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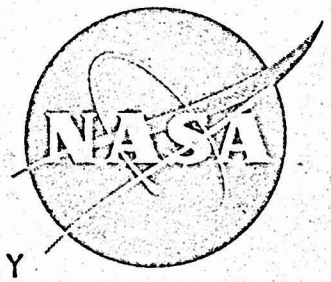
MSFC SYSTEMS ENGINEERING CAPABILITIES

(Abstracts of Reports)



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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GEORGE C. MARSHALL SPACE FLIGHT CENTER

MTP-FPO-61-6

November 1, 1961

MSFC SYSTEMS ENGINEERING CAPABILITIES

(Abstracts of Reports)

FUTURE PROJECTS OFFICE

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GEORGE C. MARSHALL SPACE FLIGHT CENTER

MTP-FPO-61-6

MSFC SYSTEMS ENGINEERING CAPABILITIES

(Abstracts of Reports)

FUTURE PROJECTS OFFICE

ABSTRACT

Abstracts of a group of 150 typical reports issued by MSFC personnel during the past four years are compiled in this report. The purpose of this abstract volume is to demonstrate the broad experience, capabilities and talents available at the George C. Marshall Space Flight Center in the area of SPACE TRANSPORTATION SYSTEMS ENGINEERING. Excellent background material for "state of the art" of Saturn Vehicle program in 1961.

INTRODUCTION

This report is a compilation of abstracts from technical studies accomplished by MSFC personnel in the past four years under the Army and NASA sponsorship. This group of 150 reports has been selected as a typical cross section of system engineering activities at this facility. The purpose of this abstract report is to demonstrate the broad experience, capabilities and talents available at the George C. Marshall Space Flight Center in the area of space transportation systems engineering. The 150 reports selected represent only a small portion of the total number of engineering studies accomplished by this group in recent years.

The individual abstracts are compiled according to subject under ten (10) major sections. For quick reference, titles of all reports used are listed by page number in the Table of Contents. Of particular interest might be the Lunar Systems Study (Sec. I. C. p. 13) completed early in 1959 and carried out on an Army-wide basis, the technical contents of which were also coordinated by personnel of MSFC. This project proposal showed a realistic approach to establishing a 12-man lunar base by 1967/68, using SATURN vehicles and the orbital operations mode.

This abstract volume covers only in-house studies. A great number of out-of-house studies (30 in FY 1961, alone) sponsored and coordinated by MSFC in the area of space transportation systems, are not included in this report. They will be summarized at a later date.

This report was compiled and edited by the Future Projects Office of the George C. Marshall Space Flight Center.

I. SYSTEM STUDIES AND PROPOSALS

SATURN SYSTEMS STUDY (PHASE I)

Secret Rpt., DSP-TM-1-59, March 13, 1959, 247 pages, illustrated
Coordinated and Edited by H. H. Koelle, F. L. Williams, W. G. Huber

ABSTRACT

This report summarizes the results of a systems study where 1375 possible SATURN configurations were screened. Fourteen of the most promising configurations were studied in detail. They represent basically four families, all using the basic 8 H-1 engine booster: (1) ATLAS family, (2) TITAN family, (3) CENTAUR family and (4) large O_2/H_2 family. The most promising configurations of each of the first two families were studied in great detail, because they seemed to be most attractive as a compromise between early availability, available resources and mission reliability. The growth potential of the basic SATURN family was emphasized.

The purpose of the report was to assemble all pertinent data needed for a decision by ARPA on a tentative SATURN vehicle configuration.

SATURN SYSTEM STUDY II

Confidential Rpt., DSP-TM-13-59, Nov. 13, 1959, 124 pages, illustrated by Development Operations Division, ABMA

ABSTRACT

The second SATURN System Study, requested by ARPA, was initiated to investigate the possibility of more optimum upper stages after removal of the initial restrictions of using available components from the ICBM program. The alternate configurations, their performance, various schedules, and funding requirements are presented. A 220-inch diameter is recommended for use in the upper stages. Chapters I through IV of this report are a summary of the study, and Chapter V covers the detailed technical discussion and background material.

SATURN C-1 VEHICLE PROJECT DEVELOPMENT PLAN

Confidential Report, August 10, 1961, 170 pages, illustrated
by SATURN Systems Office

ABSTRACT

This report represents the project development plan for the SATURN C-1 vehicle system. This plan provides for the development of a two-stage SATURN C-1 launch vehicle based on the primary mission requirement to place unmanned and manned APOLLO spacecraft into earth orbits. The report contains a project summary, justification, history, description of the technical approach, plans for management, procurement and operations, schedules and estimates of resource requirements.

THE NOVA (Liquid) VEHICLE
A PRELIMINARY PROJECT DEVELOPMENT PLAN

Confidential Rpt., October 27, 1960, illustrated
by Lunar Planning Committee

ABSTRACT

The Preliminary NOVA Project Development Plan describes the Liquid NOVA, a general purpose space vehicle designed with the primary objective of providing a heavy weight lifting capability for carrying out our nation's advanced space programs. The plan deals with various aspects of the proposed development program including the engineering, manufacturing, facility, scheduling, and historical phases. Emphasis has been placed on the Technical Plan.

The proposed vehicle is a large, multi-stage design measuring approximately 360 feet in overall length and weighing in excess of 10 million pounds at lift-off. Its basic capabilities will include placing 350,000 pounds of payload in a 300-mile earth orbit or imparting escape velocity to 180,000 pounds of payload.

A comprehensive technical discussion of each stage of the launch vehicle is presented in the Preliminary NOVA Project Development Plan. Principal areas covered by the Technical Plan include performance characteristics, propulsion systems, structural systems, manufacturing concepts, quality and reliability control, transportation and launch operations. The Technical Plan includes several unique approaches for solving development problems such as those created in the manufacturing, testing, and transportation areas as a direct result of the enormous size of the N-I stage.

The Preliminary NOVA Project Development Plan proposes a 10-vehicle development program using the block concept of progressive development. Facility requirements, scheduling, and mission objectives are discussed as a function of this proposed program.

ABMA PRESENTATION TO THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (U)

Secret ABMA Rpt. Nr. D-TN-1-59, 15 December 1958, 149 pages, illustrated.

By
Dr. Wernher von Braun, Mr. H.H. Koelle, Dr. Ernst Stuhlinger

ABSTRACT

At the request of the National Aeronautics and Space Administration, ABMA and AFBMD made presentations on vehicular programs for the national space flight program at NASA Headquarters in Washington, D.C., 15 December 1958.

The ABMA presentation was broken down into the following four parts:

Present and Future Vehicles and Their Capabilities	Dr. W. von Braun
Vehicle-Mission Compatibility and System Integration	Mr. H.H. Koelle
ABMA Contributions in the Area of Earth-Launched Vehicles	Dr. W. von Braun
Vehicle Components and Research Objectives	Dr. E. Stuhlinger

This publication documents the ABMA presentation. The text was prepared from the stenotype copy of the proceedings. Replicas of the charts have been inserted in the text at the point of first reference. A limited number of NASA reports which document the complete proceedings will also be available in the near future.

A STUDY OF TYPICAL ENGINEERING SATELLITE PAYLOADS

Unclassified ABMA Rpt. Nr. DSP-TM-6-59, 12 August 1959, 59 pages, illustrated.

By
Alfred P. Warren

ABSTRACT

This report contains the results of a study on engineering satellites. The requirement for such a satellite is discussed together with a description of three typical payload vehicles varying from a 100-lb non-recoverable to a 16,000-lb combination recoverable and non-recoverable system. Several vehicle configurations, experiments and operational procedures are described and illustrated together with a development schedule and cost estimates for a typical engineering satellite program.

A brief description is presented in Appendix A of engineering experiments received from a canvass conducted at ABMA and the Army Signal Corps.

A LUNAR EXPLORATION PROGRAM BASED UPON SATURN-BOOSTED SYSTEMS (U)

Confidential Rpt., DV-TR-2-60, 1 February 1960, 381 pages, 54 figures, 80 tables.

ABSTRACT

This is the final technical report on the Lunar Soft Landing Study, accomplished by the Development Operations Division of the Army Ballistic Missile Agency for the National Aeronautics and Space Administration under NASA Order HS-219. The report covers accomplishments during the period 1 July - 31 December 1959.

The study covers the soft landing on the moon of a stationary payload and a payload with roving capability, and the circumnavigation of the moon by a manned vehicle with subsequent recovery on earth.

This report covers the same subjects as the smaller interim technical report of 1 October 1959, but in much more detail and scope. It describes the SATURN launch vehicle for the lunar missions, the guidance and control requirements, the injection and post-injection guidance schemes, tracking requirements, the lunar approach trajectory and the lunar soft landing guidance scheme. It describes the circumlunar orbit and flight mechanics for earth re-entry for the manned payload.

Detailed designs for the soft landing stationary and roving payloads are presented, including detailed analyses of the thermal design and materials problems. The scientific lunar surface exploration plan is described in detail, including a discussion of the influence of the lunar enviroment, a discussion of the most favorable landing sites, details of twelve scientific instruments, description of a program for operation of the instruments, and the communication system. Schemes and vehicles for manned circumlunar flights and manned lunar landings are described. Power supplies for the stationary and roving payloads are described in detail. Finally, a method of implementing the project is described, including aproposed organization, a listing of required future efforts, a test and training program, and ground support and launch site facilities.

SATURN 24-HOUR COMMUNICATION SATELLITE SYSTEM DEVELOPMENT PROPOSAL

Confidential Rpt., November 30, 1959, 460 pages, illustrated

By

U. S. Army Ballistic Missile Agency
U. S. Army Signal Research and Development Laboratory

ABSTRACT

This report proposes the development of a system of communication satellites to be placed into the 24-hour equatorial orbit by the SATURN launch vehicle and for installation of three ground stations for engineering tests and evaluation of the system. It is the purpose of this program to provide for the necessary research and development effort leading to an operational, secure, military communication satellite system in the time frame 1965-1970. The proposed program encompasses a total of ten satellite launchings. The report contains in Vol. I (Preliminary Design Characteristics) the results of a complete system study, and descriptions of all communications satellite and launch vehicle subsystems, trajectories and operations. Vol. II (Funding, Schedules and Management) contains cost estimates, schedules and a proposed management plan.

