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# SYRACUSE/NASA PROGRAM

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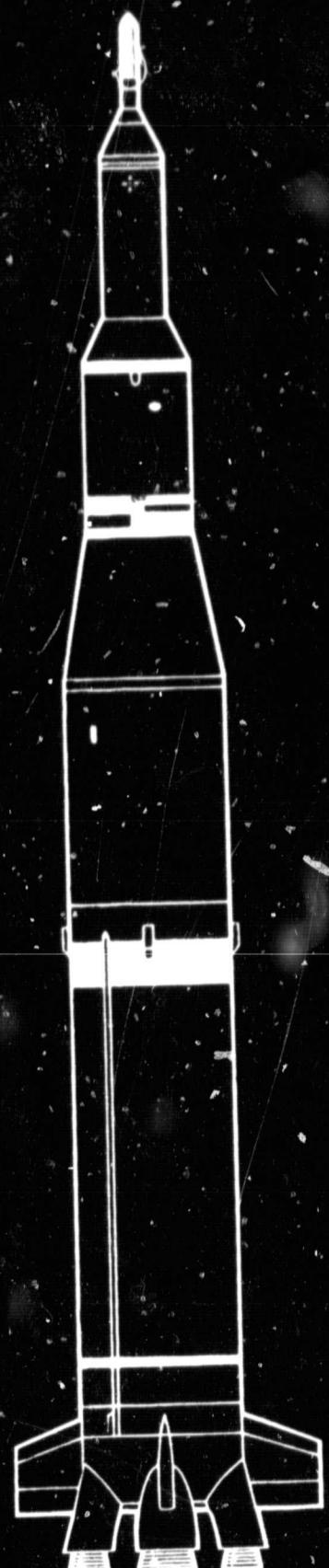
FACILITY FORM 602

N70-42298  
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FIFTH SEMI-ANNUAL REPORT  
SYRACUSE/NASA PROGRAM  
for the period

January 1, 1970 - June 30, 1970

MULTIDISCIPLINARY STUDIES IN MANAGEMENT AND  
DEVELOPMENT PROGRAMS IN THE PUBLIC SECTOR

Grant No. NGL 33-022-090

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Principal Investigator

SYRACUSE UNIVERSITY

September 1970

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## I. INTRODUCTION AND ADMINISTRATION

During the period January 1 to June 30, 1970, as in previous report periods, the four major interdisciplinary research projects, Role of the Project Manager, NASA/Business Relations, Case Studies, and Regulations in Space continued to be of central concern, but two major projects were added. The first new project was entitled, "Social and Physical Processes in Systems Science," and is under the direction of Prof. Nathan Schwartz. Although the topics under consideration were somewhat varied, the group began to work together with a central focus on modeling techniques. A more detailed description is contained later in this report.

A major research effort under the direction of Prof. George Fisk on non-economic criteria for evaluating space application projects got underway with the bulk of the work to be undertaken in the summer period. This project, while separately funded, is included under the subject grant.

The work of Prof. McLaughlin in "Exposition and Real-Time Decision-Making" continued. There were several offshoots from this work, but the main activity centered around the use of the computer in decision-making at MSC in Houston.

Mr. Frank McGee continued his work in Public Administration under the direction of Prof. Frank Marini of the Maxwell School.

During the reporting period William Davis completed his Master's thesis, "Interdisciplinary Research in Theory and Practice: A View From the University," under the direction of Dr. John C. Honey; and Prof. Malcolm Schlusberg completed his Ph.D. dissertation, "NASA Contract Dispute Adjudication: A Study in Legal Systems Perspective," based on previously funded research under the Regulations in Space project.

Prof. W. Henry Lambright continued to serve as a Special Assistant in NASA's Office of University Affairs, working on policies relating to the phase-out of the Sustaining University Program. In that capacity he has performed numerous duties related to helping NASA develop new policies in dealing with universities as SUP is phased out. In addition, he has

related closely with other offices of NASA, especially those involved with the application of space technology to problems of communications, weather, and earth resources. Most recently he has engaged in a long-range planning effort associated with space applications.

In addition, because of Prof. Lambright's special interest in weather modification, he has joined the NASA representatives in attending meetings of the Inter-Agency Committee on Atmospheric Sciences.

During Prof. Lambright's time at NASA he has continued his professional activities, having delivered papers on weather modification at meteorological meetings at Santa Barbara and Monterey, California.

Some additional highlights for the subject period are the following:

1. NASA/University Conference in Washington, D.C., February 10, 1970

This conference was called by Mr. Frank B. Smith, Assistant Administrator for University Affairs, to discuss plans for university research under NASA for the remainder of this year and next. At the meeting, which was attended by Prof. Barzelay, there was a discussion of the general overview of the NASA Program for FY 1971, reports from NASA Program Officers on university research in space sciences, space applications, advanced research and technology, and manned space flight. The outlook for the Sustaining University Program and new legislation affecting universities was discussed as well as prospective changes in the pattern of government-university relationships.

2. Annual Meeting of the American Society for Public Administration

This meeting was held in Philadelphia April 6-8, 1970. Several informal sessions were conducted between those persons attending the meeting who were also involved in the NASA Sustaining University Program. Under the direction of Mr. Richard Stephens, students from a number of universities participated in the general critique of the traineeship program and its relationship to the sponsored research. The Drexell Institute of Technology hosted a dinner for the participants, following which both faculty and students gave reports on the activities in which they were engaged. Professors Honey, Barzelay, Bock, Marini and Frederickson were

among the attendees at the meeting who were also involved in the NASA Program activities.

