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University of Houston

LLV

Lunar Logistic Vehicle

Houston - NASA MSC - Rice

Faculty Systems Engineering Institute

September 1969

Administrative Program

FINAL REPORT

by:

C. J. Huang, Director

J. L. Youngblood, Co-Director

S. L. Dickerson, Associate Director

A. N. Paul, Assistant Director

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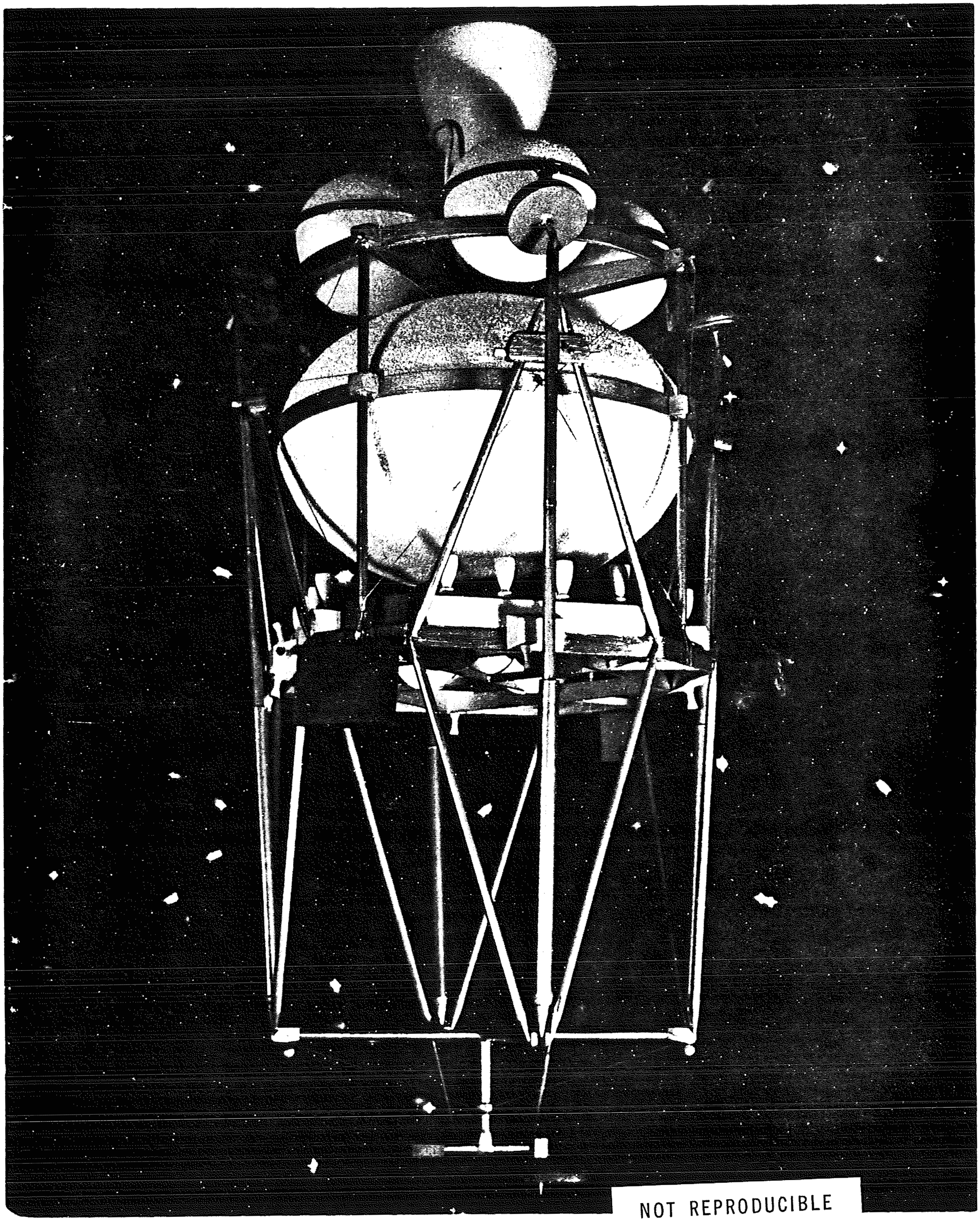

T A B L E O F C O N T E N T S

I. INTRODUCTION

The system design summer institute conducted at the University of Houston in cooperation with NASA - Manned Spacecraft Center and Rice University was modelled on similar programs and academic courses given at M. I. T. and Stanford during the past seven years. The latter activities have been described elsewhere* and are primarily the brainchild of Dr. William Bollay. The basic purpose of the institute is to provide engineering faculty with experience in the development of multidisciplinary engineering design courses. The conduct of such courses follows a prescribed pattern* and the institute itself becomes a case study in organized creative design for the benefit of participating faculty.

