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GEORGE C. MARSHALL **SPACE
FLIGHT
CENTER**

HUNTSVILLE, ALABAMA

SATURN HISTORY DOCUMENT
University of Alabama Research Institute
History of Science & Technology Group

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DIGEST OF FY-65 FUNDED ADVANCED STUDIES

JULY 1966

National Aeronautics and Space Administration



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FOREWORD

This publication is one of a planned series to summarize the advanced study program for each fiscal year beginning with FY-61. A separate report will cover the study program for each fiscal year. The purpose of these documents is to provide reference information which should be helpful in planning future study programs.

The FY-65 funded studies are covered in this document. These investigations are covered under four major headings: Launch Vehicle Studies, Earth Orbital and Lunar Studies, Planetary/Nuclear Studies, and AAP Studies. The information presented on each study includes a brief description of the objectives and pertinent contract data.

SECTION I. LAUNCH VEHICLE STUDIES

A. REUSABLE AEROSPACE PASSENGER TRANSPORT: INCREMENTAL DEVELOPMENT APPROACHES

Objectives

The purpose of this study was to investigate and compare alternate routes available for development of a reusable orbital transport system in an incremental fashion, as an extension of presently approved launch vehicles. The approaches will be evaluated from the standpoints of systems utility, development risk, and cost. The yardstick for comparison will be the reusable orbital transport system previously defined as a two-stage, all reusable launch vehicle system. The study will result in the recommendation of conditionally preferred development approaches.

Contract Data

1. Contractor: Lockheed Aircraft Corporation
2. Contract No.: NAS8-20294
3. Period of Performance: Dec 65 - Oct. 66
4. Contract Amount: \$237,100
5. Code: 981-40-30
6. COR: D. Fellenz

B. REUSABLE ORBITAL TRANSPORT: LAUNCH MODE COMPARISON

Objectives

The purpose of this study is to investigate the relative merits of HTO and VTO modes of partially or fully reusable aerospace passenger transport systems. Systems analysis will focus on establishing the differences between the launch modes rather than furnishing complete systems descriptions.

Contract Data

1. Contractor: Martin-Denver
2. Contract No.: NAS8-20277
3. Period of Performance: Dec. 65 - Aug. 66
4. Contract Amount: \$51,000
5. Code: 981-40-30
6. COR: M. Akridge

C. REUSABLE AEROSPACE TRANSPORT: LAUNCH VEHICLE OPTIMIZATION
COMPUTER PROGRAM (PHASE III)

Objectives

The purpose of this effort was to develop the theory of optimizing vehicle stage sizes and propellant capacities simultaneously with the desired trajectory characteristics. The theory shall include throttle control, and step or continuously varying mixture ratio control of the stage engines. The theory will be developed into a digital computer program compatible with MSFC computation systems.

Contract Data

1. Contractor: Raytheon
2. Contract No.: NAS8-18001
3. Period of Performance: June 66 - July 67
4. Contract Amount: \$49,143
5. Code: 981-40-30
6. COR: T. Deaton/D. Fellenz

D. SATURN IB IMPROVEMENTS

Objectives

The purpose of these studies was to investigate several methods by which performance capability of the Saturn IB could be increased, including the use of a solid first stage. To be determined were the design changes necessary, performance gains attainable, impact upon facilities and ground support equipment, and cost and schedule estimates.

Contract Data

1. Contractor: Douglas Aircraft Company
 - a. Contract No.: NAS8-20259
 - b. Period of Performance: Dec. 65 - Oct. 66
 - c. Contract Amount: \$116,346
 - d. Code: 981-40-10
 - e. COR: M. Page
2. Contractor: Chrysler Corporation
 - a. Contract No.: NAS8-20260
 - b. Period of Performance: Dec. 65 - Oct. 66
 - c. Contract Amount: \$450,000
 - d. Code: 981-40-10
 - e. COR: M. Page

3. Contractor: Douglas Aircraft Company (Solid First Stage)
 - a. Contract No.: NAS8-20292
 - b. Period of Performance: June 65 - March 66
 - c. Contract Amount: \$191,000
 - d. Code: 731-03-00
 - e. COR: M. Page

E. SATURN V IMPROVEMENTS

Objectives

The purpose of these studies was to investigate potential means of increasing Saturn V payload capability or otherwise improving its design and operation. Also to be investigated is the potentially attractive use of Saturn vehicles for mission applications in the payload range between the current Saturn IB and Saturn V capabilities.