3. Meeting in Syracuse, April 22-23, 1970

This meeting was attended by Messrs. Bingman, Daniels and Stephens of NASA Headquarters and by Syracuse/NASA Program participants. A discussion was held during which plans were made for the proposed association of Mr. James Daniels as a practitioner-in-residence at Syracuse University.

During a meeting with participants from the Project Manager's group, Messers. Bingman and Stephens made plans with them for their presentation to be made to Washington Headquarters personnel. This presentation was subsequently made on June 29-30 in Washington and is detailed elsewhere in this report.

4. Study Group in Science, Technology and Public Policy

In the two-week period from June 10 to June 23, 1970, a study group met at Syracuse University both on and off campus. The conference was concerned with "Management of Earth Resources and Environmental Quality: Role of NASA and Other Federal Agencies."

Approximately twenty faculty members and ten students participated in the study, many of whom were new to the Syracuse/NASA Program. Presentations were made by Messrs. Daniels, Lambright, Stephens and Vitale of NASA Headquarters in addition to those by campus faculty.

## II. MAJOR PROJECT RESEARCH

### A. ROLE OF THE PROJECT MANAGER

The study of the Role of the Project Manager by an inter-disciplinary team continued during the reporting period with no major change in personnel. The stability of the inter-disciplinary group has facilitated its work, which basically involved two tasks.

First, and most important, the process continued of collating, assessing, and evaluating the materials and data already gathered. Each member of the group reviewed and drafted a segment of a comprehensive report dealing with the project manager in the Apollo Program. Frequent work sessions were held where each member's working drafts were discussed and critiqued. Through this continuous individual re-writing, coupled with the group evaluation feedback process, a clear and comprehensive report began to take shape. It is one to which all members of the research project are able to make significant contributions.

An interim oral report was presented to NASA Headquarters personnel in Washington on June 29-30 (see sections on "Trips by Research Participants" and "Research Reporting and Dissemination"). This provided the opportunity to see a major product in capsule form. It also enabled the group to receive invaluable feedback from NASA people who were intimately familiar with the material that was covered. In the lively discussion following the presentation, it was pointed out that the research had stopped short of a critical examination of top level conflicts and decision-making procedures in NASA. The relevance of these considerations for an analysis of Apollo Project Managers and their organizations are currently being assessed.

The second task involved planning for future research which would extend our current efforts and which would be useful to NASA. The specifics of the planned future research are detailed in the final section of this report (Future Research Directions).

#### Trips by Research Participants

In previous reporting periods, numerous trips were taken by research participants for the purpose of interviewing NASA and contractor personnel. In the current period, there were fewer trips because of the large amounts of interview data and ancillary material already gathered.

On March 24, Mr. Barry Kelmachter visited NASA Headquarters in Washington, D. C. The purpose of this trip was to gather background data on seventeen NASA program or project managers for his study of the training and development of project managers. Through Mr. Frank S. Miceli of NASA's Executive Personnel Staff, Mr. Kelmachter was given access to the Executive Inventory Records on the assurance that specific individuals and positions would not be identifiable in his thesis or in our published reports. While in Washington, Mr. Kelmachter had chance meetings with Mr. Earle B. Young of MSC's Management Analysis and University Programs Office, and with Mr. Joseph T. Sippel of the Training Branch of Headquarter's Office of Administration.

From February 14 to February 16, Professor D. L. Wilemon attended a project management seminar conducted by the American Management Association in New York City. Because this seminar was closely related to the work we are doing, an invitation from AMA to attend without fees was requested and received. This provided an opportunity to see project management from the point of view of a broad spectrum of non-government people and to exchange ideas in informal discussions. The following are examples of the various topics discussed:

1. Planning the project
2. Role of project communication
3. Staffing the project
4. Methods of project organization
5. Role of the project manager
6. Controlling the project

Written material and notes taken at the seminar were placed on file for the Syracuse project team.

The most important trip taken in this period was to NASA Headquarters, Washington, D. C., June 29 and 30. Professors E. E. Drucker,

W. Pooler, D. L. Wilemon, and B. D. Wood presented a concise review of the findings of this research group to a gathering of NASA Headquarters personnel. Arrangements had been made through Mr. Charles F. Bingman and Mr. Richard E. Stephens with the cooperation of Associate Administrator Bernard Moritz. Thirty-one other persons from seven different Headquarter offices attended the presentation on June 29. (A list of attendees is available).

The presentation was divided into four sections: "Apollo and General Organizational Considerations" (Pooler), "The Role and Problems of the Project Manager" (Wilemon), "Utilization of In-House Technical Competence in Apollo Projects" (Wood), and "The Project Manager - Contractor Relationship" (Drucker). These have been put together and submitted as Interim Report 6223-R-1, which is summarized under Research Reporting and Dissemination, below. There was considerable discussion among attendees and our group members immediately following the presentation, and there has been some follow-up correspondence on the usefulness of this work to NASA.

The following day, June 30, Wilemon and Wood interviewed General John D. Stevenson, Director of Mission Operations at NASA Headquarters; Dr. James H. Turnock, Special Assistant for Mission Operations, OMSF; and Mr. Harry H. Gorman, Deputy Associate Administrator for Management, OMSF. These were separate interviews. All three men had attended the presentation on June 29 and had comments to make on its usefulness, as well as its shortcomings, and on possible directions for future work by the research team. They also spent some time elaborating on the higher level management interfaces and conflicts at Headquarters. They believed that the study would be incomplete without some record and analysis of these relationships. Wilemon and Wood noted that the work had been deliberately limited to project management and project managers at a lower level in NASA. They also remarked on the difficulty of extending the work upwards with the present personnel and resources.