The academic objectives of this type of course revolve around the following key concepts:

- The systems approach views the problem in its entirety, not as a set of unrelated aspects.
- Communication and cooperation among engineering and scientific disciplines is of great potential importance to the solution of major technological problems.
- Engineering and systems theories must be applied to actual engineering problems to be properly appreciated.
- The successful execution of a system design project is highly dependent on the careful organization of the technical team for which industrial project management concepts offer a useful model.

The academic content of the course should include the following components:

- Opportunity for invention and innovation
- The formulation of a complex system problem
- The synthesis of alternatives

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*Bollay, William, "MIT and Stanford Projects in Systems Engineering - An Educational Experience in Creative Design," Journal of Engineering Education, pp. 387-390, June, 1966.

- System analysis and decision analysis (trade-offs)
- The application of scientific principles to real problems
- The development of technical leadership
- Project planning and management experience
- Actual constraints of time and money on a system
- Formal presentation, the imaginative use of visual aids
- Assignment of individual responsibilities
- The production of a formal design report

Critical to the conduct of a successful course or institute is the choice of a problem. This choice should be compatible with the resources of technological information and talent at hand. In the present instance, the proximity of NASA's Manned Spacecraft Center offered an outstanding opportunity for a design project in spacecraft design. The program directors and faculty are grateful to NASA-MSC for their energetic encouragement and support in the form of lectures, reports, library services and consultation which provided a marvelous climate for the execution of a design of a Lunar Logistic Vehicle for soft landing a 2500 pound payload on the visible face of the moon. In general terms, the problem chosen should be:

- A sophisticated real current system problem
- At the interface of technologies and on the fringe of state-of-the-art science and engineering developments
- Significant to society
- Suited to faculty and student interest
- Include political, sociological and humanistic aspects

The design of an unmanned lunar lander to make our middle 1970's a more productive period,for our manned and unmanned lunar exploration amply fulfilled these requirements.

Finally, the overall philosophy underlying creative system design is to provide an environment where one can exploit the tension between:

- What is desirable and what is available
- The state-of-the-art and known theoretical limits
- System capabilities and external constraints
- Cost and effectiveness

This tension combined with analogical knowledge of natural or man-made systems in other fields is the fertile ground of human inventiveness. Invention without evaluation is a semi-sterile occupation; the program must emphasize a systematic approach to decision under uncertainty through the use of rational criterion design functions.

The design of a complex space system such as the Lunar Logistics Vehicle (LLV) is a multidisciplinary engineering activity. The development of sophisticated subsystems and components requires a highly specialized knowledge with experience in a specific field. In a complete system design, the integration of all subsystems to optimize the overall performance requires a detailed analysis of the interaction of all components as well as that between man and machine. The integration of designed subsystems into the LLV is a major system design effort and more time than the 11 week session would have been required to do this phase in detail.

This program was an educational exercise that established successful communications between the 19 participants of different specialties. The program introduced several methods of parametric evaluation of the many complex system alternatives. Design trade-offs were considered which resulted in a relatively simple effective system using a maximum of developed hardware. The dollar cost of the LLV program should be quite low relative to the contributions of the missions.

In order to break the social barrier which always exists among strangers, a series of social functions were planned and held on an average of better than one a week. They were as follows:

Picnic and volleyball game with research group at Webster Park.

Six productions at the Houston Music Theatre usually followed by after theater party hosted by various members of the team.

Outing at Surfside Beach with Professor Art Paul as host.

Boat trip down the ship channel.

Family tour of Manned Spacecraft Center.

Dinner meeting with Marshall Summer Faculty Fellows.

Houston's tribute to NASA and Apollo 11 astronauts at the Astrodome.

Pre-theatre dinner party hosted by Dr. Steve Dickerson.

All nineteen participants in the System Design Engineering Institute attended the 8 special seminars on Aerospace engineering and sciences related to "Identifying Earth Resources by Remote Sensing". See Appendix A.

II. PROGRAM PLANNING

2A. Publicity and Selection of the Participants

The announcement of the Houston - Rice Engineering Systems Design fellowship program appeared in the December, 1968 issue of the Journal of Engineering Education and the American Institute of Astronautics and Aeronautics Journal along with those of the programs at Auburn, Old Dominion with Langley, and Stanford with Ames. In addition, a brochure was prepared based on the journal announcements and mailed to about 2,000 deans of engineering, department heads, and other research administrators. The announcement brochure, etc., and the application are shown in Appendix A.