Contract Data

1. Contractor: Douglas Aircraft Company
 - a. Contract No.: NAS8-20264
 - b. Period of Performance: Dec. 65 - Nov. 66
 - c. Contract Amount: \$97,730
 - d. Code: 981-40-10
 - e. COR: R. Davies
2. Contractor: North American Aviation, Inc.
 - a. Contract No.: NAS8-20265
 - b. Period of Performance: Dec. 65 - Nov. 66
 - c. Contract Amount: \$329,624
 - d. Code: 981-40-10
 - e. COR: R. Davies
3. Contractor: Boeing Company
 - a. Contract No.: NAS8-20266
 - b. Period of Performance: Dec. 65 - Nov. 66
 - c. Contract Amount: \$400,000
 - d. Code: 981-40-10
 - e. COR: R. Davies

SECTION II. EARTH ORBITAL AND LUNAR STUDIES

A. DEFINITION OF EXPERIMENT PROGRAM IN SPACE OPERATIONS AND TECHNIQUES AND SUBSYSTEMS (EXTRAVEHICULAR MANIPULATIONS)

Objectives

The purpose of this study was to develop two concepts of manned extravehicular maneuvering/manipulation units which could enhance man's ability to inspect, maintain, repair, and erect equipment and structure in space. Two mockups of the selected concepts will be provided to aid overall concept development and configuration analysis. A preliminary program definition plan covering all phases of effort leading to a flight article will be developed.

Contract Data

1. Contractor: Ling-Temco-Vought
2. Contract No.: NAS8-20316
3. Period of Performance: March 66 - Oct. 66
4. Contract Amount: \$134,000
5. Code: 981-10-30
6. COR: D. Cremlit

B. MISSION MODES AND SYSTEMS ANALYSIS FOR LUNAR EXPLORATION (MIMOSA)

Objectives

The objectives of this study are to define and analyze potential concepts for systems applicable to lunar exploration; develop a representative lunar exploration mission spectrum for the 1970-1980 time period; define lunar exploration programs, responsive to resource constraints; and conceptually define the exploration equipment necessary to perform a variety of scientific missions.

Contract Data

1. Contractor: Lockheed Aircraft Corporation
2. Contract No.: NAS8-20262
3. Period of Performance: Jan. 66 - March 67
4. Contract Amount: \$897,000
5. Code: 981-20-30
6. COR: D. Paul

C. LUNAR SURFACE MOBILITY SYSTEMS COMPARISON AND EVOLUTION

Objectives

The objectives of this effort are to identify, evaluate, and compare a spectrum of lunar surface mobility systems, and to define and utilize a methodology by which an evolution plan for lunar surface mobility systems may be developed. This shall be considered as including rolling and flying devices with no more than 10 percent of the effort devoted to flying devices. The study was divided into three phases. Phase I was to determine the feasibility of modifying existing Apollo systems (LEM, CM, etc.) for use as lunar surface mobility systems. Phase II too was to evaluate the data gained in Phase I and develop a methodology whereby designs can be synthesized into a mobility evolution program. Phase III was to result in a reasonable and orderly evolution plan utilizing data developed in Phase II.

Contract Data

1. Contractor: Bendix Corporation
2. Contract No.: NAS8-20334
3. Period of Performance: Feb. 66 - Jan. 67
4. Contract Amount: \$499,888
5. Code: 981-20-30
6. COR: C. Darwin

D. EARLY LUNAR SHELTER DESIGN AND COMPARISON

Objectives

The purpose of this study was to develop, define, and analyze conceptual designs of optimized, 2-man, lunar personnel shelters for application in the early 1970's. The shelter is to be designed so that it and all required support equipment, other than what can be brought up by the crew in a LEM, can be delivered to the Moon by an unmanned LEM-Truck in concert with the Saturn V/Apollo system. Two shelters will be designed: One will be mission optimized allowing consideration of new systems, and the second will be an off-optimum configuration constrained to utilization of Apollo developed subsystems. A comparison of the two shelters will be accomplished.