THE APOLLO "A"/SATURN C-1 LAUNCH VEHICLE SYSTEM

Confidential Rpt., MPR-M-SAT-61-5, July 17, 1961, 360 pages, illustrated
by SATURN Systems Office

ABSTRACT

This report is a compilation of technical information on the APOLLO "A"/ SATURN C-1 two-stage launch vehicle system. It contains a complete description of all subsystems, and of the trajectories, performance, dynamics and operation of the two-stage SATURN C-1 launch vehicle. The primary purpose of this report is to provide prospective bidders for the APOLLO spacecraft contract with information on the SATURN C-1 launch vehicle system. It may also be used to acquaint NASA personnel with the SATURN C-1 as applied to Project APOLLO "A".

PROJECT HORIZON
A U.S. ARMY STUDY FOR THE ESTABLISHMENT OF A LUNAR MILITARY OUTPOST
(U)

Secret U.S. Army Report, four volumes, 8 June 1959, total 720 pages, illustrated.

ABSTRACT

The objective of Project HORIZON is the establishment of a lunar base. This feasibility study was conducted by the technical services of the U.S. Army upon request of the Chief of Research and Development, the Department of the Army (letter dated 20 March 1959). The prime responsibility for this study was assigned to the Army Ordnance Missile Command, the technical coordination to the Development Operations Division, ABMA. This four-volume report was completed and submitted early in June, 1959.

The major conclusions resulting from this study are:

1. The establishment of a lunar base is highly desirable.
2. The establishment of a lunar base by 1966 is feasible by using SATURN-class vehicles and orbital operations, assuming project initiation by July, 1959.
3. The outlined development program will lead to the accomplishment of the desired objective earlier than any other program.

The four volumes of this report are entitled:

Volume I	Summary	39 pages
Volume II	Technical Considerations and Plans	289 pages
Volume III	Operational Aspects	139 pages
Volume IV	Technical Services Capabilities and Support	233 pages

II. MISSION COST AND ANALYSIS

MANNED LUNAR LANDING: THE PROBABILITY OF MISSION SUCCESS (U)

Confidential Internal Note, M-FPO-1-61, September 8, 1961, 35 pages, illustrated.

By
H.O. Ruppe, W.G. Huber, J.C. Hughes

ABSTRACT

This study is concerned with the development of a rational decision regarding the "best" method for performing the lunar-landing mission. A method for deriving such a decision is developed and applied to a numerical example. The input data for the numerical example are felt to be typical, but are "best" estimates only; the results, therefore, serve to illustrate trends, but should not be taken too seriously.

In addition to the criterion developed in this study, many other factors influence a final decision, e.g., cost, availability and state of the art. The result of this study, therefore, is no more than one input toward a proper systems analysis, where the goal is to replace opinion with rational argument.

COMPARISON OF LUNAR AND MARTIAN MISSION REQUIREMENTS AND PAYLOAD CONVERSION FACTORS

Unclassified Paper presented to the XIIth International Astronautical Congress, Washington, D.C., October, 1961, 36 pages, illustrated.

By
H.H. Koelle,* H.O. Ruppe,** H.F. Thomae***

ABSTRACT

The mission planner requires convenient "payload conversion factors" to distribute the space-flight resources properly over the great number of missions of interest. These payload conversion factors provide dimensionless mission factors based on a reference mission, such as a soft lunar landing. This paper gives such conversion factors between Lunar and Martian missions for both cargo and personnel. As a first approximation, it can be stated that one pound of cargo soft-landed on the Lunar surface is equivalent to one pound of cargo soft-landed on the Martian surface. A one-man round trip between the Earth orbit and the Martian surface is five times as expensive as the equivalent trip to the Moon, if minimum energy transfer (Hohmann) is used. This increases to a factor of 25 in case of a fast trajectory with a round-trip travel time of 500 days with a stay time on Mars of 100 days. The realization of this mission can be expected about 1970, using early nuclear propulsion in both cases. One million pounds of initial launch vehicle weight per man in the Earth orbit can be used as a planning figure for the latter case.

A quantitative analysis and comparison of chemical, nuclear heat exchanger, and nuclear electric propulsion systems indicate that the latter becomes competitive only for long transfer times and in the period of 1975 and beyond.

An estimate of round-trip cost between the Earth surface and the Lunar surface shows initial cost of approximately 15 million dollars per man in 1968, dropping down to less than one million dolllars around 1974. The round-trip cost to Mars is approximately 50 million dollars per man in 1970 and might come down to one million dollars per round trip by 1980.

* *Director, Future Projects Office, MSFC.
**Special Assistant to the Director, Future Projects Office, MSFC.
***Special Assistant to the Chief, Dynamic Analysis Branch, Aeroballistics Division, MSFC.

BASIC REQUIREMENTS FOR THE EXPLORATION OF JUPITER AND ITS MOONS

Unclassified ABMA Rpt. Nr. DSP-TR-1-60, 4 March 1960, 57 pages, illustrated.

By
Warren H. Straly & Robert G. Voss

ABSTRACT

This report establishes the basic requirements for exploring the planet Jupiter and its moons.

Jupiter, the largest planet in mass and size and occupying a central position in our solar system, is some four hundred million miles from Earth; its mass amounts to more than 300,000 fold. Past observations of the great planet and its satellites have made major contributions to astronomical knowledge. In the light of this knowledge, it is very desirable that a probe or other exploration of the Jovian system be made as soon as practicable.

This report is concerned largely with the compilation of knowledge made available from studies of physical phenomena concerning Jupiter, and the application of this knowledge to the areas of space-flight mechanics and space-system design. These two broad areas serve to form a basis for the investigation of the requirements necessary for exploration. Communications and data transmission, guidance and control, auxiliary power sources, and flight environment are examined in the light of energy requirements, trajectories, orbital navigation, large transfer times, vehicle capabilities, mission objectives, and payload characteristics.

Consideration is also given to the time element involved in any exploration of Jupiter. It would obviously be very inefficient,and perhaps economically impracticable, to spend a very long time sending a payload to Jupiter which was only capable of short-time operation in the vicinity of the objective. This time element is, of course, related to the mission objective and vehicle capabilities, but it deserves special emphasis because it is the key to the establishment of feasibility...

PROPULSION REQUIREMENTS FOR EMERGENCY RECOVERY AT NEAR ESCAPE VELOCITIES

Unclassified Rpt., MTP-M-S&M-F-61-6, March 10, 1961, 43 pages, illustrated.

By
D.W. Fellenz, W.E. Thompson, C.M. Akridge

ABSTRACT

This study is based on the assumption that a lunar mission has to be aborted at certain supercircular conditions shortly before regular cutoff. The minimum velocity and propulsion requirements to return the payload to the shallowest non-skipping entry conditions were evaluated for different cutoff altitudes and flight path angles, range of thrust-to-weight ratios, and fixed thrust-vector-orientation angles. The velocity losses due to aerodynamic drag during continued ascent were also evaluated. Consideration of both aspects indicates the most suitable cutoff conditions for a lunar mission.

MANNED EARTH-LUNAR TRANSPORTATION SYSTEMS

Unclassified Rpt., MTP-M-S&M-F-60-4, November 28, 1960, 17 pages, illustrated.

By
James H. Hurst & Robert G. Voss

ABSTRACT

The purpose of this preliminary study is to present the basic weight requirements for a typical Earth-Lunar transportation system. Data are obtained using typical APOLLO type vehicle weights of 14,000, 15,000, 16,000 and 17,000 pounds by considering flight times of 51, 60, and 72 hours. The transportation system is considered as three distinct phases, each with its own assumptions concerning weights, propulsion and velocity requirements. The phases are:

1. Launch from earth orbit
2. Lunar landing
3. Lunar launch

The results are presented in Figures 1 through 4 and summarized in Tables I through III.

THE INDIRECT LUNAR APPROACH SCHEME

Unclassified Rpt., MTP-M-S&M-F-60-2, October 17, 1960, 35 pages, illustrated.

By

Warren H. Straly

ABSTRACT

This scheme, the indirect approach method, lends itself to the use of ferry vehicles between the earth, moon, and planets. Use of this technique is envisioned as mandatory when these ferry vehicles utilize low-thrust propulsion. These low-thrust vehicles are incapable of landing directly on a central body; therefore, they must orbit it, and use a high-thrust propulsive system to soft-land their cargo. Re-entry techniques and landing operations should use the indirect approach since a maneuverable, low-angle approach to the surface, easily accomplished, similar to a standard aircraft landing, may be desirable.

Adoption of the indirect approach scheme for both outboard lunar and planetary flights and return flights to the earth will result in a reasonable and realistic exploration program, either manned or unmanned. The indirect scheme will allow most of the major problem areas, such as guidance, control, propulsion, communications, etc., to be resolved in unmanned missions before an APOLLO-type mission is attempted. Specialized experiments can be accomplished to greater advantage by this method. Seismic exploration of the moon and planets is a vivid example. Other capabilities are unique to the indirect landing approach; e.g., predetermination of landing sites at no extra propulsive costs, monitoring of landing sequences, communications staging, etc. In summary, increased overall reliability, expanded mission capability, and greater program flexibility are inherent with the indirect approach method.

ECONOMY OF SPACE FLIGHT

Unclassified Rpt., MTP-M-FPO-60-2, October 28, 1960, 130 pages, illustrated.

By
H.H. Koelle & W.G. Huber

ABSTRACT

This report summarizes all areas of space-flight economy; for example:

1. Trends in Transportation Cost
2. Resources
3. Space-Flight Expenditures
4. Elements of Space-Flight Cost
5. Development and Production Cost
6. Experience Curves
7. Definitions of Cost Parameters
8. Typical System Cost
9. Trends of Orbital, Lunar and Planetary Mission Cost
10. Expected Space-Flight Capabilities

Relationships between individual parameters are also investigated in this report.