2B. Planning

Dr. W. J. Graff and Professor A. N. Paul attended the Co-Directors meeting of ASEE-NASA Summer Faculty Institute at Langley Research Center in October, 1968. A review of the 1968 programs and plans for the 1969 Institutes were made and the announcements of the programs outlined.

On April 2, 1969, Messrs. Bass Redd, Jim Youngblood, Bob Abel, Bob Bristow, and Paul Thomas of MSC met at NASA with Dr. C. J. Huang, S. L. Dickerson, Fred Davidson and A. N. Paul to discuss the design project that should be used for the 1969 Houston Engineering System Design Institute. The project suggested as being of particular interest to MSC was a study of extending the lunar module's capabilities on the lunar surface. This was agreed on by all concerned as a suitable project. However, shortly thereafter MSC funded a contractor study of this problem and in order to avoid duplication of efforts a change in project was suggested and by telephone conference a new system which would support an extended LM--namely the LLV--was chosen as the 1969 design project.

It was agreed at the April 2 meeting that (1) a considerably more detailed statement of the project would be prepared by MSC than in earlier years, (2) that Mr. Bob Abel and Mr. Bob Bristow would be assigned a good fraction of their time to preparing for and advising the Institute, (3) that a NASA Summer intern would be assigned to the project to assist in layout drafting and (4) that MSC would provide a number of background lectures during the first two weeks of the project. All of these were carried out and proved very fruitful.

For the use of the project team, one lecture room and one design drafting type classroom was set up with tables and chairs. A permanent conference-type telephone amplifier system was also installed in the lecture room for the duration of the program. An overhead projector and transparency reproduction facilities were also provided for the routine presentation of lectures and informal talks. One room was used for project and group meetings, and one for formal lectures. The display of project literature and materials and a library was set up near the large drafting room which was used as a quiet work area.

Each participant was provided with a basic set of reference materials and a project library was established with books and reports loaned to the project for its duration by the University of Houston library and the MSC library. The automated literature searching service at NASA-MSC was of great value to the participants. Searches were run in anticipation of the program and were followed by additional search requests by the participants as the technical needs became more precisely defined.

The Civil Engineering Department furnished the use of the schools visual aids preparation supplies, 2x2 slide reproduction and photocopy equipment, and the services of a technician for drafting and tracing drawings and figures for the presentations. This supporting service saved considerable time and detail work for each of the participants. The many fine figures in the final technical report reflects the effort put forth by Civil Engineering Dept. student assistant, Terence Cheng.

2C. Administration

Faculty and staff for the project included:

Dr. C. J. Huang, University of Houston, Director

Dr. S. L. Dickerson, Georgia Institute of Technology, Associate Director

Mr. A. N. Paul, University of Houston, Assistant Director

Mrs. Inez Law, University of Houston, Secretary

To aid in establishing inter-institutional cooperation and in selecting participants, an advisory committee was formed consisting of:

Dr. Max Faget, NASA-MSC

Dean W. E. Gordon, Rice University

Dean C. V. Kirkpatrick, University of Houston

Mr. Paul Purser, NASA-MSC

The technical direction of the project during the initial planning stages consisted of faculty and staff of the project and:

Dr. Jim Youngblood, NASA-MSC

Mr. Bob Abel, NASA-MSC

Mr. Bob Bristow, NASA-MSC

Mr. Bass Redd, NASA-MSC

Mr. Paul Thomas, NASA-MSC.

Dr. D. B. Mackay, Rice University

III. CONCLUSIONS AND RECOMMENDATIONS

The preliminary design of the Lunar Logistics Vehicle was successfully executed and the first report completed. Appendix B is the Preface, Table of Contents, Table of Figures, and Abstract from this report. It is felt that the closer working arrangement with MSC was very helpful in producing an end result more useful to NASA.

In order to secure feedback on how the program might be improved

- The participants each were asked to complete a four page questionnaire on the operational aspects of the program.
- Each of the participants were asked to complete a one page questionnaire on the housing situation for the summer.
- A critique session was held after the final presentation for discussion of possible changes.

A brief summary of the response to the questionnaires is on the pages 10and 11. Many questions required a subjective written answer (in contrast to a Yes or No answer). Some suggestions which appeared repeatedly in these answers and in the verbal critique session included

- Establish a closer relationship with MSC by such mechanisms as (1) assigning a contact man for each participant in the field of his interest, (2)having a senior engineer assigned full time to advise the group or actually serve as project manager, (3)physically housing the institute at MSC.
- Greater initial definition of goals, responsibilities and operating procedures on both the technical and management aspects. Principle items include more complete and precise (1)statement of problem, (2)schedule, (3)job descriptions.