Contract Data

1. Contractor: AiResearch Manufacturing Company
2. Contract No.: NAS8-20261
3. Period of Performance: Feb. 66 - Dec. 66
4. Contract Amount: \$200,000
5. Code: 981-20-30
6. COR: W. Powers

E. SCIENTIFIC MISSION SUPPORT FOR EXTENDED LUNAR EXPLORATION

Objectives

The primary objective of this effort is to provide an estimate of experimental systems and operational requirements for typical lunar scientific programs to establish scientific mission requirements in order to influence the definition of future lunar exploration systems starting with AAP missions. These systems and operational requirements, imposed by the science program on the lunar mission equipment, represent a vital input to a concurrent study of systems requirements for an evolutionary program of lunar exploration.

Contract Data

1. Contractor: North American Aviation, Inc.
2. Contract No.: NAS8-20258
3. Period of Performance: Dec. 65 - Aug. 66
4. Contract Amount: \$195,060
5. Code: 981-20-20
6. COR: J. Downey

F. MAN-SYSTEM LOCOMOTION AND DISPLAY CRITERIA FOR EXTRATERRESTRIAL VEHICLES

Objectives

The basic objectives of the study were to determine the feasibility of man to operate a maneuverable lunar roving vehicle in both a shirt sleeve and a space-suited environment for forward and reverse mobility situations. Combinations of steering and braking controls, field of view, lighting intensity and contrast, and crew seating were to be optimized. Operator performance and workload relative to the locomotion tasks of obstacle avoidance, terrain negotiation, and navigation between stations were to be studied. Energy management criteria were also to be developed.

Contract Data

1. Contractor: Grumman Aircraft Engineering Corporation
2. Contract No.: NAS8-20015
3. Period of Performance: April 65 - Feb. 66
4. Contract Amount: \$77,554
5. Code: 127-51-01
6. COR: C. Larson

G. LUNAR SURFACE EXPLORATION EQUIPMENT

Objectives

This effort is an experimental investigation to develop man-system design criteria for lunar scientific equipment. The study will define a prototype mission in terms of valid, quantitative parameters. Comparisons between the pressurized and unpressurized states of a suited subject are required.

Contract Data

1. Contractor: United Aircraft
2. Contract No.: NAS8-20095
3. Period of Performance: Aug. 65 - Aug. 66
4. Contract Amount: \$58,586
5. Code: 981-20-20
6. COR: P. Fisher

H. DEVELOPMENT OF TABLES FOR CELESTIAL NAVIGATION OF THE LUNAR SURFACE

Objectives

Tables will be developed for all lunar surface operations including surface vehicle operation, exploration using a Lunar Flying Vehicle, exploration on foot, and for use in setting up the LEM Inertial Measurement Unit in preparation for lift-off for return to the orbiting Apollo spacecraft.

Contract Data

1. Contractor: University of Virginia
2. Contract No.: NAS8-20274
3. Period of Performance: Dec. 65 - Jan. 67
4. Contract Amount: \$23,500
5. Code: 129-04-01
6. COR: J. Harden

SECTION III. PLANETARY/NUCLEAR STUDIES

A. LOW ACCELERATION SPACE TRANSPORTATION SYSTEMS (TRAJECTORY MODEL DEVELOPMENT)

Objectives

This effort was a continuation of the FY-64 funded study to further develop and verify a simplified trajectory model for low acceleration space transportation systems, and to utilize the model to develop criteria and requirements for low acceleration propulsion systems for manned planetary missions.

Contract Data

1. Contractor: United Aircraft Corporation
2. Contract No.: NAS8-11309 (Mod 1)
3. Period of Performance: June 64 - April 66
4. Contract Amount: \$47,111 (FY-65 Funds); Total \$132,111
5. Code: 120-26-07
6. COR: J. Russell

B. LOW ACCELERATION SPACE TRANSPORTATION SYSTEMS (SOLAR CELL POWER UTILIZATION)

Objectives

This was a continuation of the FY-64 funded study. The objective of the extension (Modification 1) was to prepare layouts of a complete spacecraft and all major subsystems for a specific mission profile and propulsion system of an optimized combination of high-low acceleration mode. Preliminary designs were to be prepared of advanced propulsion subsystems such as direct heated ionizers, and variable specific impulse thrusters with associated equipment, to determine feasibility. Interface problems were to be defined, and the optimum strategy for achieving a high overall vehicle reliability was to be determined.