ON THE OPTIMUM SIZE OF ORBITAL CARRIER VEHICLES BASED ON OVERALL ECONOMY

Unclassified Paper submitted for presentation to the 11th International Astronautical Congress of the International Astronautical Federation, Stockholm, Sweden, 15 - 30 August 1960, 32 pages, illustrated.

H.H. Koelle
Director, Future Projects Office

ABSTRACT

This study is a first and rather crude attempt to develop a procedure which can supply the answer to whether, and when, we need larger launch vehicles than currently developed. The preliminary results of numerical calculations indicate the trends to be expected. It is concluded that operational considerations, rather than economy, will determine the vehicle size, since much larger vehicles would result in only small savings in cost.

The approach taken was as follows: Velocity requirements for a typical low altitude orbit, engine performance, and structural ratios have been assumed for typical orbital carrier vehicles. These assumptions, when combined, result in vehicle weights and payload capabilities as functions of vehicle size. Adding operational assumptions, such as, mission reliability, annual transport volume, pad time, etc., results in certain firing rates and the number of launch pads required. Combining all these parameters with specific cost data on the vehicle facilities, and operation, one can determine the total operating cost and the specific cost in dollars per pound of the payload delivered into the specified orbit. This parameter is a very good indication of the efficiency of the transportation system under consideration, and one of the important factors in determining the most desirable vehicle size.

This approach, with a more refined study, will answer, in a satisfactory manner, the question as to which is the most desirable launch vehicle size for large scale space transportation as a function of the annual transport volume.

ON THE ECONOMY OF RECOVERABLE TWO-STAGE ORBITAL CARRIER VEHICLES

Unclassified Paper presented at the ARS 14th Annual Meeting, Washington, D.C., November 16-20, 1959, 27 pages, illustrated.

By
H.H. Koelle & H.F. Thomae

ABSTRACT

This paper presents a convenient method for calculating the approximate overall costs per flight and specific costs per pound net payload in orbit for generalized two-stage orbital carriers for a broad range of parameters such as individual payload capabilities, specific hardware costs, number of flights per year and number of years of operation. Two more parameters are introduced by the assumption that both stages are recoverable. The LOX/RP boost stage is recovered by means of wings and turbojets over a downrange distance of approximately 800 km with horizontal landing. The second stage represents the return vehicle from orbit. In this manner, specific recovery gear costs and rejuvenation costs consitute another set of parameters which are also varied over a wide range of practical application.

For the sake of simplification, constant velocity losses due to air drag and gravity are assumed and, by considering a typical circular 96-minute orbit (306.6 nautical miles), the resulting overall vehicle mass ratio is divided into such parts as to provide a reasonable velocity contribution by the first stage. Some other less important factors such as payload compartment weights, amount of required propellants for mixture ratio shift, and flight performance reserve are assumed to be linear functions of net payload, propellant loadings, and of the velocity requirement, respectively. Furthermore, the weight of the guidance unit and the price per pound propellant were set equal to a constant.

Results are presented in a series of graphs which illustrate the problem and indicate development trends. These results make comparisons between multistage orbital carrier vehicles with partial or no recovery, and fully recoverable two-stage orbital carrier vehicles,possible. Thus, design criteria can be derived for two-stage fully recoverable orbital carrier vehicles to be economically equal or better than multistage partially or non-recoverable systems. Furthermore, a numerical comparison indicates that the fully recoverable two-stage system may prove economically superior to the three-stage concept.

OVER-ALL ECONOMY COMPARISON OF TWO-STAGE CHEMICAL-NUCLEAR AND THREE-STAGE CHEMICAL ORBITAL CARRIER VEHICLES

Unclassified Rpt., MTP-M-S&M-F-60-3, October 28, 1960, 44 pages, illustrated.

By
R.G. Voss, W.H. Straly, J.H. Hurst

ABSTRACT

The purpose of this study is to compare the overall economy of transporting large volumes of payload into a typical low-altitude orbit using three-stage chemical vehicles and two-stage nuclear-chemical vehicles.

In comparing these two types of transport vehicles, take-off weight and desired annual transport volume are allowed to vary. Vehicles of each type are sized to represent a span of take-off weights yielding a span of payload capabilities. These transporters or orbital carriers are typical of their class and are based on the velocity requirements for a typical low altitude orbit. Operational assumptions, concerning mission reliability and pad time, establish firing rates and launch pad requirements for a given annual transport volume.

The total operating cost can be determined by combining these data with specific cost data on the vehicles, facilities, and operations. The total operating cost can be converted into specific cost in dollars per pound of payload delivered into orbit, and it is this parameter which is used to indicate the economy of the transportation systems under consideration.

Under the given assumptions the results show a similar economy of operation for the three-stage chemical vehicle and the two-stage chemical-nuclear vehicle. To make the comparison more comprehensive, the effect of increasing the reliability and the total development cost of the chemical-nuclear two-stage is studied.

HOW MUCH SPACE FLIGHT CAN WE AFFORD?

Unclassified Paper Presented to American Rocket Society Space Flight Report to the Nation/New York Coliseum, October 9-15, 1961
by H. H. Koelle

ABSTRACT

The techniques of space transportation are expected to progress rather rapidly in the next two decades, and reduce the cost for a round trip to an earth orbit or to the moon by orders of magnitude.

The trends of such round trip costs and national capabilities versus time, for orbital and lunar transportation, are investigated in this paper. Large manned orbital space stations should become economically feasible in the 1968/69 period. Resources and the state of the art will permit the establishment of a permanent manned station on the moon by 1970 which could, if desirable, grow into a lunar settlement by 1975. It seems possible that manned planetary expeditions could start in the 1972/74 period. Calculations show further that, by 1975, approximately 5,000 man round trips from the earth surface to a low altitude orbit could take place yearly. In addition to this operation, approximately 500 annual man round trips from the earth to the moon could be financed. These figures indicate that commercial manned space flight is expected to develop in the 1975 to 1980 period. It will be witnessed by the middle-aged generation of today, with the younger generation of today taking an active part in it.

The opinions expressed in this paper are those of the author and not of the National Aeronautics and Space Administration.

LONG RANGE PLANNING FOR SPACE TRANSPORTATION SYSTEMS

Unclassified NASA Technical Note D-597, January, 1961, 36 pages, illustrated.

By
H.H. Koelle
Director, Future Projects Office

ABSTRACT

Integrated space operations planning is based upon balancing the available resources with expected expenditures in the areas of research and development, facilities, payloads, and basic space transportation. Some system parameters effecting long-range planning for launch vehicles are discussed in detail. Trends in space transportation cost for earth-orbital, earth-lunar, and earth-planetary missions for the next decade are given, based on typical programs.

III. SYSTEMS ENGINEERING

PROPOSAL FOR STANDARD WEIGHT DEFINITIONS FOR SPACE VEHICLES

Unclassified ABMA Rpt. Nr. DSP-TR-6-59, 10 December 1959, 27 pages, not illustrated.

By
H.H. Koelle

ABSTRACT

This list of symbols and definitions of space vehicle parameters was developed at ABMA over a five-year period for purposes of preliminary design and evaluation of multistage missiles and space vehicles.

When more fully developed, this list may eventually be used as standard throughout Government agencies and industry for uniform comparison procedures.

These definitions will also be used in the forthcoming "Handbook of Astronautical Engineering" to be published by McGraw-Hill Book Company.

Corrections and suggestions for changes should be forwarded to the author: H.H. Koelle, 4522 Panorama Drive, Huntsville, Alabama.

OPTIMIZATION CONSIDERATIONS FOR ORBITAL PAYLOAD CAPABILITY

Unclassified Reprint from VIIIth International Astronautical Congress, Barcelona, 1957, 12 pages, illustrated.

By
H.H. Koelle

ABSTRACT

Various phases of orbital techniques and optimization of orbital carrier vehicles are discussed in detail. Design criteria for "optimum" solutions are mentioned. Special emphasis is being placed on the selection of orbit and ascent trajectory parameters. The difference in requirements for elliptical and circular orbits is explained. Means and procedures how (nearly) circular orbits can be obtained are discussed in detail. Three diagrams are illustrating the influence of the main parameters on Payload-Lifetime capability. It is finally concluded that the VANGUARD can be considered as a starting point only and that at least two decades will pass by until we can claim that orbital techniques are well under control, reliable, economically reasonable and approaching a certain perfection which is desirable and necessary for a large scale space flight development.

GENERAL THEORY OF MULTISTAGE ROCKETS & PERFORMANCE THEORY OF AN N-STAGE SATELLITE CARRIER WITH A SPECIFIC TURNING PROGRAM

Unclassified Submission to ARS Space Flight Report to the Nation, October 8-14, 1961, New York, 63 pages, illustrated, from Structures & Mechanics Division.

By
Dr. H.G.L. Krause

ABSTRACT

This paper presents a general theory for the optimization of design parameters of a multistage rocket and discusses the flight performance theory of such a vehicle. Definitions are carefully established, and a general theory for obtaining the optimum stage number is developed. Optimum conditions for steprockets with both similar and dissimilar stages are discussed, and differences between series staging and parallel staging are investigated. Finally, the flight dynamics of a multistage rocket in the atmosphere with a specific turning program, including a coasting period between powered phases is developed.

AN ESTIMATE OF SUCCESS-TO-FAILURE RATE FOR FUTURE LAUNCH VEHICLES (U)

Confidential Internal Note M-FPO-2A-61, September 18, 1961, 11 pages, illustrated.

By
H.H. Koelle*

ABSTRACT

This paper attempts to find a simple and practical approach to estimate expected success-to-failure rates of future launch vehicles in general. The term, "success-to-failure rate," is preferred in this connection; the term, "reliability," is more correctly used in connection with past flight histories which are accomplished facts.

An attempt is also made to make a quantitatively correct analysis of most of the major influence factors as a first iteration of a solution to the problem. A more refined qualitative analysis, which seems to be possible, requires more time and will be undertaken at a later date.

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* With Contributions by J.C. Hughes, C.H. Rutland, L.T. Spears and E.A. Weaver.