On the same trip, Professors Wilemon and Wood took the opportunity to meet with Mrs. Grace B. Reeder of the NASA Headquarters library and

Mr. Victor L. Coles of the Scientific and Technical Information Division. Both were most obliging in explaining their respective operations. Mr. Coles demonstrated the computerized literature search facilities and described their usefulness.

#### Research Reporting and Dissemination

Several papers and publications were written and distributed during the report period.

##### 1. Interim Report

"Project Management in the Apollo Program," E. E. Drucker, W. Pooler, D. L. Wilemon, and B. D. Wood; (April, 1970), Interim Report 6223-R-1.

This report was prepared for oral presentation at NASA Headquarters on June 29, 1970, (see Trips by Research Participants, above) and consists of four sections. In the first, some general organizational features of the Apollo program are discussed in relation to the broader organizational scheme of NASA itself. In particular, the apparent purposeful use of conflict and the flow of problems and disagreements up the organizational ladder are described.

The second section treats the role and problems of the Apollo project managers. It discusses the managers' use of expert power, reward and punishment power, and referent power as influence tools. Special problems faced by project managers are also described.

The third section concerns the utilization of in-house technical competence in Apollo projects. The excellence of this competence provided both the essential strength and the major difficulty in the management of Apollo projects. It is concluded that the success of the program depended heavily upon personal commitment and dedication to the overall Apollo goal.

The last section treats the relationship between NASA project managers and their respective major contractors. The differences in these working relationships at the MSC and the MSFC are pointed out, as well as the differences between NASA and industrial contractor project management. Resident management at the prime contractor sites is also discussed.

2. Working Papers

a) "On the Application and Dissemination of Space Age Management Technology," D. L. Wilemon, (January, 1970) 6223-WP-23.

This paper is concerned with transferability of the project management approaches as practiced by NASA and the aerospace industry to the pressing problems in the public sector. Some controversy has arisen as to whether or not these advanced techniques are really applicable to the management of public problems. If they are applicable, can they be used? What procedures can be used to transfer these techniques from NASA/aerospace experience to other potential applications? This essay, in order to answer such questions, explores the characteristics of project management so that a more realistic appraisal of its transfer potentialities to the private and public sectors can be made. To do so, the general characteristics of project management are examined and its possible role in public sector management is discussed.

b) "The NASA-Apollo Contractor Interface: The Resident Management Operation," R. L. Kelmachter, (February, 1970) 6223-WP-24.

This paper discussed the role of the NASA resident managers at contractor sites. The role depends very much on the Center to which the resident manager reports. There are certain features of the role common to both Centers (MSC and MSFC), but center backgrounds do influence strongly the operations of the resident office.

The resident manager must maintain a delicate balance between the contractor and the particular Center involved. Otherwise he is beset by problems with one or the other of the principals. From their particular viewpoints, contractor personnel and resident office personnel voice complaints and criticisms of their counterparts.

A hypothesis has been set forth concerning the effectiveness of the two resident operations based on data and analysis presented in the paper.

- c) "NASA Priorities in Orbit: The Waxing and Waning of Moon Mania," H. G. Frederickson and R. A. Loverd, (February, 1970) 6223-WP-25.

This paper, written in a light vein, was intended for publication in a non-technical periodical. It emphasized the necessity for NASA, if it is to continue as a viable organization, to capture the public imagination. In this way, enthusiasm is transferred to Congressmen, and in the American political system this is transformed to support for NASA.

- d) "The Power Spectrum in Project Management," G. Gemmill\* and D. L. Wilemon, (February, 1970) 6223-WF-26.

This paper concerns the types of influence that a project manager in a "matrix" organization can exert on people with whom he interfaces in order to achieve his project goal. The relatively new management approach in complex, technological undertakings involves the integration, primarily on a horizontal basis, of the various skill centers or functional areas within an organization. The focus of the paper is on identifying the types of influence project managers employ to secure the services of personnel on whom they are dependent for project success but who are at times reluctant to voluntarily offer it. The types of influence examined are reward power, punishment power, expert power, and referent power.

### 3. Articles accepted for publication or recently published

- a) "Managing Product Development Systems: A Project Management Approach," D. L. Wilemon, (July, 1969), 6223-OP-4.\*\*  
Published in Business and Economic Dimensions, May, 1970.
- b) "Project Authority: A Multidimensional View," J. P. Cicero and D. L. Wilemon, (December, 1969), 6223-WP-17.\*\* Published in Transactions on Engineering Management, May, 1970.
- c) "The Apollo Project Manager: Anomalies and Ambiguities," D. L. Wilemon and J. P. Cicero, (December, 1969), 6223-WP-18.  
Forthcoming in Academy of Management Journal, September, 1970.

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\* College of Business Administration, Syracuse University.

\*\* Summarized in Fourth Semi-Annual Report, Syracuse/NASA Program, March, 1970.

- d) "The Power Spectrum in Project Management," G. R. Gemmill and D. L. Wilemon, (February, 1970), 6223-WP-26. Forthcoming in Sloan Management Review, Fall, 1970.
- e) "Bureaucracy and the Urban Poor," H. George Frederickson and H. J. Anna, (August, 1969), 6223-OP-5.\*\* Published in Urban Social Changes Review, 1970.