Less frequently mentioned suggestions were

- A single project manager who is a member of the staff rather than a participant. Could be a NASA employee well versed in systems design.
- Less formal presentations for phase I and II.
- Have the participants attend a <u>real</u> contractors presentation.

- Provide better physical working facilities.
- Provide more typing and drafting support.
- Provide more lectures on systems design philosophy and methodology.
- Provide a more complete set of references at beginning of project.

These suggestions will be considered in arranging future programs.

As indicated in the final administrative report for 1968, one of the problems of this type of program is recruitment of qualified participants. Two factors in this dilemma were recognized there as publicity and stipends. During the past year these aspects have improved with the result that more applications were received than in previous years. However, as in the past, the research program attracts a larger number and it appears to attract the more successful professors, as indicated by number of publications, academic rank, etc. It is felt that this may be related to the academic environment which biases professors and graduate studies (and to a less er extent undergraduate studies) toward research. This bias is partially from tradition and partially pragmatic. The pragmatic reasons concern publications and funding--the two principle measures of success in the academic world. Both are more difficult to achieve for design work than research work. With regard to funding it is not surprising that government agencies and industries turn to non-academic organizations for design studies. The universities are not set up to meet a tight schedule for results nor are they equipped to manufacture the final result if required. It is felt that in the long run these factors may be more significant than stipend and publicity in achieving the goals of the Summer Faculty Fellowships in Systems Engineering and that some thought should be given to finding mechanisms to improve the standing of design work in the university environment.

SUMMARY OF PROGRAM EVALUATION QUESTIONNAIRE

Number of participants returning questionnaire:	16
The Fellowship stipend was:	Meager 2; Adequate 9; Generous 4.
Housing arrangements satisfactory:	Yes 11; No 3.
Technical area of work was of interest:	Yes 14; No 2
Adequate chance of technical area:	Yes 12; No 2
Work challenging:	Yes 13; No 2
In area of primary interests:	Yes 8; No 7
Stimulated to start related classes or research at home university:	Yes 12; No 3
Inclined to use "systems approach" in future classes:	Yes 14; No. 1
Desire in principle to have seminars not directly related to project:	Yes 11; No 5
Number of technical lectures was:	Too many 1; O.K. 7; too few 7.
Approve of approximately 25% graduate students in project:	Yes 6; No 10
Enough advisory support:	Yes 9; No 7
Desire more completely specified project at beginning:	Yes 7; No 7
Should have spent more time on	
Library research:	Yes 8; No 6
Consultation at MSC:	Yes 12; No 3
Design calculations:	Yes 11; No 4
Administrative tasks:	Yes 2; No 12
Project meetings:	Yes 2; No 13
Group meetings:	Yes 5; No 10
Interested in continuing as Faculty Fellow during Summer of 1970:	Yes 15; No 1
	Design 9; Research 14
Enough social activity:	Yes 14; No 2
NASA objectives(as perceived) met:	Yes 14; No 1
Would recommend better students for employment at NASA:	Yes 14; No 2

Obtained personal objectives:	Yes 14; No 2
Sustained a financial sacrifice in accepting Fellowship:	Yes 4; No 11
Feel that modern undergraduate education sufficiently emphasizes	
Basic science:	Yes 11; No 3
Mathematics:	Yes 11; No 3
Engineering practice:	Yes 9; No 5
Design procedures:	Yes 2; No 12
Graphical communication:	Yes 6; No 8
Oral communication:	Yes 3; No 11
Written communication:	Yes 6, No 8
Graduate education is more research oriented than desirable:	Yes 9; No 4
The systems approach is different than conventional approach to design:	Yes 11; No 3

ASEE - NASA SUMMER FACULTY FELLOWSHIP PROGRAM

U of H - Rice U - MSC

EVALUATION QUESTIONNAIRE FOR USE OF PROGRAM STAFF AND ADVISORS

1. Name ______________________________

2. Home Institution ______________________________

3. Was the Fellowship stipend meager ____ adequate ____ generous ____?
   Please comment if you wish: ______________________________

4. Were the arrangements for housing satisfactory? ______________________________

   Suggestions: ______________________________

5. Technical area of activity (eg. thermal control) ______________________________

   ____

6. Were these areas of interest to you? ______________________________

7. Did you have an adequate choice of technical areas? ______________________________

8. Was the work challenging and within your field of primary interest and competence? ______________________________

9. If not, do you regret it? __________ Why? ______________________________

10. As a result of the summers work, are you stimulated to start related classes or research at your home university? ______________________________

11. Are you inclined to use the philosophy of the "system approach" in your present or future classes? ______________________________

12. Do you agree in principle with the desirability of having lectures and seminars in areas not directly related to our project?