INVESTIGATION OF PRESSURIZATION SYSTEM PROPOSALS FOR LARGE BOOSTERS UTILIZING LOX AND RP-1 AS PROPELLANTS (U)

Confidential. ABMA Rpt.Nr., DSD-TN-33-59, 14 December 1959, 10pages, with illustrations.

Max E. Nein & Gordon K. Platt

ABSTRACT

The feasibility of using hot gases from solid propellants for the pressurization of large booster propellant tanks has been investigated. A great number of organizations prominent in solid propellant research were asked to submit proposals for improved tank pressurization.

The evaluation of these proposals indicates that based on the present state of the art solid propellants do not offer radical weight nor space improvement. No solid propellant acceptable for use as pressurant on liquid oxygen will be available within the next two years.

Comparison of various pressurization systems based on realistic pressurant temperatures at cutoff indicates a possible reduction of about one-third of the weight of the initial SATURN pressurization system.

LOX TANK PRESSURE INVESTIGATION IN AN INTERCONNECTED TWO-TANK SYSTEM

Unclassified Rpt., MTP-M-TEST-61-15, June 16, 1961, 101 pages, illustrated
by John Funkhouser

ABSTRACT

This report presents the results of a LOX tank pressurization investigation conducted at the Cold Calibration Test Stand, Test Division, Marshall Space Flight Center. The purpose of this test program was to assimilate and examine the phenomenon of pressure collapse which occurred in the 70-inch LOX tanks during static testing of SA-T.

This pressure collapse was assimilated without a standpipe, and also with the 30-inch open-end standpipe. The collapse was eliminated with the installation of standpipes No. SK30-103A and SK30-120. The addition of antislosh baffles produced no appreciable change in pressurization requirements.

ESTIMATED THERMAL ENVIRONMENT OF SATURN BASE REGION

Confidential Rpt., MTP-M-S&M-P-61-6, March 29, 1961, 33 pages, illustrated
by R. D. Stottle

ABSTRACT

The inflight thermal environment of the SATURN SA-1 heat shield and flame shield is estimated. Results of base heating tests performed on a 1/26 scale model SATURN at the NASA Lewis Research Center are used primarily, and, to a lesser extent, base heating data applying to POLARIS, ATLAS, and TITAN missiles.

During powered flight, a 0.313-inch-thick layer of X-258 ablative material on the heat shield (the average thickness of X-258 on the SA-1 heat shield is approximately 0.313 inch) will yield a maximum inner surface temperature of 210°F at 120 seconds flight time. If one engine is out of operation and a seven-engine trajectory is followed, the inner surface temperature will be 270°F at 145 seconds flight time.

COMPARATIVE EXPERIMENTAL AND THEORETICAL CONSIDERATIONS ON THE MECHANISMS OF FLUID OSCILLATIONS ON CYLINDRICAL CONTAINERS

Unclassified Rpt., MTP-M-S&M-P-61-11, May 29, 1961, 37 pages, illustrated
by Werner R. Eulitz and Rudolf F. Glaser

ABSTRACT

The motion of liquids in containers of different sizes and shapes has received a good deal of study in recent years, most of it theoretical. This work is necessary in the analysis of flight stability of aircraft but assumes prime importance in connection with missiles. The motion of liquids in oscillating containers is called sloshing.

Theoretical studies are directed toward mathematically describing the time history of the liquid motion and deriving the forces and moments exerted on the container. Because of mathematical difficulties, commonly a linearized theory is used which neglects the products of the flow velocities and surface amplitudes of second and higher order. For this reason theoretical investigations are confined to cases of small flow velocities and small surface amplitudes.

Comprehensive experimental investigations with circular cylindrical containers of different sizes up to full scale missile containers were carried out four years ago at the Army Ballistic Missile Agency, Huntsville, Alabama (ABMA). Primary attention was given to the phenomenon that the liquid level oscillating at frequencies lower than the natural frequency of the system suddenly becomes turbulent.

The purpose of this present study is:

1. To compare the experimental results with the theory. This comparison reveals a thorough understanding of the limitations of the linearized theory and the clarification of the term "small oscillations."

2. To derive the linearized theory from the general eigenvalue theory of small liquid oscillations developed at the turn of the century by Poincare', Volterra, Hilbert, and others.

Investigations delineated in this report result in a thorough agreement between experiment and linearized theory. Even experimental findings thus far neglected in theoretical reports consequently can be derived from the theory. In this regard the study is believed to fill the until-now existing gap concerning the problem of sloshing.

THE COLLISION BOUNDARY BETWEEN THE TWO SEPARATING STAGES OF THE SA-4 SATURN VEHICLE

Unclassified Rpt., NASA TN D-598, August 1961, 21 pages, illustrated
by William B. Chubb

ABSTRACT

The methods employed in analyzing collision problems associated with separating stages of multistage vehicles are presented in this report. These methods are applicable for determining collision boundaries between two separating stages of any vehicle configuration, specific results being a function only of the physical system being considered. The collision area is that area of the lower stage within which no portion of the upper stage can lie prior to separation, if collision is to be avoided after separation. The "collision boundary" is defined as the line dividing the collision and non-collision areas. Collision boundaries are determined for seven specific cases of separation between the S-I and S-IV stages of the SA-4 version "A" (escape mission payload) Saturn vehicle. The S-IV stage of the SA-4 version "A" configuration is assumed to be powered by four 17.5K engines.

SATURN SA-1 VEHICLE ELECTRICAL INTEGRATION

Unclassified Rpt., MTP-G&C-E-61-37, Sept. 13, 1961, 40 pages, illustrated
by H. K. Bennett

ABSTRACT

The SATURN SA-1 electrical hardware and systems that are integrated into the overall vehicle electrical circuitry are presented. The various subsystems to which electrical energy is supplied are pointed out, and these subsystems are described only as necessary to define the units that require electrical integration. The cable interconnect diagrams of the system are included to show the integration scheme. The major electrical components employed to integrate these subsystems are described in more detail. These components are: batteries, power supplies, distributors, flight sequencer and plug "J" boxes. The "J" box is a standard plug with certain pins connected to either relays or resistors, with the outer resistor terminals being connected to form a bus. The discussion is confined to the area of responsibility assigned to the Airborne Systems Integration and Components and Power Supply Sections of the Electrical Systems Integration Branch.

MERCURY-REDSTONE ABORT SYSTEMS DESCRIPTION

Confidential Rpt., DRP-TN-1-60, March 15, 1960, 16 pages, illustrated
by Frank G. Bryan

ABSTRACT

The methods and results of giving emergency abort due to Capsule/Booster failure or Astronaut difficulties are detailed sequentially in this report. The information was gathered during preparation of the final checkout procedures in the Systems Analysis and Reliability Laboratory, ABMA. The emergency escape methods are redundant except between normal cutoff and trailoff of the Booster engine at 1/4 G. During this time only the Astronaut can initiate separation.

THE SATURN SYSTEMS AUTOMATION PLAN

with Appendix on

DATA ACQUISITION AND TRANSMISSION FOR AUTOMATIC VEHICLE MONITORING AND CHECKOUT

Unclassified Report, Internal Note, September 15, 1961
by Ludie G. Richard, Charles O. Brooks, and Walter O. Frost

ABSTRACT

This report describes a concept for automatic checkout and launch of the C-3 Saturn vehicle as presented by the Quality and Guidance and Control Divisions to MSFC Management. The proposal includes standard automatic checkout of all stages at the Manufacturer's plant, the static test site, and the launch site staging building. Use of this standard automatic checkout equipment by all stage manufacturers would develop standard testing, tests similar to launch operations, automatic data acquisition and standard data format. The system, as proposed was accepted by MSFC management and is now being implemented.

S-I STAGE FLIGHT PERFORMANCE PREDICTION - SATURN SA-1 (U)

Confidential Rpt., MTP-M-S&M-P-61-4, Feb. 2, 1961, 124 pages, illustrated
by Chrysler Corporation Missile Division for MSFC

ABSTRACT

SATURN SA-1 will be the first flight test vehicle for the SATURN space probe launch vehicle program. SA-1 will be a three stage vehicle consisting of a powered first stage (S-I) carrying dummy S-IV and S-V stages with a JUPITER nose cone and aft unit as payload. The S-I stage is a nine propellant tank configuration powered by a cluster of eight 165,000-lb thrust H-1 liquid propellant (LOX/RP-1) rocket engines. The dummy S-IV and S-V stages will be filled with water to simulate upper stage weight of later vehicles.

A detailed S-I stage propulsion system flight performance prediction is presented for S-I stage dry weight plus upper stage total weight of 302,485 lb and S-I stage mainstage engine propellant weight of 600,000 lb. Parameters describing the engine, propellant supply system, and exterior ballistics are predicted as a function of flight time for a normal flight and an engine-out flight.

Propellant loading for SA-1 will be facilitated by the data presented for propellant loading weights vs fuel fill density, and required propellant loading transducer ΔP vs propellant loading weights.

The computations for this flight prediction were performed with the IBM 7090 digital computer. The SATURN Mark IV Computation Procedure used for the prediction is described briefly in Appendix I.

This report supercedes DSD-TM-9-60, "Preliminary Evaluation of the Block I SATURN S-I Stage Performance Characteristics" and DSDF 89-60, "Preliminary SATURN S-I Stage Performance Characteristics."

SOME SELECT PHYSIOLOGICAL, ANTHROPOMETRIC, AND HUMAN ENGINEERING DATA USEFUL IN VEHICLE DESIGN AND LOGISTIC PROBLEMS OF SPACE FLIGHT OPERATIONS

Unclassified Rpt., DSP-TM-2-60, Feb. 24, 1960, 31 pages, illustrated
by J. W. Carter

ABSTRACT

Technical investigations into the many facets of space flight, particularly where man is concerned, have prompted queries regarding man's tolerances, measurements, volume requirements, and metabolic processes. This report merely tabulates specific data that are useful to engineers in advanced design of space vehicles, space stations, and the associated logistics problems. By far, all data available have not been presented. Had this been done, an extremely large volume would have resulted. It is hoped that future reports will provide more data as they are collected and analyzed.