#### Future Research Directions

Cognizant of the potential limitations NASA faces in funding management-oriented research the project management team is currently investigating a number of alternative avenues for further research. The directions that this research might take include the following:

1. Conflict resolution in complex organizations. This research area would include Apollo-oriented topics as well as the newer developmental programs. Specific examples of research are the following:
  - a. Complex project/program coordination (e.g., Division of responsibility among centers).
  - b. Office of Manned Space Flight (OMSF) and Apollo Program Coordination, compared to Skylab and Space Shuttle programs.
  - c. OMSF/OSSA/OART Integration and Coordination. (Past, present, and future).
  - d. Role of the Executive Council as an Integrative/Control mechanism.
  - e. Role of the Apollo Management Council in Apollo Planning and Coordination.
2. Professional Development of Project Managers

Investigations currently are underway to determine the feasibility of developing a management preparation program for project managers, subsystem managers, and supporting interfaces.

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\*\* Summarized in Fourth Semi-Annual Report, Syracuse/NASA Program, March, 1970

3. Role of Long-Range Planning in Complex Organizations

- a. A significant problem for the large public agency is how to plan years in advance for major program undertakings. Research on this topic would include forecasting NASA-relevant future tasks and the processes by which NASA can make its supportive resource environment more responsive to the potential capacities of the organization.
- b. Associated with this is research directed at uncovering techniques which can serve to facilitate the accomplishment of proposed or alternative long-range plans within NASA.

The project management team also is currently working on an integrative paper titled, "The Apollo Experience: Future Organizational Implications." The objective of the paper will be to discuss some of the team's most significant observations regarding the management of Apollo. In essence, the report will be a presentation of the team's practical research findings during the past two years.

Although some work remains to be done on the present project, alternative research avenues are all being explored. It is hoped that a conference with top administrators within NASA can be arranged in the near future to further develop and assess the feasibility of these ideas as well as to uncover and explore additional research topics.

#### B. NASA/BUSINESS RELATIONS

Once again, during the period under review, staff members were concerned with two aspects of transfer of technology to and within the public sector. These were the decision-making criteria and organizational structure which affect the absorption of new technology by manufacturing firms, both large and small; and evaluation of institutions specifically funded to assist in the process of making technology more widely available to commercial firms.

Administration of the research and development program within the firm is closely tied to the overall problem of technology transfer, and it is often difficult to separate the two. Professor Eric Lawson has reviewed much of the literature on R&D budgeting and has conducted numerous interviews with personnel involved in this process. He perceives the widespread use of incorrect procedures for determining the amount of the firm's annual expenditure on R&D activities. Pay-as-you-go methods of budget maximums constrained by the current level of profit lead to expenditures which are often less than optimum. A working paper, "R&D Budgeting Practices: A Case of Sub-Optimization," is being prepared.

After conducting extensive interviews at many industrial firms, Professor Peter Franck has found an excellent case study for detailed, penetrating analysis of the complex relationships which determine whether new technology actually achieves commercial success. The case is the electron-beam metal refining process developed by the Air Reduction Company. A monograph detailing each step in the development and commercial application of this technology is in preparation.

A published article, "The Role of Technology Transfer in Product Development and Marketing," by Professors E. Bruce Fredrikson and Eric W. Lawson, appeared in the July, 1970, issue of Research Management, published by the Industrial Research Institute, Inc.

In the institutional area, a vital and worthwhile program died during the period under review. The joint federal-state State Technical Services program administered through an office in the Department of Commerce, came to a virtual end when no additional funds were appropriated for it.

We learned a great deal about both technology transfer and political reality by studying this program. It had proved particularly valuable in the area of person-to-person dissemination of technical information and problem solving, especially for small companies. It was favorably regarded by two panels of external consultants and by most authorities familiar with the program. Congressman John Rooney of Brooklyn, chairman of the House subcommittee handling Commerce Department appropriations was unfavorably disposed toward the program. This led to its termination despite a favorable report by the consulting firm of Arthur D. Little.

#### C. CASE STUDIES

Two long case studies of science-technology national decision-making are being prepared under the Syracuse/NASA Program by the Inter-University Case Program of the Maxwell Graduate School. One of these is a description of decision-making about the Post Apollo (Manned Space Flight) Program down to the start of the Nixon Administration in 1969. This is being prepared by Professor Emmette Redford of the University of Texas and Professor Orion White, who is moving to Syracuse University from the University of Texas in the summer of 1970.

The second study is of the evolution of Weather Modification from the stage of scientific possibility arising in the mid 1940's to the stage requiring national governmental decision-making in the 1960's. This study, designed also to be the first model of a set of clinical studies of science-technology "decisions in the making", has been written by Professor W. Henry Lambright of the Maxwell School, Syracuse University.

During the report period, Professor Bock, who is directing the preparation of both studies, conferred with the authors about preparation of revised drafts in light of comments received from participants and experts after earlier circulation of the first drafts. At a meeting in Austin, Texas in February, lines for the revised version were agreed upon by the co-authors of the Post Apollo case and Professor Bock. During the later part of the report period, following similar discussions, the second draft of the weather modification study was edited and its typing begun. A shorter version of Part I of the Weather Modification Study was prepared by Professor Lambright during the latter part of the report period, while he was serving with NASA Headquarters in Washington.

By the end of the report period, Professor Redford had completed his revision of the early chapters of the Post Apollo study. Professor White, like Professor Redford, carried out interviews in Washington and Houston to gather additional data for their revised draft. Meanwhile, Professor Bock had begun a rereading of the two cases and other studies

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of NASA activities in preparation for writing an introductory essay for the two studies.