    ____

13. Were there too many or too few technical lectures related to our project? ______________________________

14. What technical areas relevant to our project should have been covered in more depth? ______________________________

    ____

    Less depth? ______________________________

15. Which one or two lectures stand out as most valuable? ______________________________

    ____

    ____

16. How would you feel about having a few (25%) carefully selected graduate students in the program? ______

17. Was there enough advisory support? ______ If not, what areas need more support? ______

18. Would a more completely specified project at the beginning of the summer have increased the value of the experience for you?

______

19. Looking back on the summer, do you think you should have spent more time on:

 a. Library research? ______

 b. Consultation with MSC personnel? ______

 c. Individual design calculations? ______

 d. Administrative tasks? ______

 e. Project meetings? ______

 f. Group meetings? ______

20. Are you interested in the possibility of continuing as a Faculty Fellow during the summer of 1970? ______ Design? ______ Research? ______

21. Did we have enough social activity? ______

 Comments: ______

22. What would you suggest for improvement of the special Tuesday - Thursday lecture series? ______

23. a. What is your general impression of the Summer Systems Design Program?

 b. What was the most valuable experience of this summer?

 c. Least valuable?

24. In <u>your opinion</u>, what were the NASA objectives and benefits of this program? How well do you believe they were met? Are any benefits (to NASA) likely to be of a long-term or short-term nature?

25. Were you sufficiently impressed by NASA's work, goals, and personnel to recommend that your better students seriously consider employment with NASA?

26. What were your personal objectives in participating in the program? Did you attain the objectives?

27. Was there any financial sacrifice on your part in accepting the fellowship? If so, about what sum, in terms of salary, family expenses, transportation, etc.?

28. How could future summer institutes be improved? (Please make specific recommendations)

DESIGN PROCEDURES

(organization, creativity, optimization, etc.)

Do you feel that modern graduate education is more research oriented than it should be(relative to engineering design)?

Do you feel that the systems approach to design differs from the conventional approach taught (or formerly taught) in engineering schools?____

If so, what distinguishes the systems approach?

FOREWORD

Steve Dickerson

0.1. Introduction

Nasa, the University of Houston and Rice University intend that the Summer Faculty Programs in Systems Engineering acquaint the faculty of selected engineering colleges with the systems approach to complex design problems. The technique used is to involve the participating professors in a real conceptual design of a space system. See Figure 0.1-1. These summer educational experiences are based on Dr. William Bollay's initial graduate courses at MIT and Stanford. It is hoped that some of the major beneficial results of the program are the following.

- The participants will have a better understanding of NASA's contributions, goals, and operations.
- The participants will be able to organize new or modify existing design courses at their home institutions along the lines of the summer program.
- The participants and their students will have a better appreciation of the contributions of other disciplines, including the non-engineering, and the need for effective cross fertilization.
- A study of value to NASA will result.

0.2 Participants

Nineteen professors and instructors from eighteen different universities and colleges attended the program. By discipline there were three in electrical engineering, five in mechanical engineering, five in civil engineering, three in aerospace

TABLE 0.2-1 PARTICIPANTS AND STAFF

Dr. Floyd O. Calvert
Research Institute
University of Oklahoma

Dr. Jack H. Cole
Mechanical Engineering Dept.
University of Arkansas

Dr. Frederic M. Davidson
Electrical Engineering Dept.
University of Houston

Dr. Izydor Eisenstein
Mechanical Engineering Dept.
Purdue University

Dr. Clift M. Epps
Mechanical Engineering Dept.
Texas Tech University

Dr. George E. Gless
Electrical Engineering Dept.
University of Colorado

Dr. George F. Hauck
Civil Engineering Dept.
Tri-State College

Dr. Frank J. Hendel
Aeronautical Engineering Dept.
California State Polytechnical College