There are many sources from which data are available and, in most cases, the data do not exactly coincide. These differences are small. However, the information tabulated herein can be used as typical of the present state of knowledge.

These data were compiled for mission planning and preliminary design purposes.

SOME SPACE FLIGHT GUIDELINES FOR THE QUARTERMASTER RESEARCH AND ENGINEERING COMMAND

Confidential Report, February 21, 1961, 42 pages, illustrated
by James W. Carter

ABSTRACT

This report has been prepared for the Quartermaster Research and Engineering Command for general orientation and planning purposes. It is a consolidation of schedules and concepts that will serve not only for staff planning elements, but also for personnel who are technically oriented. General discussions of the National Aeronautics and Space Administration (NASA) and George C. Marshall Space Flight Center (MSFC) organizations, the MSFC Launch Vehicle Technology Study Program, present SATURN capabilities and schedules, present and future manned programs, lunar and earth orbital operations activities, and some problem areas associated with space flight are presented in the subsequent paragraphs of this report.

CREW SUPPORT EQUIPMENT

Unclassified Rpt., MTP-M-FPO-1-60, Oct. 17, 1960, 27 pages, illustrated
by James Carter

ABSTRACT

This report gives a definition of Crew Support Equipment which includes: personal equipment, safety equipment, rescue and survival equipment, food, food preparation equipment and handtools. Tables are included which reflect weight, dimensions, materials, and recommended quantities of flying equipment for specific climatic conditions, first aid and medical kits, flashlights, fire extinguishers, survival gear for Global, Arctic, Temperate and Tropical areas, food kits, tableware, food preparation equipment, tools, recreation equipment, etc. Weight and dimension data are also given on portable respiratory equipment.

LAUNCH VEHICLE TECHNOLOGY PROGRAM (FY-1961)
Approved Supporting Research Projects

Unclassified Report from Research Projects Division, January 3, 1961, 150 pages, no illustrations.

ABSTRACT

This document indicates the program planning of projects for inclusion into the George C. Marshall Space Flight Center's FY-1961 Launch Vehicle Technology Program as of January 3, 1961, and is essentially a summary of the FY-1961 program.

It should be pointed out that approximately one hundred and twenty-five projects have been generated under the LVT Program (FY-1961). This report mentions only those projects that were planned at the time of publication.

This summary was issued as a planning document only and was not intended to represent a comprehensive technical report of the projects included in this book.

The results of these investigations are being made available in the form of a periodic progress report and will be available in the near future.

IV. FLIGHT MECHANICS

CORRELATIVE SURVEY REPORT ON POWERED FLIGHT TRAJECTORY OPTIMIZATION INCLUDING AN EXTENSIVE CRITICAL BIBLIOGRAPHY

Unclassified Submission to ARS Space Flight Report to the Nation, October 8-14, 1961, New York, 60 pages, not illustrated.

By
Rowland E. Burns
Structures and Mechanics Division

ABSTRACT

The calculus of variations is a powerful tool in the theoretical determination of optimum trajectories for aerospace vehicles. This paper, based on the works of many authors, presents a unified general theory of the subject. In particular, a theorem is proved which states the necessary conditions for an optimum trajectory to exist. A short discussion of direct methods is presented and a bibliography of 241 references with critical comments is given.

THE PATH-ADAPTIVE MODE FOR GUIDING SPACE FLIGHT VEHICLES (U)

Unclassified Paper, August 7-9, 1961, by W. E. Miner and D. H. Schmieder

ABSTRACT

The need for a more flexible guidance mode than the types now commonly known is established as growing out of requirements imposed by large staged and clustered space flight vehicles. A new guidance mode is then developed which meets these requirements. The steering function, which is the heart of this Path-Adaptive Mode, is derived in general terms. A concluding description is given of the principal features of the mode.

SATURN VEHICLE: COMPARATIVE STUDY OF PERFORMANCE AND CONTROLLABILITY OF TWO-STAGE AND THREE-STAGE VERSIONS FOR LOW ALTITUDE ORBITS (U)

Confidential Rpt., DA-TM-44-60, May 25, 1960, 15 pages, 3 illustrations
by R. F. Hoelker and O. C. Jean

ABSTRACT

The three-stage SATURN vehicle C-1 is compared with the two-stage SATURN vehicle, with the S-IV stage as second stage, for missions that require circular orbits not higher than 300 nautical miles of altitude. The payload performance is studied for direct ascent as well as Hohmann transfer ascent into the orbits. The controllability of the attitude is investigated for the critical region of high dynamic pressure during first stage flight where the throw-angle requirements are established for dynamic response to wind gusts, with drift-minimum and load-minimum control modes, for the two cases of four and three control motors operative. The benefits derivable from stabilizing fins attached to the SATURN booster for the reduction of throw angles are shown.

STUDIES OF PILOT ABORT FROM SATURN C-2 TRAJECTORIES (U)

Confidential Rpt., MTP-AERO-61-22, March 21, 1961, 22 pages, 10 illustrations
by R. F. Hoelker, Roger Teague, Ben J. Lisle

(C) ABSTRACT

The impulse requirements for abort from SATURN C-2 trajectories amount to between 1000 and 1800 m/s, the larger values associated to combinations of high injection altitude (170 km) and steep injection direction (88 degrees from the vertical). Least impulse requirements are found for injection angles near to 91 degrees.

In reasonable altitude limits best payload performance is given for injection path angles of 84 to 85 degrees. Retaining abort capability, the largest allowance for capsule weight is found in the region of 89 to 91 degrees of injection angle.

Abort propellants are derived on the assumption that ballistic trajectories are flown with not more than 11.3 g peak deceleration.

The impulse requirements translate into propellant weights of between 3800 and 5700 pounds for specific impulse assumption of 250 seconds and of between 2400 and 4000 pounds for specific impulse of 420 seconds. These figures do not include weight for tanks, or casings, and engine. The combined weight assumed for the capsule and the propulsion system before impulse expenditure is assumed here as 11000 pounds.

Two schemes of mechanization of the abort modes are discussed with emphasis on simplicity of operation. The first scheme utilizes two space-fixed directions for the abort thrust, resulting in staggered impulse requirements; the second scheme utilizes at all times a fixed impulse amount, but requires varied directions of impulse applications.

More complex systems are briefly discussed and some recommendations are given. No concern is given here to the problem of abort during the early atmospheric flight phase with its associated high dynamic pressure problems.

SATURN C-1: PERFORMANCE AND TRAJECTORY SHAPING ON ORBITAL AND ESCAPE MISSIONS FOR THRUST OF 17.5K ON UPPER STAGE ENGINES (U)

Confidential Rpt., MTP-AERO-61-8, Feb. 16, 1961, 30 pages, 17 illustrations
by O. C. Jean and John B. Winch

(C) ABSTRACT

The combined optimum trajectory shaping and propellant loadings of the upper stages are determined for an earth escape mission and low altitude circular orbits. The configuration is a three stage missile with the S-I stage as booster and the Douglas S-IV stage as second stage and Convair S-V as terminal stage. The thrust level of the engines used in the upper stages is 17.5K lb.

For an escape mission at 155 km altitude, the optimum loading of S-IV stage is 86,000 lb, coupled with the assumed loading of the S-V at 29,000 lb. The cutoff weight for the above loadings is 11,810 lb.

In the circular mission of 100 N. Mi. orbit, the combination of 66,800 lb of propellants in the S-IV and 25,500 lb in the S-V produces the maximum cutoff weight of 25,840 lb.

PRELIMINARY TRAJECTORY OPTIMIZATION OF THE SATURN C-2

Confidential Rpt., MTP-M-AERO-61-12, Feb. 28, 1961, 72 pages, illustrated
by R. C. Callaway

ABSTRACT

This report presents the results of a trajectory analysis for the Saturn C-2 vehicle. The investigation was geared to determine the optimum trajectory shape for circular orbital and escape missions with the three stage version of the Saturn C-2. The analysis was conducted under various constraining conditions for the ascending phase of the trajectory. Constraints applied were injection altitude, injection angle, and, in some escape cases, a coasting orbit. Calculus of Variation techniques were employed during the upper portion of the trajectory. The results are presented in form of optimized cutoff weight as function of the constraints. Typical trajectories for various missions and conditions are included.

PERFORMANCE CAPABILITY OF THREE NOVA CONFIGURATIONS (U)

Confidential Report, Aeroballistics Internal Note 17-61, Sept. 27, 1961, 28 pages
by Doris C. Chandler

ABSTRACT

The purpose of this report is to present the payload capability of three typical NOVA configurations. Payloads are examined at three points: at injection into a 177 kilometer circular orbit; at local escape velocity; and at lunar landing. All trajectories have a launching due east from Cape Canaveral, and the "Patrick Atmosphere" is used. Calculus of variation techniques are applied to the near vacuum portions of the upper stages to optimize for payload. A rotating oblate spheroidal earth is assumed throughout the trajectory.

Table 1 gives payload quotations both for nominal cases and for "engine-out" cases. Table 2 gives trajectory data - both at cut-off of first stage and at the region of maximum dynamic pressure - which are pertinent to control investigation. Trajectory time histories are given in Tables 3 through 5.

CHARACTERISTIC ORBITAL VARIABLES AND THEIR TIME RATES IN UNPERTURBED ELLIPTIC ORBITS

Unclassified Report, NASA TN D-558, December, 1960, 11 pages, not illustrated.

By
Dr. H.G.L. Krause
Structures & Mechanics Division

ABSTRACT

The intention of this report is to represent, for an unperturbed elliptical orbit, characteristic orbital variables (radius vector, anomaly, flight path angle, velocity and acceleration with their respective components) and their time rates (first and second derivatives) in dimensionless form as functions of the eccentricity and the true or eccentric anomaly, or in dependence of a dimensionless velocity factor and the flight path angle. Furthermore, a good approximation is given for the location and the value of the maximum and minimum tangential acceleration in a Keplerian orbit.