Modification 2 was a further extension of the study. The objectives were to evaluate the manned, high-low acceleration Mars ferry concept utilizing solar cell electric power as a part of the propulsion system, and study the feasibility of having one basic vehicle design perform both the lunar and Mars missions.

Contract Data

1. Contractor: General Electric
2. Contract No.: NAS8-11423 (Mod 1 and 2)
3. Period of Performance: June 64 - July 66
4. Contract Amount: \$142,630 (FY-65 Funds); Total \$220,259
5. Code: 120-26-07 (Mod 1); 780-30-01 (Mod 2)
6. COR: J. Russell

C. MISSION ORIENTED STUDY OF ADVANCED NUCLEAR SYSTEMS

Objectives

The objective of this study was to identify and define the essential design requirements for a nuclear rocket propulsion system for application in the 1975 to 1985 time period. Modifications 3 through 6 to the contract extended the scope of work to expand the mission evaluations to include trade-offs and sensitivities of a Venus swingby for manned Mars stopover missions. Vehicle and engine sizing computations were to be performed, and the programs modified to incorporate additional mission concepts and parameters.

Contract Data

1. Contractor: TRW
2. Contract No.: NAS8-5371 (Mod 3 and 6)
3. Period of Performance: June 63 - March 66
4. Contract Amount: \$152,513 (FY-65 Funds); Total, \$552,000
5. Code: 122-29-04
6. COR: R. Harris

D. MODULAR NUCLEAR VEHICLES, TECHNOLOGY PROBLEMS, AND SAFETY SYSTEMS

Objectives

This was a continuation of a study to establish the overall test program requirements for developmental ground testing of the most probable nuclear rocket stages envisioned at that time. These requirements were to serve primarily as a basis for specific engine/stage test stand planning, and are necessary for preparation of work for preparation of a report required to support budgeting submissions. The report will also provide the basic data needed for detailed design of the test stands.

Contract Data

1. Contractor: Lockheed Aircraft Corporation
2. Contract No.: NAS8-20007
3. Period of Performance: Jan. 65 - Jan. 66
4. Contract Amount: \$396,920 (FY-65 Funds)
5. Code: 122-29-04 (Mod 1); 121-30-04 (Mod 2)
6. COR: W. Jordan

SECTION IV. AAP STUDIES

A. LOCAL SCIENTIFIC SURVEY MODULE (LSSM)

Objectives

The objectives of this effort were to perform a preliminary design study and program definition of an LSSM, which is a small lunar surface vehicle. The LSSM will provide astronauts with local mobility for transportation from the Shelter-Laboratory, and will provide a means of deploying scientific equipment. The vehicle is to be capable of transporting an astronaut/scientist and at least 150 kg (330 lbs.) of equipment for round trips of at least 16 km in traversed distance.

Contract Data

1. Contractor: Bendix Corporation
 - a. Contract No.: NAS8-11287
 - b. Period of Performance: June 65 - Aug. 66
 - c. Contract Amount: \$1,370,000
 - d. Code: 908 (200K); 981 (1,170 K)
 - e. COR: H. Schaefer
2. Contractor: Boeing Company
 - a. Contract No.: NAS8-11411
 - b. Period of Performance: June 65 - Aug. 66
 - c. Contract Amount: \$1,365,000
 - d. Code: 908 (195K); 981 (1,170K)
 - e. COR: H. Schaefer

B. MAN-SYSTEM CRITERIA FOR EXTRATERRESTRIAL SURFACE ROVING VEHICLES

Objectives

This study covers a man-system integration investigation for a lunar surface roving vehicle to establish cabin volume, sleeping and work accommodations, and crew safety design criteria.