D. REGULATIONS IN SPACE

1. Research Personnel Activities

a) The research activities during the subject report period continued to be directed by Dr. George J. Alexander, Professor of Law.

Field research has been mostly completed. With the exception of occasional consultations, it is now possible to complete the research for the space law casebook at Syracuse University. Four graduate students of law have been engaged, for varying periods of time, in the research and editing process. In addition to problems suggested by the field experience, work has been done on a selection of problems of the international law of space and space law problems concerning communication uses of space. With respect to communications problems, discussions with Mr. Steven Doyle of the Department of State, in addition to consultations with NASA personnel have been especially useful.

After the final research and editing, the work to be done this coming summer, the materials will be completed. Thus, the activities of the director and the students have centered on discussions of organization and final editing, as well as on the completion and checking of previously prepared materials.

Because of their interest in earth resource satellite problems, Dr. Alexander has consulted with Dr. Churman of the Space Sciences Laboratory about this problem. The work of the project has continued to be of interest to those at the University and, to an increasing extent, to persons outside the University. The director was invited to participate in a Practicing Law Institute conference. The P.L.I. program is the best known and best attended continuing legal education program in the United States. It is significant that the space law segment was presented this year for the first time, indicating the new awareness of the practicing bar. Previously, law meetings concerning space law were the exclusive province of a small group of pioneering practitioners and scholars. The space law materials were presented by Paul Dembling, former General Counsel of NASA, and Dr. Alexander.

Another "first" was the presentation of a paper on space law at the annual meeting of the New York Medical Association by Dr. Alexander. Although the N.Y.M.A. has had a long standing interest in space medicine, having previously invited speakers in many space related fields, including Dr. Werner von Braun, this was the first time that a lawyer was invited or that space law was recognized as a field of general interest by the group.

A new association known as the Association of the United States Membership of the International Institute of Space Law of the International Aeronautical and Astronautical Federation was formed with a distinguished group of U. S. space law scholars. Its first President will be Paul Dembling, late General Counsel of NASA. Dr. Alexander was named to membership and elected a director and member of the Executive Committee.

b) Dr. Malcolm D. Schlusberg, Associate Professor of Business Administration, completed his writing and submitted the product as his doctoral dissertation. After defense of his thesis, Dr. Schlusberg was awarded a doctor of philosophy degree by Syracuse University. He was not supported by the space law project budget during the subject report period, but the work was produced by research conducted in prior report periods.

Prof. Schlusberg's dissertation, entitled, "NASA Contract Dispute Adjudication: A Study in Legal Systems Perspective," 6224-TD-1, utilized both traditional public law methodology and extensive field studies within the agency to explore the means by which NASA resolves its contractual difficulties. The legal systems analysis identified some of the strengths and weaknesses of NASA contract adjudication as a legal phenomenon and pointed to various areas wherein future processual developments might be productive.

## 2. Work Product

The teaching materials were, as indicated, being reduced to final form. From over one thousand typed pages, a book of about eight hundred typed pages seemed to be taking shape. About seven hundred

were completed as of the end of the reporting period. It remains necessary to obtain releases for material with outstanding proprietary rights and unpublished NASA internal documents. Steps were underway to obtain these releases.

A paper entitled "Two Legal Problems in the Earth Resource Satellite Program," a derivative work from Alexander's and McDonald's "Some Domestic Legal Problems in the Earth Resource Satellite Program," (6224-WP-8, October, 1969), was accepted for future publication in the Proceedings of the International Institute of Space Law.

"The Legal Frontier in the United States Space Program," (6224-WP-6, June, 1969), once published in the Syracuse Law Review, was republished in the Proceedings of the International Institute of Space Law.

As previously indicated, Dr. Schlusberg's monograph on contract administration was accepted as his doctoral dissertation.

## E. SOCIAL AND PHYSICAL PROCESSES IN SYSTEMS SCIENCE

### General Comments

Research under this program is being pursued by the following faculty:

P. Bruce Berra - Industrial Engineering  
W. D. Coplin - Political Science  
B. N. Horwitz - Business Administration  
M. Onsi - Business Administration  
N. Schwartz - Electrical Engineering

Currently a series of specific problems are being addressed that require a variety of approaches and modeling techniques. The series include:

1. Partitioning Models for Incentive Contracts (Berra)
2. Dynamic Models for Simulating Political Environments (Coplin)
3. Cost Estimating Models for Hospital Services in Metropolitan Areas (Horwitz)
4. Models for Assessing Cost Information Accuracy for Decision Makers (Onsi)
5. General Dynamic Models for Coupled Socio-physical Systems (Schwartz)

Meetings were held throughout the reporting period to give affected faculty and graduate students opportunity to discuss problems and interests of mutual concern.

### Specific Investigations

#### 1. Partitioning NASA Incentive Contracts (Berra)

This small project began in June 1969 and is under the direction of Professor P. Bruce Berra of the Department of Industrial Engineering. The majority of the effort is being performed by Mr. William J. Stevenson, a doctoral candidate in the College of Business Administration.

The principal aim of the research is to study a series of similar contracts and to analyze the cost and timing of contract changes in an effort to develop a series of mathematical models that can be utilized in predicting uncertainty.

Mr. Stevenson is nearing the completion of his research and should complete the requirements for the Ph.D. degree during the next reporting period. At the completion of his work two reports will be submitted to NASA. The first will be based directly upon his dissertation and the second will be a summary report on the entire project.

A paper entitled "Predicting Contract Changer on Large, Government Projects" has been accepted for presentation at the Eleventh America Meeting of The Institute for Management Sciences in Los Angeles in October, 1970.