THE SECULAR AND PERIODIC PERTURBATIONS OF THE ORBIT OF AN ARTIFICIAL EARTH SATELLITE

Unclassified Paper presented at the VII International Astronautic Congress, Rome, 17 - 22 September 1956, 59 pages, illustrated.

By
Dr. H.G.L. Krause
Translated from the German by Seymour Nelson

ABSTRACT

In the paper presented here, the motion of an earth satellite in an orbit inclined to the earth's equator is generally investigated, the orbit of this satellite being disturbed by the oblateness of earth, by the sun and the moon, and finally by the atmosphere of the earth. For a selected orbit of the earth satellite, it is shown numerically which secular and periodic perturbations are the most important. Furthermore, for a nonstationary orbit, where the atmospheric resistance has still relatively great influence, an analytic formula is developed for the computation of the lifetime of the satellite. Numerical values for this lifetime are in fairly good agreement with other estimations.

COMPARISON OF PRECALCULATED ORBITAL ELEMENTS OF THE ARMY EXPLORER SATELLITES WITH THE ACTUAL ELEMENTS DERIVED FROM OBSERVATIONS

Unclassified ABMA Rpt. DSP-TR-2-60, 20 June 1960, 26 pages, with illustrations.

By
Dr. H.G.L. Krause & R.N. DeWitt

ABSTRACT

Orbital elements, based on precalculated data for the position and velocity vector of the injection points for the EXPLORERS I through V, are derived and compared with the actual orbital elements at injection time, calculated from position and velocity data obtained from radar measurements. Calculations were also made for the different orbital periods of a satellite perturbed by the earth's oblateness. For EXPLORER I, it is shown that the actual orbital elements derived from tracking observations agree well with the elements derived from early astronomical observations.

THE TWENTY-FOUR HOUR ORBIT

Unclassified ABMA Rpt. Nr. DSP-TN-15-58, 5 December 1958, 21 pages, with illustrations.

By
Conrad D. Swanson, Walter H. Stafford, James W. Russell

ABSTRACT

Interest has been expressed in a satellite whose period exactly equals that of the earth's rotation. Several reasons for this interest can be given. Among the more important are the following:

1. The twenty-four hour satellite remains continually above the same terrestrial point or meridian, or very nearly so.
2. Such a satellite, from present evidence, would be above the Van Allen zone.
3. This type of vehicle would have a very long lifetime.
4. Such satellites could be employed as:
   a. navigation aids
   b. radio and television relay stations
   c. manned and instrumented space stations for research and interplanetary take-off
   d. meteorological and nuclear-test monitoring stations
   e. cosmic ray and meteorite monitors
5. Regression of the nodes due to polar flattening, and luni-solar perturbations are very small.

TWENTY-FOUR HOUR SATELLITE MOTIONS OF THE ORBIT PLANE DUE TO SECULAR PERTURBATIONS

Unclassified ABMA Rpt. Nr. DSP-TM-5-60, 12 May 1960, 32 pages, illustrated.

By
William R. Perry

ABSTRACT

Long-range planning of various satellite missions requires a broad description of orbital elements and the changes of these elements with time. This study was initiated in order to assist in establishing design criteria for astronomical and other 24-hour satellites (e.g., SATURN-AURA Telescope and SATURN Communciations).

The effects of long-term secular perturbations on the 24-hour orbit are shown for orbits that were initially in the equatorial and ecliptic planes and at an inclination of 28.3 degrees. The equatorial orbit was found to become inclined about 0.8 degrees in one year and to move to a maximum inclination of about 14.9 degrees in 27 years. The ecliptic orbit moves out of the ecliptic plane at an initial rate of 1.75 degrees per year.

The proper plane is described and it is shown why this plane may be the preferred reference plane for high-altitude (24-hour) orbits.

The perturbation equations used are those of Dr. H.G.L. Krause (Ref. 4) and are shown in Appendix I. The results given here do not include effects of periodic perturbations. This report is a continuation of the material presented in Internal Note DSP-20-59. Some of the constants used in the calculations have been changed in order for the initial data to be as consistent as possible.

ORBITAL AND ROTATIONAL MOTION OF A RIGID SATELLITE

Unclassified Paper of Research Projects Laboratory, ABMA, Redstone Arsenal, Alabama, from JPL Seminar Proceedings, 7 pages, no illustrations.

By
Dr. Charles A. Lundquist & Robert J. Naumann

ABSTRACT

The equations of motion of a rigid body in an orbit around the earth are usually separated into one set determining the motion of the center of mass of the body and a second set specifying the motion of the body around its center of mass. However, the two sets are intricately coupled.

Computer programs have been developed at ABMA to study the motion about the center of mass, as well as the orbital problem. The coupling between the two sets of equations has been explored with these programs. Particular emphasis has been given to the motions of 1958 ϵ, EXPLORER IV.

THE EFFECT OF LUNAR AND SOLAR PERTURBATIONS ON THE PERIGEE HEIGHT OF A HIGH ECCENTRICITY SATELLITE (AM-19C)

Unclassified ABMA Rpt. No. DV-TN-5-60, 4 March 1960, 22 pages, illustrated

By
Robert J. Naumann

ABSTRACT

In the case of a high eccentricity satellite, the position of the orbit in relation to the sun and moon can have a strong effect on the perigee height. Because of this, the firing time must be chosen so that the perigee will not fall below a certain critical height during the desired lifetime of the satellite.

This paper shows how this effect comes about and how perigee will vary over a year for different firing times for AM-19C.

GEO-STATIONARY ORBIT: ANALYSIS OF INJECTION SCHEMES (U)

Unclassified Rpt., ABMA DA-TM-130-59, Oct. 14, 1959, 58 pages, 33 illustrations
by Robert Silber and James Horner

ABSTRACT

It is the purpose of this report to investigate a number of schemes for injecting a satellite into an equatorial, circular 24-hour (geo-stationary) orbit from AFMTC. The merits and flaws of each scheme are analyzed with the viewpoint of aiding one in deciding on a particular scheme for a particular mission.

Much of the background for the following schemes may be found in reference one. Some of this material will be repeated herein for the sake of continuity, but it is advised that the reader be acquainted with the entire report (in reference one) for the benefit of some familiarity with the more intricate relationships involved.

FLIGHT MECHANICS OF RE-ENTRY AFTER CIRCUMLUNAR FLIGHT BY MEANS OF VARIOUS LIFTING TECHNIQUES (U)

Unclassified Report, MNN-M-AERO-4-60, Sept. 15, 1960, 19 pages, 9 illustrations
by Roger Teague

ABSTRACT

This memorandum presents the results of a study of the problem of re-entry into the earth's atmosphere by a vehicle returning from a circumlunar flight. Two re-entry configurations are investigated - a capsule type of body and a nose cone type. Flight mechanical studies using these configurations have been made employing three different lifting techniques:

(1) Zero lift throughout

(2) Lift constant with respect to time

(3) Lift variable with respect to time.

Emphasis is placed on restriction of deceleration, lift to drag limitations, and avoidance of trajectories that "skip" back considerably in altitude.

The report presents data as to the allowable spread of re-entry conditions, correction possibilities in range and cross-range, and feedback of re-entry requirements on midcourse and guidance tolerances.

The study shows that flight mechanically there is a permissible re-entry path angle spread from 94.5° to 97.5° from the local vertical for the body given by $\frac{W}{c_D A}$ = 50 lb/sq ft and from 95.3° to 98.1° for the re-entry body given by $\frac{W}{c_D A}$ = 500 lb/sq ft. These spreads in re-entry path angle are achieved by employing aerodynamic lift, where $\left|L/D\right| \leq 0.5$, and assuming a re-entry altitude of 120 km.

SATURN PAYLOAD RE-ENTRY CHARACTERISTICS

Confidential Rpt., DSP-TN-5-60, June 20, 1960, 80 pages, illustrated
by Dietrich W. Fellenz

ABSTRACT

The present status of re-entry flight mechanics is reviewed. Equations of motion, considering the total lift over drag spectrum of a vehicle, are derived.

For lunar circumnavigation vehicles, based on the SATURN-booster, calculations of flight path parameters have been performed for:

1. Entry with escape velocity (variation of entry angles).

2. Entry after aborted boost mission (based on a series of cutoff conditions derived from the "standard" SATURN C-2 - trajectory).

In order to compare the compatibility with the entry conditions imposed on the vehicles, the following configurations have been considered.

1. Pure Drag Vehicle (Mercury Capsule).

2. Lifting Body Vehicle (Egger's type shape).

A SIMPLE RE-ENTRY CONTROL SCHEME (U)

Unclassified Rpt., Aeroballistics Internal Note No. 1-61, Jan. 4, 1961, 16 pages
by James P. Lindberg

ABSTRACT

This note presents some preliminary results from a study being made of a conceivable emergency control scheme for atmospheric re-entry to the earth's surface after a circumlunar flight. The emergency mode developed is to be used in case the primary navigation mode should fail.

Primary emphasis has been placed on feasible ways of re-entry condition sensing and optimization of the aerodynamic control. Leading viewpoints for the optimization are (1) widening of the "re-entry survival window" and (2) simplicity of the scheme.

The re-entry survival window (or corridor) is defined on one side by the non-skip condition and on the other side by a peak load not exceeding 10 g's. For all practical cases investigated, the maximum tolerable heat rate was not exceeded if the deceleration peak was kept below 10 g's.

Only single-pass re-entries (less than one orbit) are considered.

It is obvious that use of impulse corrections to augment this scheme can significantly widen the aerodynamic re-entry window investigated here.

ANALYSIS OF QUARTZ AND TEFLON SHIELD FOR A PARTICULAR RE-ENTRY MISSION (U)

Unclassified Rpt., MTP-AERO-61-25, March 28, 1961, 18 pages, 7 illustrations
by Ernst W. Adams

ABSTRACT

The transient performance of ablation type heat protection shields is treated herein for the surface of a vehicle returning from outer space to the earth. The vehicle weighs 8, 640 kg, has a ballistic factor of 500 lb/ft^2, re-enters with a speed of 11 km/sec at 120 km altitude, has a lift over drag ratio of -0.5, and is subjected to a maximum deceleration of 7.7 times the gravity constant.