Dr. Benjamin Koo
Civil Engineering Dept.
University of Toledo

Dr. Samuel J. Kozak
Geology Department
Washington & Lee University

Prof. Thomas M. Perkins
Engineering Technology Dept.
Western Kentucky University

Dr. Angelo J. Perna
Civil Engineering Dept.
Newark College of Engineering

Dr. George Pincus
Civil Engineering Dept.
University of Houston

Dr. Charles G. Richards
Mechanical Engineering Dept.
University of New Mexico

Dr. Joseph E. Robertshaw
Physics Department
Providence College

Dr. Juda E. Rozenberg
Civil Engineering Dept.
Christian Brothers College

Dr. Alvin M. Strauss
Mechanical Engineering Dept.
University of Kentucky

Prof. Frank R. Swenson
Mechanical & Aerospace Engr. Dept.
University of Missouri

Dr. Jesse M. Wampler
Geophysical Sciences
Georgia Institute of Technology

C. J. Huang, Director
Associate Dean of Engineering
University of Houston

A. N. Paul, Assistant Director
Industrial Engineering Dept.
University of Houston

Dennis Laue
NASA Summer Interne
Purdue University

S. L. Dickerson, Associate Director
University of Houston and
Georgia Institute of Technology

D. B. Mackay, Faculty Advisor
Dept. of Aerospace Engineering
Rice University

Terrence Cheng
Draftsman
University of Houston

engineering, one in physics and two in geology. Table 0.2-1 contains a complete list of the participants. With one exception they had no previous experience in space system engineering.

0.3 Time Table

The program started June 9 and ended August 22, 1969. This eleven week period was broken into three phases, characterized roughly as the problem and alternative definition phase, alternative evaluation phase, and the reports preparation phase. Oral reports on project progress were prepared by the participants and presented at the end of each phase to members of the Engineering and Development Directorate at the Manned Spacecraft Center. The presentation for Phase III was a complete summary of the entire project and was open to the public. A chronological listing if the major milestones during the summer are given in Table 0.3-1.

TABLE 0.3-1 PROJECT MILESTONES

Date	Milestones
June 9	Program begins
June 13	Project teams organized, Phase I leadership selected.
June 27	Phase II leadership selected
July 1	Phase I oral review - statement of problem, alternative solutions, revelant technical material.
July 25	Phase III leadership selected
July 29	Phase II oral review- trade off studies and recommendation of basic design.
Aug 19	Final oral report -review of entire project and presentation of recommended LLV design.
Aug 22	All final report contributions due. Program ends.

0.4 Organization

The coordination of the team effort was accomplished by structuring the group as indicated in Figure 0.4-1. The project manager and group leaders were elected for each phase and were members of the executive committee. This committee met daily and was charged with overall technical direction of the project. The three project groups also met daily to coordinate efforts in their areas of responsibility. If a task required special attention and in the opinion of the executive committee could not properly be assigned to one of the project groups, an ad hoc committee was formed to accomplish the task in a specified time and prepare a report. It was then dissolved. The staff advisors primary functions were support of the technical work through continuous review, arranging for outside inputs, arranging for experimental work, model building, computer aids, audio-visual aids, drafting work, etc. All final technical decisions were in the hands of the participants.

0.5 Acknowledgements

The participants and staff thank MSC personnel for their support, We particularly thank Bob Abel, Bob Bristow Paul Thomas and Bass Redd for providing close technical liaison and Jim Youngblood for administrative support. It should be borne in mind, however, that MSC or NASA are not in any way responsible for shortcomings of this report, nor do they necessarily support the conclusions.