Contract Data

1. Contractor: Honeywell Incorporated
2. Contract No.: NAS8-20006
3. Period of Performance: Feb. 65 - May 66
4. Contract Amount: \$152,000
5. Code: 127 (89K); 908 (51K); 127 (11K)
6. COR: H. Grubbs

C. OPTICAL SYSTEM FOR AAP

Objectives

The objectives of this study were to examine in detail the technical, operational, and programmatic feasibility of adapting the GEP (Goddard Experimental Package) to AAP lunar surface missions; to define the range of scientific investigations which could be conducted with GEP instruments used with AAP; and to make an initial assessment of the type of optical astronomy equipment which may be desirable for post-AAP lunar surface missions.

Contract Data

1. Contractor: Kollsman Instrument Corporation
2. Contract No.: NAS8-20132
3. Period of Performance: June 65 - Feb. 66
4. Contract Amount: \$144,000
5. Code: 981-20-20
6. COR: E. Wells

D. RESEARCH PROGRAM ON RADIO ASTRONOMY AND PLASMA FOR AAP LUNAR SURFACE MISSIONS

Objectives

The objectives of this investigation were to evaluate the suggested radio astronomy and plasma program and propose other possible experiments for lunar surface missions. A detailed discussion of the advantages of performing the various suggested experiments on the lunar surface compared to Earth-based equipment, Earth-orbital missions, etc., will be furnished. Detailed descriptions will be developed of the corresponding instrumentation, operational procedures, and techniques that will permit accomplishment of the suggested experiments.

Contract Data

1. Contractor: North American Aviation, Inc.
2. Contract No.: NAS8-20198
3. Period of Performance: June 65 - June 66
4. Contract Amount: \$98,226
5. Code: 981-20-20
6. COR: A. Weber

E. SCIENTIFIC MISSION/INSTRUMENT STUDIES

Objectives

The objectives of this effort were to study potential AAP lunar surface missions with emphasis on communications and operational problems; study system integration of scientific instruments into compatible packages with emphasis on data handling and telemetry, power, thermal control, packaging, and human factors; perform conceptual engineering instrument designs; and generate a detailed resources plan.

Contract Data

1. Contractor: Bendix Corporation
2. Contract No.: NAS8-20199
3. Period of Performance: May 65 - July 66
4. Contract Amount: \$298,779
5. Code: 981-20-20
6. COR: J. Downey

F. STUDY OF MANNED FLYING SYSTEMS

Objectives

The objectives of this study were to produce preliminary conceptual designs, development plans, system specifications, and preliminary estimates of development schedules and costs for manned lunar flying systems. A baseline vehicle will be studied to which can be added, as desired, additional subsystems or components to enhance accomplishment of a designated mission.

Contract Data

1. Contractor: Bell Aerosystems Company
2. Contract No.: NAS8-20226
3. Period of Performance: June 65 - April 66
4. Contract Amount: \$489,898
5. Code: 981 (300K); 908 (190K)
6. COR: L. Bradford

G. LOW THRUST THROTTLEABLE ENGINE PERFORMANCE
EVALUATION (MFS ENGINES)

Objectives

This program was to demonstrate the feasibility of modifying engines currently in an advanced state of development to meet the propulsion requirements of lunar manned flying systems. The data gained will be input to the MFS study.

Contract Data

1. Contractor: Bell Aerosystems Company
 - a. Contract No.: NAS8-20086
 - b. Period of Performance: June 65 - June 66
 - c. Contract Amount: \$58,570
 - d. Code: 908-40-22
 - e. COR: L. Bradford
2. Contractor: TRW
 - a. Contract No.: NAS8-20248
 - b. Period of Performance: June 65 - April 66
 - c. Contract Amount: \$106,413
 - d. Code: 908-40-22
 - e. COR: L. Bradford

H. R & D MICRO-MINIATURIZATION TECHNIQUES AND ITS ADAPTIBILITY
TO RADAR ALTIMETERS (MFS ALTIMETER)

Objectives

The objective of this study was to determine, through basic R & D, the extent that micro-miniaturization can be adapted to the next generation space vehicle program. The goals in this area were to obtain higher reliability, longer operating life, and savings in space and weight.