By use of well-known equations for the heat transfer and the mass transfer at a heated surface, a numerical calculation method is derived which, for the investigated ablation processes, yields exact transient solutions of the fundamental system of partial differential equations. The method is applied to various quartz shields and to one Teflon shield, which all evaporate so readily under the conditions of the problem at hand that practically no flow of molten shield material exists. The solutions also show comparatively small temperature changes parallel to the surface.

The results show that the nose of the vehicle is cooled predominantly by the evaporation of the quartz or the Teflon; the rest of the vehicle's surface is cooled by radiation of the quartz or evaporation of the Teflon. The large mass transfer effects on the nose of the vehicle are detrimental since the resulting low surface temperatures prevent the radiative heat transfer out of the shield, which does not involve any mass loss, from being the desirable governing cooling factor.

DERIVATION AND CALCULATION OF INITIAL VALUES OF MOON-HITTING TRAJECTORIES

Unclassified ABMA Rpt. Nr. DSP-TM-3-58, 30 May 1958, 26 pages, illustrated.

By
Warren H. Straly & Harry O. Ruppe

ABSTRACT

This report was written to satisfy the need for a rapid and a simple method of calculating the initial data for earth-moon flight paths. If the time and date of impact on the moon, flight time, and launching place are known, this method enables one to find the approximate launching time, injection angle and azimuth. The report is intended as an aid in computing such values without the use of an electronic computer.

ORBIT AND SPACE TRAJECTORY DETERMINATION

Unclassified ABMA Rpt. No. DIR-TR-1-59, 3 June 1959, 32 pages, illustrated.

ABSTRACT

On March 12, 13 and 14, 1959, the National Aeronautics and Space Administration sponsored a Conference on Orbit and Space Trajectory Determination. The first day of the conference was held at the U.S. Naval Research Laboratory and the last two at NASA Headquarters. This conference was in some sense a sequel to the Seminar on Satellite Orbital Computation sponsored by the Technical Panel for the Earth Satellite Program of the U.S. National Committee--IGY, held on February 14 and 15, 1958.

The five papers collected in this report were presented by Development Operations Division personnel at the NASA conference. They summarize the considerable activity of the Development Operations Division in the conference topics since the earlier seminar. Their number is commensurate with the three satellites and two space probes which have been successfully launched by the Army Ballistic Missile Agency to date.

The growth of interest in these topics is witnessed by the growth of the two-day 1958 seminar into a three-day conference in 1959. Several times as many individuals from many more agencies participated in the latter conference. The Development Operations Division contributions to the meeting show a parallel growth from one paper in 1958 to the five papers listed below which were presented in 1959.

1. "The Present State of Orbit Determination at ABMA," by Dr. Fridtjof A. Speer, Aeroballistics Laboratory.
2. "Vari-Centric Method of Calculating Lunar and Space Probe Trajectories," by William Miner, Aeroballistics Laboratory.
3. "Characteristics of Computational Programs Used by ABMA," by Thomas C. Yarbrough, Computation Laboratory.
4. "Errors Caused by Numerical Integration in Lunar Trajectory Decks in Use at ABMA," by William Miner, Aeroballistics Laboratory.
5. "Some Research Problems Considered at ABMA Concerning Satellite and Probe Orbits," by Dr. Charles A. Lundquist, Research Projects Laboratory.

PARAMETER SENSITIVITY AND GUIDANCE VIEWPOINTS FOR CIRCUM-LUNAR FLIGHT AND RETURN (U)

Unclassified Rpt., MNN-M-AERO-3-60, August 15, 1960, 45 pages, 33 illustrations
by R. F. Hoelker, N. J. Braud, O. C. Jean and A. J. Schwaniger

ABSTRACT

For a circum-lunar trajectory that is laid out co-planar with the assumed planar motion of earth and moon, this memorandum investigates the sensitivity of the periselenum point and of the return path for (1) variations of injection conditions and (2) correction impulses applied at any time in free flight. The effect of the impulses is studied for changes in the geometry as well as in the time of the terminal events.

The critical directions of impulse applications are derived with respect to time and position attainment of the terminal events. Their correlation is discussed and suitable points of impulse applications are proposed.

It is shown that with a total amount of correction impulses of between 200 and 400 m/s, the nominal re-entry conditions can be acquired well enough that moderate maneuvers in the atmosphere of a lift magnitude of less than half the drag brings the vehicle to the pre-flight selected landing area.

NASA RESEARCH ON MANNED LUNAR MISSIONS (U)

Confidential MSFC Paper, November, 1960, 18 pages

ABSTRACT

This paper contains some results of Marshall in-house investigations into APOLLO entry-test and circumlunar flights. Some pertinent data are given on flight mechanics, tracking and its accuracy, and entry flight mechanics including aerodynamic heating and protection.

TRACKING ACCURACIES FOR LUNAR MISSIONS (U)

Unclassified Report, MTP-AERO-61-3, January 18, 1961, 30 pages
by H. F. Kurtz, F. A. Speer

ABSTRACT

The tracking accuracies to be achieved by a world wide tracking net during a lunar circumnavigation are investigated. Tracking errors are shown in terms of impact position errors after return to earth.

Elliptic error distributions are compared at re-entry altitude and the earth surface.

The relative merits of different tracking types, the length and the positioning of the tracking period are investigated.

The influence of uncertainties in both moon mass and atmospheric density is shown.

It is concluded that, in all likelihood, terminal tracking and terminal maneuvering will be required to meet the specified landing conditions of a circumlunar flight.

COMPARISON OF ON-BOARD AND GROUND TRACKING FOR LUNAR MISSIONS (U)

Unclassified Report, MTP-AERO-61-26, March 30, 1961, 35 pages
by F. A. Speer, Fletcher Kurtz, Ann R. McNair

ABSTRACT

The tracking potential of an earth based system and an optical on-board navigation system is compared for lunar missions.

Operational and functional aspects of both systems are compared, as system accuracy potential, distance limitation, propagation errors, and communication links.

The relative merits of single angle and multiple angle on-board tracking, the influence on tracking accuracies of launch date and star selection, and the relative value of tracking time periods are investigated for circumlunar flight.

Comparisons of ground and on-board tracking for lunar impact and circumlunar missions are made.

VELOCITY REQUIREMENTS OF MIDCOURSE CORRECTIONS FOR A LUNAR RETURN VEHICLE

Unclassified ABMA Rpt., DSP Internal Note No. 1, 27 January 1960, 7 pages, illustrated.

By
James W. Russell

ABSTRACT

The altitude of the conic perigee determines the velocity and angle at which a lunar-return vehicle will enter the earth's atmosphere. Due to the inherent error in determining the position and velocity of the vehicle, a certain number of midcourse corrections must be made to assure the effectiveness of using aerodynamic forces in safely reducing the velocity to a point such that a safe recovery is possible.

After analyzing the trajectory, it is seen that the sum of the perturbative forces will be approximately the same for the corrected and uncorrected trajectories. Therefore, for the present analysis, two-body mechanics were employed and results presented in generalized, non-dimensional form.

It is found in this analysis that the velocity requirements for midcourse corrections are small and that they are more effective when used to alter the flight path angle.

TRANSIT TIMES FOR INTERPLANETARY PROBES

Unclassified Rpt., DSP-TN-7-59, April 7, 1959, 11 pages, illustrated
by James W. Russell

ABSTRACT

The primary purpose of this note is to present a convenient means of finding flight times between various points along an interplanetary orbit, such as will be used for space probes. This note is intended as a supplement to Report No. DSP-TN-2-59, "Departure Velocities for Interplanetary Probes."

DEPARTURE VELOCITIES FOR INTERPLANETARY PROBES WITH INCLINED ORBITS

Unclassified Rpt., DSP-TN-11-59, Aug. 12, 1959, 19 pages, illustrated
by William R. Perry

ABSTRACT

The departure velocity requirement for an interplanetary transfer orbit that is inclined to the plane of the orbit of the departure planet can be determined by finding the coplanar velocity requirement and adding to it an orbit-tilting velocity increment.

This velocity increment is shown to be a function of the departure planet's orbital velocity, heliocentric orbital velocity, heliocentric departure angle, and the angle of inclination of the transfer orbit relative to the departure orbit.

REVISED CALENDAR OF PLANETARY PHENOMENA FOR SPACE MISSION PLANNING

Unclassified Rpt., MNN-M-S&M-F-1-60, July 10, 1960, 34 pages, illustrated
by Frank M. Cameron

ABSTRACT

Dates of opposition and conjunction of the Planets have been linearly interpolated from "Planetary Coordinates for the years 1960 - 80," prepared by the British Nautical Almanac Office. The planet Pluto has not been included.

For initial planning of space missions, dates of injection into Hohmann transfer ellipses during the period 1960 - 80 have been tabulated together with corresponding travel times and dates of arrival.

V. ASTRIONICS

SATURN GUIDANCE SYSTEM DEVELOPMENT AND FUNDING PLAN

Unclassified Report, October 1960, 34 pages, illustrated
by Guidance and Control Division

ABSTRACT

The Development and Funding Plan for the SATURN Guidance System as described herein is based on all presently known schedule and vehicle mission requirements. The objective of the Plan is to provide the most reliable and advanced guidance system by the end of the R&D Phase as is possible within the time frame and vehicle capability parameters already established. Emphasis is directed towards parallel efforts of relatively short duration in the two major areas, the stabilized platform and the digital guidance computer, for comprehensive evaluation of the two most promising schemes. In this approach full advantage is taken of past experience in various missile and vehicle systems and experience that will be gained during this period in other vehicle systems, using guidance components comparable to those required for the operational SATURN vehicle. For confirmation of laboratory qualification and reliability tests, subcomponents of the major items are scheduled for flight tests, followed by flight tests of the item itself as a passenger, with the goal of full operational capability in SA-10. The associated ground support equipment (GSE) shares the composite time phases to insure overall system compatibility for the equipment on board each vehicle. To provide optimum flexibility in the operational guidance system, a digital command link is planned. Its development schedule is such that it is considered an integral part of the capability goal planned for SA-10. Charts No. 1 and 2, attached, present the Development and Funding Plan in tabulation form.