## 2. Dynamic Models for Simulating Political Environments (Coplin)

Work is under way on the development of a Programmed International Computerized Environment (PRINCE). Professors M. K. O'Leary and W. D. Coplin, with the aid of two undergraduates highly proficient in computer-programming, have been developing a simulation through which to introduce undergraduates to the scientific study of international relations. We hope to have an operating model by mid-September.

PRINCE provides a five nation world in which students attempt to make decisions. Playing the role of foreign policy-maker for the United States, the student has to deal with domestic economic and political factors as well as four other nations (USSR, France, India and Pakistan). PRINCE consists of four sub-models: (1) the domestic economic system which focuses primarily on macro-economic trends and issues such as balance of payments created by the international economic environment; (2) an international economic environment in which a set of decision rules operate to simulate the flow of goods, capital and investments; (3) an international political environment in which states react to policy issues like Vietnam and the spread of nuclear weapons in terms of their own policy positions, the pressures introduced by other states, the salience of the questions to their own interests and foreign policy tools; and (4) a domestic political system in which policy-influence groups react to the foreign policy decisions of the student as United States foreign policy-maker.

The application of computer programming techniques to the development of a simulation of such a complex social process allows for the use of a wide variety of mathematical tools. The overall effect is to integrate various islands of theory that heretofore are relatively unrelated in the international relations literature. Therefore, although the primary purpose of the exercise is to generate a teaching tool, a secondary purpose is to provide a heuristic device for theory-building. In terms of the latter purpose, we have attempted to relate existing concepts and findings in the field to the relevant components of the model.

3. Development of a Financial Planning (Simulation) Model for a Hospital (Horwitz and Wells)

The following is an outline for the development of a hospital financial model. This project has just recently been started and the outline presented reflects the philosophy of approach.

- a. Purpose--to aid long range (three year) financial planning.
- b. Model will consist of:
  - (1) Aggregative Cost Function
  - (2) Aggregative Revenue Function
  - (3) Aggregative Capital Accumulation Function (Funds)
- c. Model Inputs
  - (1) Hospital costs are correlated with product mix (types of cases), size, number of patients, occupancy rate, length of stay and extent of teaching. Level of aggregation of costs:
    - (i) Direct--Professional Services (Medical, Surgical, etc.)
    - (ii) Indirect--Household and Property (Laundry, Depreciation, etc.)
  - (2) Operating revenues are correlated with the demand for hospital services which is a function of price, income, health insurance, age, family size and education. Rate setting:

- (i) Cost plus compensation by third parties.
  - (ii) Methods of cost allocation for rate setting.
  - (iii) Examination of incentive contracts.
- (3) Capital accumulation (funds) are correlated with donations, long term debt and anticipated capital expenditures.
- (4) Probabilistic approach will be used to derive most likely estimates and expected mean values rather than single point estimates.
- d. Model Output for Next Three Years
- (1) Cash Flow
  - (2) Summary Balance Sheet
  - (3) Summary Income and Expense Statement
- e. Questions to be answered
- (1) What is the expected effect on income for possible changes in patient days?
  - (2) What is the expected effect on the financial statements of different kinds of capital expansion, e.g., building, equipment, increase teaching, etc.?
  - (3) What is the effect on the financial statements for different reimbursement plans?
  - (4) How sensitive are the financial statements to optimistic or pessimistic values of the independent variables?

#### 4. Analysis of the Accuracy of Cost Estimation (Onsi)

This project is primarily directed to the analysis of "cost estimation uncertainty" and not "requirement uncertainty." The NASA cost system is being studied in terms of its utility in providing information relevant to the decisions to be made at three different dimensions and the desired level of accuracy of the information transmitted for each decision. Since one source of such information is the contractor, the analysis encompasses both "in-house" estimating capability and the major contractor's capability. The accounting and economic concepts, statistical techniques, etc., used by each are being analyzed. For the time

being no attempt will be made to analyze the reliability of the subcontractor's estimates.

Fourteen interviews were held with the resource analysis group in Washington, D.C.; in Goddard Space Center, Maryland; and in Manned Space Flight in Houston, Texas. Since the NASA cost system has derived certain concepts from DOD cost analysis work, eight interviews were held with the DOD cost analysis group and economic analysis group.

The results of the interviews and the data collected from NASA and DOD are being analyzed and evaluated to obtain practical information on contractors' cost account systems and how they provide their estimates for government contracts. Dr. Onsi has relied, so far, on a questionnaire sent to 700 companies in 1968 by a consultant group to the General Accounting Office. The results of this questionnaire serve a general purpose in outlining the problems from the industry's point of view. However, by analyzing these results, it was found that their usefulness is limited in nature since the major contractor and each of his subcontractors are treated as equal. For example, a major contractor may have a good cost system but his subcontractors have an inadequate cost system; their replies to the questionnaire and the statistical analysis carried forward will lead to inconsistent results. What is needed is to test the major contractor's cost system and the subcontractors' cost systems separately. Then a variance analysis can be applied to see if there is a significant difference in attitude, reliability of estimate, etc. of major contractor vs. subcontractor. Dr. Onsi has requested the original data collected from the consultant group to the GAO to carry out such a test, since it is more relevant to this study.

Three major contractors doing work for NASA were chosen as the primary source for collecting a pilot sample on the contractor's approach to estimating cost for major space hardware. From such data the feasibility of developing and testing a cost model incorporating cost estimation uncertainty to the "state of the art" will be carried out. Additional interviews with Apollo officials are planned.