The participants thank the many individuals who addressed

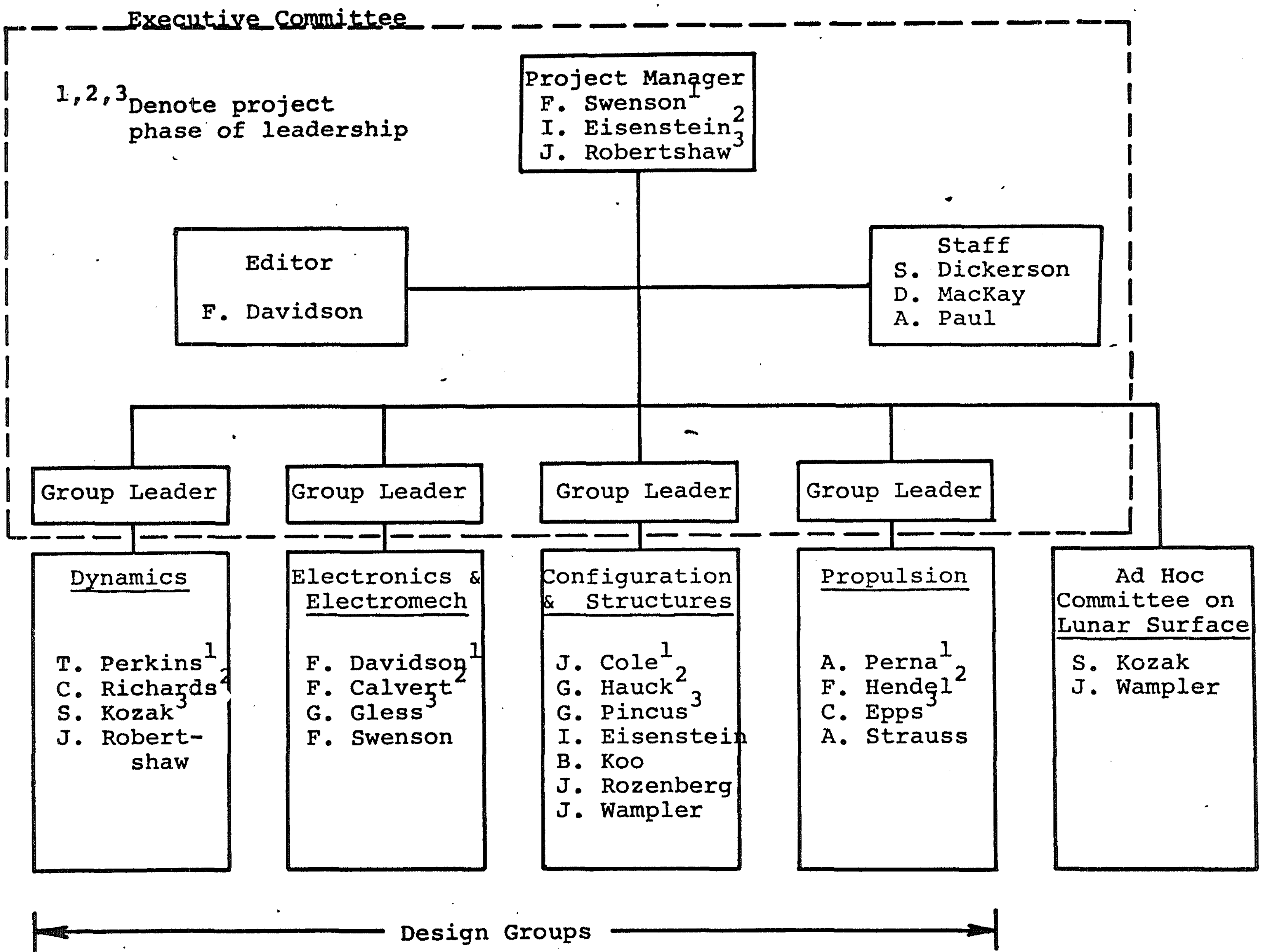

FIGURE 0.4-1 DESIGN GROUP STRUCTURE

the team to provide the essential background information. A list of the speakers, their topics and affiliations is given in Table 0.5-1.

Many others at MSC provided informal assistance to the group through individual consulting. Among these people are Arlie Fisher in the area of structural design, Jerry Smithson in propulsion, and Wilbur Wallenhaupt in flight operations.

Don Mackay, of Rice University, gave the group the benefit of his considerable industrial experience in aerospace firms.

We are indebted to the encouragement of Messrs. Francis B. Smith, Frank D. Hansing and Charles H. Carter of NASA Office of University Affairs; President Philip G. Hoffman, Mr. Paul Purser, Special Assistant to the President, and Dean C. V. Kirkpatrick of the University of Houston; Dr. Maxime Faget of NASA-MSC; and Vice President W. E. Gordon of Rice University.

Finally, we thank Mrs. Inez Law for tolerating twenty some bosses for eleven weeks.

TABLE 0.5-1 OUTSIDE SPEAKERS

TOPIC	SPEAKER	AFFILIATION
The Intermediate Size Lunar Logistic Spacecraft	P. G. Thomas	Engineering Analysis Office, MSC
Advanced Lunar Operations and ISLLS Payloads	A. J. Meyer	Adv. Missions Program Office, MSC
The Lunar Surveyor Program	C. Kirsten	Jet Propulsion Laboratory
Lunar Terrain	L. Wade	Mapping Sciences Lab., MSC
Costing	H. Mandell	Program Control Division, MSC
Main Propulsion and Reaction Control Systems	M. Lausten N. Chaffee	Propulsion and Power Division, MSC
Electrical Power Systems	D. Haines	Propulsion and Power Division, MSC
Communications and Instrumentation	J. Shephard	Space Electronics Systems Div., MSC
Structural and Thermal Consideration	A. Mackey	Structures and Mechanics Div., MSC
Landing Dynamics	George Zupp	Structures and Mechanics Div., MSC
Guidance and Control Systems	M. Jones Ed Chevers	Guidance and Control Div., MSC
Lunar Trajectory and Performance	B. Able	Engineering Analysis Office, MSC

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ABSTRACT

The preliminary design of an unmanned space vehicle that can land a payload of 2500 pounds on the moon is presented. The design is based on a maximum use of developed, space qualified hardware so that the vehicle can be made operational by 1973. The Titan III-D Centaur will be the launch vehicle. This booster combination can insert a 12,000 pound spacecraft into a translunar trajectory. Total program costs for an eight mission program would be approximately $400,000,000, exclusive of payload costs.

