal to the appropriate technical organization for parallel preliminary review.

Step 6 - This is a straightforward, routine function which is appropriate. No change suggested.

Steps 7, 8 and 11 - As in the case of Step 5, there is a potential reduction in processing time and possibly effort by a parallel rather than a serial approach to the evaluations. The proposal could be subjected to the comprehensive technical and business reviews simultaneously instead of delaying the business review until completion of the technical evaluation. Also, this area (Steps 7, 8, 11) seems to be ideally suited for a team approach. This could be consolidated as a single operation with three objectives: technical, business and the competitive factor decisions. All three are interrelated and to a very large degree involve the same individuals. It is also particularly important to include the budget decisions as early in the process as feasible. It seems that this is the appropriate place to cover the entire question of "do we want what the proposal offers, can we afford it, is the proposal comensurate (price wise) with the work, should it be purchased from the initiator or competitively, and is the proposal complete enough to proceed?"

The remainder of the model is, in our opinion, a normative situation. Any improvement will be in educating the participants rather than changing the model. Actually, this may be the most important point in the area of changes or improvement. It is clear that the decision making process is almost entirely subjective and that decisions will be influenced by the values of the participants.[27] Observation of the process indicates that much of the decision making is presently conducted in a fragmented fashion wherein the participants in any specific step are not necessarily aware of the preceding or subsequent activities. This is of course not the case

[27] Herbert A. Simon, Administrative Behavior, 2nd ed. (New York: The Macmillan Company, 1969), p. 112.

at the higher management levels, but all decisions are not made at these levels. The thought then is that there is value to be gained by making the participants througnout the process aware of the total picture. This could be accomplished by providing a description, possibly a flow chart or diagram of the decision process with the proposal as it moves through the system. This may also help with the fragmentation problem. People would be more inclined to coordinate and discuss the proposal with other participants if they were aware of the total process.

The only suggestion offered for improving the quality of the technical evaluation is to make each evaluator and each source board member aware of the subjective factors involved in the evaluation. This is not to eliminate all subjectivity. That would be not only impossible, but undesirable. Subjective evaluations are frequently the best clues to potential high risk situations. One way to assure that these factors are considered would be to provide a check list and to require every subgroup and group leader, as well as the proposal evaluation leader, to prepare and include with his recommendation a list of all subjective as well as objective variables considered.

PART IV

SUMMARY AND CONCLUSIONS

The exercise of modeling a decision process is an excellent way of learning to appreciate Bross's comment that "Models are vitally important in scientific work and, in my opinion, in any intellectual endeavor."[27] The complexity and interrelationship of the multiple decision process could not be fully appreciated or understood without first examining the process via the medium of some type of model. Although the authors have observed the system described in this paper over a period of years we were not aware of many facets of the sub-decision processes identified in the modeling exercise. In reflecting on this point it appears that a model may well be the best method of dealing with one of the improvements discussed for the "normative" model, namely, the education needs. A model of the total process, or if more appropriate, certain segments, could serve a real need if it were to accompany the unsolicited proposal through the review cycle.

As stated in the analysis, little can be offered in the way of constructive improvement in the model. We believe the system has capitalized on years of experience in federal agencies resulting in a reasonably efficient and effective procedure for processing unsolicited proposals. The main two points, the fragmented operation

[27] Bross, p. 161.

and the value of familiarity with the total process represent the substance of the authors' recommendations for improvement. The suggested changes in the sequence of certain steps would also be a positive move, but the gain would not be of major magnitude.

In summary, the system and its Headquarters have devised a decision process which meets the objectives. Complications resulting from individual deviations are only a minor problem and would exist regardless of the type of system employed.

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APPENDIX-5

ARTICLE VIII - TECHNICAL DIRECTION AND SURVEILLANCE[a]

A. The work to be performed by the contractor under this contract is subject to the surveillance and written Technical Direction of a "Technical Representative" who shall be specfically appointed by the Contracting Officer in writing. Technical Direction is defined as that Government direction to the contractor which fills in details, suggests possible lines of inquiry or otherwise more specifically defines the work set forth herein. In addition this Contracting Officers Representative may act as the Contracting Officer's authorized representative for the purpose of the final evaluation and acceptance of end-item documentation required by this contract. The Technical Direction to be valid:

1. Must be issued in writing consistent with the general scope of the work set forth in this contract;

2. May not modify the Statement of Work or change the expressed terms and conditions of this contract;

3. Shall not commit the Government to any adjustment of the estimated cost, fee or other contract provisions.

B. In the event any Government Technical Direction is interpreted by the contractor to fall within the Clause of the General Provisions hereof entitled "Changes", the contractor shall not implèment such direction, but shall:

1. Notify the Contracting Officer in writing of such interpretation within five (5) working days after the contractc receipt of such direction. Such notice shall (i) include the reasons upon which the contractor bases its belief that the Technical Direction falls within the purview of the "Changes" clause; and (ii) include the contractor's best estimate as to revision in estimated cost, fee, performance time, delivery schedules and any other contractual provisions that would result from implementing the Technical Direction.

2. If, after reviewing the information presented pursuant to subparagraph (1) above, the Contracting Officer is of the opinion that such direction is within the purview of the "Changes" clause, he will issue unilateral direction to proceed pursuant to the authority granted him under the clause.

3. In the event the Contracting Officer determines that it is necessary to avoid a delay in performance of the

[a]Source: NASA Contract NAS 9-9953.

contract he may, in writing, direct the contractor to proceed with the implementation of the Technical Direction pending receipt of the information to be submitted under subparagraph (1) above. Should the Contracting Officer later determine that Change direction is appropriate, the written direction issued hereunder shall constitute the required Change direction.

C. Failure of the contractor and the Contracting Officer to agree on whether Government direction is Technical Direction or a Change within the purview of the "Changes" clause shall be a dispute concerning a question of fact within the meaning of the Clause of the General Provisions entitled "Disputes."