From the data collected so far, the NASA cost system as a subsystem of NASA management information system, is subject to a different hierarchy of pressures that stems from other NASA subsystems and the environmental systems, especially the political system. The research will be concentrated, for the time being, on a static cost system, leaving the dynamic and interface aspects to later research.

Mr. Stanley Michel, a graduate assistant, prepared a working paper entitled Cost Analysis for New Systems: Survey of Literature, May 1970, 6236-WP-1, under the supervision of Dr. Onsi. This paper presents literature findings on cost analysis and the problems attendant thereto.

##### 5. General Models (Schwartz)

This investigation, recently underway, deals with finding new representations for complex system models. Primary concern is directed to handling variables that are intrinsically non-quantifiable in the usual sense and subjective in nature.

The basic tool under consideration is the concept of "fuzzy sets" introduced by Zadeh.<sup>1/2</sup> Zadeh points out that many classes of objects in the real world do not have precisely defined criteria of membership. He uses as examples: the class of beautiful women; the class of tall men; the class of all real numbers much greater than 1; etc.

At the heart of the concept is the stipulation of a "membership function" which assigns to each object in the fuzzy set a grade of membership ranging between zero and one. Marinos<sup>3</sup> has presented methods for synthesizing fuzzy logic functions and their electronic implementation. He points out that the strength of the technique will be realized in practical situations which are more ambiguous (fuzzily defined) than statistical in nature.

This tool should be investigated in the search for model representations that include "social" variables. Hopefully the degree of applicability can be assessed during the forthcoming reporting period.

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<sup>1</sup>L. A. Zadeh, "Fuzzy Sets", Information and Control, Vol. 8, pp. 338-353, 1965.

<sup>2</sup>L. A. Zadeh, "Fuzzy Sets and Systems", 1965 Proc. Symp. on Systems Theory (Poly. Inst. of Brooklyn) April, 1965.

<sup>3</sup>P. N. Marinos, "Fuzzy Logic and Its Application to Switching Systems", IEEE Trans. on Computers, Vol. C-18, No. 4, April, 1969.

## F. NONECONOMIC CRITERIA FOR EVALUATING SPACE APPLICATION PROJECTS

### Purpose and Output

The purpose of this study is to develop and test by case analysis noneconomic criteria for the evaluation of space application projects. The output will be a set of open-ended questions which NASA administrators can use in evaluating alternative space application project candidates. Questions which can be scaled or measured will be further refined into "go", "no-go" or multiple point scales to facilitate judgmental comparisons among projects.

### Concepts of Criteria

1. Economic criteria.
2. Noneconomic criteria.
  - a. Scientific and technical consequences which are widely employed by NASA and viewed as positive utilities in NASA documents.
  - b. Social consequences referred to only as "political", "cultural", "educational", "international", usually without more detailed specification in NASA literature.

This study focuses primarily on developing more precise identification of questions under heading 2b, noneconomic consequences of a social nature and also attempts to identify noneconomic criteria described by different terms with common meanings under 2a. We are concerned mostly with direct benefits which are under the control of NASA, but include also indirect benefits if these can be foreseen or identified.

The rationale for the major categories of criteria to be studied is already available from the 1969 study of the Task Force on Non-economic Criteria. Included under life needs, domestic political criteria, international and scientific-technical headings are 13 subcategories for which open ended questions were developed in the 1969 study. These, and related questions to be added from our present literature search will constitute the measuring instrument to be applied to three cases.

#### Rationale for Case Selection

The rationale for selecting specific cases stems from the interests of Congress or the Executive, the internal management decision problems of NASA, and the time and budgetary limitations imposed on the Syracuse Task Force on Noneconomic Criteria.

Based on this rationale we have selected two preliminary cases for testing our questions, questionnaire and scales.

1. Earth Observations Resources Satellite Projects. Case preparation by George Fisk. Environmental pollution, mineral resource, and disease and biological control benefits are included.
2. Communication Satellite Projects. Case preparation by David Curzon. Education, International Cooperation, and information transmission benefits are stressed.

A third case is still to be chosen, and at this writing will be either in the earth physics or navigation and traffic control field. Selection and compilation of benefits will begin shortly.

#### Literature Search

A search of International Aerospace Abstracts and STAR is underway for the purpose of identifying consequences and criteria for which questions, scales or measurements may be devised and applied to our case studies.

This literature search is being conducted by Mr. Tom Rockwell, Ph.D. candidate. Mr. Rockwell is also searching "key words" from the NASA Annual Subject Index to correlate the bibliography with benefits. A second and parallel search by Mr. Chandron Rajen, MBA student in the College of Business Administration, is being made in a bibliography on "Benefits of Space Applications" supplied to the Task Force by NASA's Information Retrieval Section. Mr. Rajen is also combing popular and scientific journals for discussions of benefits pertaining to Communications, Earth Observations and International Benefits.

Consideration is being given to the development of a bibliography that can be appended to our questionnaire so that NASA decision makers

using noneconomic criteria can become familiar with indirect and second order effects as well as the range of direct or first order benefits. An information retrieval code identifying major categories, subcategories, discriminating between observation, measurement, prediction and management decision benefits has been developed to permit rapid collection of literature citations for use in arriving at judgments involving non-economic criteria in making decisions.

#### Measurement Instrument

Paralleling the benefit categories being developed in the literature search, a first draft questionnaire and measurement instrument is being developed for application to the cases selected. James Fedder, Associate Professor of Quantitative Methods in the College of Business Administration has extended the questions from the 1969 study in collaboration with other members of the Task Force, and we anticipate a full scale case test and revision of our questionnaire and scales by the end of 1970. This will require further interviewing of NASA personnel responsible for programs for which our cases have been selected.