Contract Data

1. Contractor: Westinghouse Electric Corporation
2. Contract No.: NAS8-11682
3. Period of Performance: June 65 - May 66
4. Contract Amount: \$732,931, Total; \$145K, FY-65
5. Code: 908-40-22 (FY-65)
6. COR: Mr. Case

I. MOBILITY TEST ARTICLE

Objectives

The purpose of these studies was to design, develop, and fabricate a model to serve as a 1/6 g Mobility Test Article for the mobility design concept of lunar surface vehicles. The MTA was to provide accurate simulation of the contractor's LSV concept and be flexible and adaptable to all subsystems and alternates which may be suitable for comprehensive LSV mobility system development testing. The MTA will provide a means of evaluating LSV surface mobility performance, maneuverability, stability, dynamic behavior, and overall performance.

Contract Data

1. Contractor: General Motors
 - a. Contract No.: NAS8-20251
 - b. Period of Performance: June 65 - May 66
 - c. Contract Amount: \$389,528 (FY-65)
 - d. Code: 908-40-22
 - e. COR: H. Shaefer
2. Contractor: Bendix Corporation
 - a. Contract No.: NAS8-20252
 - b. Period of Performance: June 65 - April 66
 - c. Contract Amount: \$400,000
 - d. Code: 908-40-22
 - e. COR: H. Shaefer

J. SURFACE VEHICLE NAVIGATION SYSTEM

Objectives

The objective of this effort was to provide a state of the art navigation system suitable for use in the Lunar Mission Development Vehicle acquired by NASA for the USGS. The system will incorporate elements that allow determination of position on the surface of Earth and headings. It will include an automatic deadreckoning capability for use between locations where position fixes may be taken.

Contract Data

1. Contractor: Bendix Corporation
2. Contract No.: NAS8-20273
3. Period of Performance: Sept. 65 - June 66
4. Contract Amount: \$58,000
5. Code: 908-40-22
6. COR: J. Harden

K. PRELIMINARY DESIGN OF A LUNAR GRAVITY SIMULATOR

Objectives

This effort is to result in a preliminary design study of the major components of a lunar gravity simulator to be used in connection with testing manned lunar surface vehicles.

Contract Data

1. Contractor: Lockheed Aircraft Corporation
2. Contract No.: NAS8-20351
3. Period of Performance: June 66 - Nov. 66
4. Contract Amount: \$29,829
5. Code: 981-20-20
6. COR: H. Shaefer

L. HUMAN FACTORS: VISUAL SIMULATION

Objectives

The objectives of this study were to evaluate mobility system emergency modes under the same experimental conditions used for analysis of driving under normal conditions, so a direct comparison between normal and emergency vehicle control performance can be made. Mobility system malfunctions will also be investigated. Optimum display control configurations for the LSSM vehicle concepts will be established. These data will be analyzed to provide criteria and recommendations for optimum display and control panel configurations.

Contract Data

1. Contractor: North American Aviation, Inc.
2. Contract No.: NAS8-20283
3. Period of Performance: Dec. 65 - Sept. 66
4. Contract Amount: \$42,000
5. Code: 908-40-22
6. COR: Mr. Larson

M. CRYOGENIC STORAGE SYSTEM (AAP PAYLOAD)

Objectives

The purpose of this effort was to develop the technology and capability required to design light weight cryogenic storage systems for AAP payloads such as a local reconnaissance module or a lunar shelter. This data would be used by selected hardware contractors for the subsequent overall system design of a cryogenic system for the applicable payload.

Contract Data

1. Contractor: Boeing Company
2. Contract No.: NAS8-20272
3. Period of Performance: Jan. 66 - Oct. 66
4. Contract Amount: \$89,698
5. Code: 908-40-22
6. COR: A. Bowling

N. IN SITU LUNAR SAMPLE ANALYSIS

Objectives

The purpose of this study was to establish appropriate techniques for geochemically and petrologically analyzing lunar materials. Functional instrument prototypes were to be provided, and an instrument development program which would be compatible with AAP would be recommended

Contract Data

1. Contractor: Goddard Space Flight Center
2. Contract No.: Sub-allotment
3. Period of Performance: April 65 - May 66
4. Contract Amount: \$200,000
5. Code: 908-40-13
6. COR: N. Costes