Lunar touchdown 3-sigma landing dispersions of one kilometer relative to targeted geological features anywhere on the visible face of the moon are proposed. These can be obtained with the use of direct descent trajectories and terminal guidance corrections based on remote television transmissions. The vehicle can be safely landed in lunar slopes of up to 35 degrees with the aid of low touchdown velocities, hold-down rockets, and a four-pad landing gear. Retro propulsion is provided by a main cryogenic stage that consists of a Pratt & Whitney RL-10A-3-3 engine, and is jettisoned after burnout at low altitude. Touchdown is accomplished with the use of a monomethyl hydrazine, nitrogen tetroxide vernier propulsion system that consists of sixteen modified Marquardt R-4D thrusters.

Other proposed major subsystems include a fuel cell and primary battery power supply, and a guidance and navigation system composed of the Lunar Module landing radar, inertial measuring unit, and modified guidance computer.

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ENGINEERING SYSTEMS DESIGN

SUMMER FACULTY FELLOWSHIP PROGRAM

The University of Houston, Rice University, and the Manned Spacecraft Center will conclude on August 19 one of four Engineering Systems Design Programs sponsored by the National Aeronautics and Space Administration and cooperating universities. The objectives of these programs are to provide information and experience to enable the participants to develop multidisciplinary systems engineering courses or programs at their home institutions; to acquaint the participants with NASA's activities and contributions to technology; and to provide NASA with a useful study of a system of current interest.

THE LUNAR LOGISTICS VEHICLE PROJECT

The participants are involved in a preliminary design of a nominally 12,000 pound translunar spacecraft to soft land approximately 2,500 pound payloads on the visible face of the moon during the 1972-1975 period. All aspects of the design are considered by the participants in as much depth as the eleven week period will allow. The facilities and staff of NASA-MSC have supported the group's activities by providing seminar speakers, individual consulting with the participants, computational support, and periodic reviews.

FACULTY FELLOWS:

DR. F. O. CALVERT, Univ. of Okla.
DR. J. H. COLE, Univ. of Arkansas
DR. F. M. DAVIDSON, Univ. of Houston
DR. I. EISENSTEIN, Purdue University
DR. CLIFT M. EPPS, Texas Technological Col.
DR. G. E. GLESS, Univ. of Colorado
DR. G. F. HAUCK, Tri-State College
DR. F. J. HENDEL, Cal. State Polytech.
DR. B. KOO, University of Toledo
DR. S. J. KOZAK, Washington & Lee Univ.
PROF. T. M. PERKINS, Western Kentucky Univ.
DR. A. J. PERNA, Newark College of Engr.
DR. G. PINCUS, University of Kentucky
DR. C. G. RICHARDS, University of N. Mexico
DR. J. E. ROBERTSHAW, Providence College
DR. J. E. ROZENBERG, Christian Bros. College
DR. A. M. STRAUSS, Univ. of Kentucky
PROF. F. R. SWENSON, Univ. of Missouri
DR. J. M. WAMPLER, Georgia Inst. of Tech.

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Cullen College of Engineering
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Asst. for Academic Relations
NASA-Manned Spacecraft Center
Houston, Texas

ASSOCIATE DIRECTORS:

DR. S. L. DICKERSON, Associate Professor
Georgia Institute of Technology

A. N. PAUL, Associate Professor
University of Houston

MR. BASS REDD
ASTD-Flight Performance & Dynamics
NASA-Manned Spacecraft Center
Houston, Texas

PROGRAM

FINAL PRESENTATION

Welcome	C. Huang
General Program	S. Dickerson
Introduction	J. Robertshaw
Configuration Design & Analysis	G. Pincus
Questions	
Dynamics	S. Kozak
Questions	
Coffee Break	
Propulsion	F. Hendel
Thermal Control	C. Epps
Questions	
Electronics, Electro-mechanical Devices	G. Gless
Conclusion	

You are invited to attend

the final presentation on a

LUNAR LOGISTICS VEHICLE

by the

University of Houston

Rice University

Manned Spacecraft Center

Engineering Systems Design

Summer Faculty Fellows

August 19, 1969
9:00 A.M.
Room 1025
Building 30
Manned Spacecraft Center
Houston, Texas

RSVP
Houston Design Program
Cullen College of Engineering
University of Houston
Houston, Texas 77004
713-748-6600, ext. 408