#### Ancillary Consequences

George Fisk, Professor of Marketing and Study Director will present a paper at the September 1970 meeting of the American Marketing Association in Boston on "New Criteria for Evaluating Marketing Performance". This paper draws heavily on the experience gained in this research and in the 1969 Task Force study. E. Bruce Fredrikson, a member of the 1969 Task Force, is preparing a manuscript for publication based on the 1969 findings.

#### Time Table

Spring 1970 - First meetings with OSSA personnel to identify benefits and objectives of space.

Summer 1970 - Literature Search, Case Selection, Questionnaire and Measurement Instrument Construction.

Fall 1970 - Case Analysis by means of documents and interviews using questionnaire.

Spring 1971 - Presentation of Final Report to NASA.

### III. ADDITIONAL RESEARCH

#### A. EXPOSITION AND REAL-TIME DECISION-MAKING

1. Assisted by 100 students, Professor McLaughlin undertook a survey of magazines in order to devise a simple method of checking the acceptability of reading material for adults of various educational levels. This involved processing 900,000 words of material using statistical programs written in the conversational computer language APL. The programs are contained in three workspaces of the Syracuse University Computing Center's APL Public Library. Two of the workspaces document the programs which are held in the remaining workspace. A listing of all three programs was issued as the report:

"Statistical APL Programs," (June 1970), 6227-R-1.

The readability predictor itself will be published later.

2. Also during this period, Professor McLaughlin wrote an occasional paper:

"Written English Considered as a Foreign Language,"  
(January 1970), 6227-OP-6. This is to be published in the journal  
Elementary English.

3. At the end of June Professor McLaughlin returned to the Manned Spacecraft Center in Houston to obtain further material for his report on computer-assisted, real-time decision-making processes, which will be issued early in the Fall.

#### B. PARTITIONING NASA INCENTIVE CONTRACTS

This work, under Professor P. Bruce Berra, is now a part of the study, "Social and Physical Processes in Systems Science," but is noted here for coordination with the similar topic in the report of the previous six-month period.

C. MULTIDISCIPLINARY RESEARCH IN UNIVERSITIES:

NASA'S EXPERIENCE WITH THE  
SUSTAINING UNIVERSITY PROGRAM

This study, conducted by William E. Davis, Graduate Student in Political Science, under the supervision of Dr. John Honey, represents both a report to the Office of University Affairs and a Master's Thesis. The thesis was completed during the reporting period and is identified as follows:

"Interdisciplinary Research in Theory and Practice: A View From the University," (April 1970), 6221-TD-1.

Mr. Davis' thesis is a theoretical and empirical exploration into the subject of interdisciplinary research activity in the modern American university. As such, it includes an inquiry into the theoretical foundation underlying such activity, and an analysis and evaluation by the author of the experiences reported by approximately 60 research faculty and administrators from five universities who were engaged to a greater or lesser extent in what was referred to as interdisciplinary (or multidisciplinary) research activity.

Five university research programs, executed under the sponsorship (and with the financing) of NASA Sustaining University Program (SUP) multidisciplinary research grants, provide the focus for the empirical portion of the study. NASA's emphasis on "interdisciplinarity" in supported research is described, as are the typical program arrangements (i.e., the administrative structure, and the procedure and substance of research activity) developed by the visited participating universities.

Four sets of problems are isolated as major hurdles to successful interdisciplinary research: purpose; the institutional environment; the attitudes of university personnel; and the organization and management of the research team effort. An analysis of the university setting as environment for interdisciplinary activity focuses particular attention on the organizational fragmentation of the modern American university, the tendency for it not to reward--even to penalize--interdisciplinary activity, and the weakness of institutional leadership. An

exploration of disintegrative interprofessional attitudes among university personnel focuses on differing conceptions of the nature of the research process, the state of the theory among the various disciplines, and the relative competence of one's colleagues in other disciplines.

Finally, prescriptions relative to encouraging the development of sensible research designs, assembling a group of scholars to address those problems, and maintaining a productive ongoing research group are explored. Included are recommendations concerning the rationale for interdisciplinary research, the implications of "induced" research, choosing team participants, the involvement of potential participants in the research design and the bestowal of academic rewards for interdisciplinary work. Other prescriptions are related to insuring a flexible and transient organizational structure for the research team, the physical support arrangements provided the team, the relative commitment of research effort by participants, the nature of team decision-making and the broker-facilitator-conflict resolver role of the Principal Investigator.

D. PUBLIC ADMINISTRATION, THE UNIVERSITIES, AND NASA

The work of Mr. Frank McGee in the areas of education and research related to the future of Public Administration, within the context of multidisciplinary and interdisciplinary work, was continued during the period. The documents, curricula descriptions, plans, and other data which had been gathered in the previous report period were utilized. In addition, the 160 semi-structured tape recorded interviews which had been made by Professor Marini and Mr. McGee at 24 universities provided a further basis for the investigation.

Mr. McGee is currently writing his dissertation, which is tentatively titled, "Dimensions of Group Research in University Environments," based on the above-mentioned data.

E. THE ACCURACY OF COST ESTIMATION FOR  
APOLLO DECISION-MAKING IN NASA

This study, under the direction of Professor Mohamed Onsi, is now a part of "Social and Physical Processes in Systems Science," but is noted here for coordination with the similar topic in the report of the previous six-month period.