UNMANNED LUNAR LANDING WITH SATURN S-V STAGE

Unclassified Rpt. MTP-G&C-61-12, January 15, 1961, 262 pages, illustrated.

Coordinated and Edited
By
P.J. deFries

ABSTRACT

This report presents the results of a feasibility study on the use of the SATURN S-V stage for soft landing an instrument package on the surface of the moon.

The study covers the capabilities of the S-V stage as a lunar transporter, the guidance and control and tracking system, the Radio-Trim maneuver, attitude control system and the terminal guidance.

The study is based on the four stage SATURN C-2 configuration with the S-V being the fourth stage which is used for injection at earth as well as for braking at the moon.

It is concluded that the S-V is well suited to do this lunar transportation job.

MEASUREMENT AND TELEMETRY SYSTEMS FOR MISSILES

Unclassified Rpt., Vitro-2331-2-59, October 20, 1959, 86 pages, illustrated
Prepared for ABMA by Vitro Engineering Company

ABSTRACT

This document is intended to familiarize personnel both at ABMA and throughout the missile industry with recent efforts being made by ABMA in the measurement and telemetry field. It describes measurement and telemetry systems developed in accordance with ABMA's philosophy of flexibility, which contemplates continuing improvements in adaptability, accuracy, and compactness. A brief historical background of some phases of the effort is included to highlight the major advances in recent years.

The complete systems from sensing device to telemetry signal transmission are discussed, including their use in measuring and monitoring the many variables involved in the flights of missiles, satellites, and other payloads. Environmental, propulsion, attitude and trajectory, flight sequence and other types of measurements are included. Also, future trends in telemetry, necessary to accommodate the increasing complexity of missile systems, are briefly described.

SATURN TELEMETRY

Unclassified Report, 53 pages, illustrated
by Walter O. Frost and Charles D. Smith

ABSTRACT

This report describes the telemetry systems to be used on the SATURN vehicle and gives a brief history of preceding systems. Data properties and methods for handling each type are discussed. The various types of telemetry systems used on the SATURN are described, as well as the characteristics of each system. Future developments and refinements are discussed.

FORCES ACTING ON NOSE CONE ACCELEROMETERS DURING RE-ENTRY

Unclassified Rpt., DGIC-TN-14-59, June 23, 1959, 12 pages, illustrated
by James E. Tillery

ABSTRACT

This report describes the forces acting on a nose cone during the re-entry phase. These forces must be considered when determining the most suitable location for mounting the longitudinal and pitch or yaw accelerometers. Since this analysis was made primarily to help determine the best planes and locations for mounting the instrumentation, the precessional motions have been omitted for simplicity. Therefore, this analysis should not be considered as a complete report. The problem involved and the conclusions are also given.

PRELIMINARY HANDBOOK FOR ANTENNA SYSTEM OF RADAR ALTIMETER SURFACE STATION

Unclassified Rpt., MTP-M-G&C-61-7, March 24, 1961, 37 pages, illustrated
by Carl Huggins

ABSTRACT

This report presents details of the modification to Rawin Set AN/GMD-1 in making it usable in tracking missile-borne transmitters. The basic changes in the unit, the principles of operation of the modified set, and the adjustment and alinement procedures for initial operation are given herein.

GIMBAL GEOMETRY AND ATTITUDE SENSING OF THE ST-124 STABILIZED PLATFORM

Unclassified Rpt., MTP-G&C-G-61-38, Sept. 27, 1961, 22 pages, illustrated
by Richard L. Moore and Herman E. Thomason

ABSTRACT

The results of an extensive study for obtaining attitude signals from a four gimbal platform are summarized. The basic requirements were to furnish roll, yaw, and pitch attitude signals within an accuracy of six minutes of arc with a minimum number of resolvers. The system coordinates are defined, and by establishing the direction cosines in matrix algebra, the problem solution is mathematically formulated. Supplementary information pertaining to redundant gimbal control is also provided.

STUDY OF A SIMPLIFIED ATTITUDE CONTROL SYSTEM FOR A 24-HOUR SATELLITE

Unclassified Rpt., M-NN-M-G&C-7-60, Sept. 30, 1960, 47 pages, illustrated
by John Webster and David Schultz

ABSTRACT

This document describes and defines a simplified attitude control system for a 24-hour satellite to be placed in an equatorial orbit about the earth. Efforts are made to establish operating characteristics for a generalized and theoretical satellite. Use of a theoretical satellite, without the restrictions of fixed configuration, permits the mathematical determination of the satellite's behavior and orbital tendencies.

The theoretical vehicle under study uses a three-axis flywheel-control system for attitude control. Roll and pitch reference is obtained from two earth horizon seekers. The sun is used for yaw reference. In addition to attitude control, orientation of solar cell banks for optimum sun energy transfer is included.

This document will endeavor to define and evaluate a theoretically workable system capable of maintaining both attitude control and solar-cell-bank orientation for a 24-hour orbit equatorial satellite.

PROGRESS IN DESIGN & IMPLEMENTATION OF SCIENTIFIC SPACECRAFT

Unclassified Paper reprinted from "Space Research" Proceedings of the First International Space Science Symposium, (Nice, January 11-16, 1960), 22 pages, illustrated.

By
Dr. Charles A. Lundquist
Research Projects Division

ABSTRACT

The six scientific spacecraft, 1958 Alpha (EXPLORER I), 1958 Gamma (EXPLORER II), 1958 Epsilon (EXPLORER IV), space probe PIONEER III, artificial planet 2 (PIONEER IV), and 1959 Iota (EXPLORER VII) form a closely related family of spacecraft. The scientific information and technological experience gained from successive members of the series was utilized in an essential manner to improve the design of scientific experiments and technological implementation of subsequent members.

The refinements in the design of the satellite structures, of the electrical power supplies, of satellite telemetry systems and other components which implement the scientific instrumentation have paralleled the refinements in instrumentation. The details of these processes of refinement are reviewed and analyzed.

CONSIDERATIONS TO THE DEVELOPMENT OF EXPLORER VII SATELLITE

Unclassified Paper, Reprinted from IRE TRANSACTIONS ON MILITARY ELECTRONICS, Vol. MIL-4, Nos. 2 and 3, April-July, 1960, 7 pages, illustrated
by Josef Boehm

ABSTRACT

The development of the orbiting carrier Explorer VII is presented. It is shown how the many requirements inherent to the mission were incorporated into one satellite system. The design parameters are discussed. Particular emphasis is devoted to the testing of the satellite with regard to functional and environmental conditions.

INSTRUMENTATION FOR THE IONOSPHERE BEACON SATELLITE S-45

Unclassified Rpt., MTP-M-G&C-61-4, Feb. 8, 1961, 37 pages, illustrated
by Technical Data Unit, Guidance and Control Division

ABSTRACT

The Ionosphere Beacon Satellite was conceived and developed to provide a source of six coherent radio signals above the ionosphere, to permit observation of one-way transmissions through the ionized regions from which conclusions may be drawn as to the shape and structure of the ionosphere.

Engineering measurements are telemetered to the ground observer to permit evaluation of the beacon transmitter performance, which is necessary for the evaluation of wave behavior in the medium under observation. All of the measured data are telemetered via one radio circuit only, so that the phase relationship of the other waves will not be disturbed prior to transmission.

This report is a brief description of the radio beacon, satellite instrumentation, telemetry and antenna systems. It is intended to supplement rather than to supplant detailed engineering reports now in preparation, by presenting the perspective of the engineering accomplishments represented by the payload.

INSTRUMENTATION DESCRIPTION AND CHECKOUT PROCEDURES FOR THE GAMMA RAY SATELLITE, S-15

Unclassified Rpt., MTP-M-G&C-61-16, March 17, 1961, 91 pages, illustrated by Technical Data Unit, Guidance and Control Division

ABSTRACT

The Gamma Ray Satellite, S-15, was conceived and developed to detect extra-terrestrial gamma rays in the energy range from 100 to 400 million electron volts, resulting from neutral π meson decay; to map the spatial distribution of the decay gamma rays with respect to the galactic plane, the center of the galaxy, the sun and the magellanic clouds; to relate the measurements to the cosmic ray flux density and the density of interstellar matter throughout the galaxy; and, a secondary objective, to measure high-energy neutron and gamma ray albedos of the earth's atmosphere.

This paper briefly describes the instrumentation apparatus and the procedures for the final checkout of instrumentation systems and subsystems to assist the field engineer in performing final pre-launch tests.

DIRECTIONAL DEPENDENCE OF COUNTING RATES FROM EXPLORER IV (Satellite 1958 Epsilon)

Unclassified Thesis of Research Projects Division employee submitted in partial fulfillment of the requirements for the degree of Master of Science in the Department of Physics in the Graduate School of the University of Alabama, 1961, 100 pages, illustrated.

By
Robert J. Naumann

ABSTRACT

Inspection of the directional scintillation counter data from EXPLORER IV revealed fluctuations in the counting rate that appeared to be due to the body motions of the satellite and the anisotropy of the radiation flux. It was felt that the body motions of the angular dependence of the radiation flux could be determined from the data available.

This work is a description of the methods used and results obtained from this determination. It was found that the counting rate is generally a maximum when the detector axis is normal to the magnetic field which is expected from the theory of particle trapping. The counting rate falls off as the detector axis makes smaller angles with the magnetic field lines, reaching a minimum value when the detector comes within about 40 degrees of the magnetic field lines. Knowledge of this angular dependence of the counting rate will allow calculation of the radiation distribution along a particular magnetic line of force.

In the analysis of the rigid body motion, two rather surprising facts were observed. First, the components of the total angular momentum vector of the satellite do not remain constant in a space orientation-fixed reference system, although the magnitude remains essentially constant, Second, the small residual roll of the satellite about its longitudinal axis does not decay monotonically. In fact, at one point, the roll rate was observed to increase by almost an order of magnitude in one day. These two observations suggest that external forces were present and exert body torques on the satellite. It is possible that the origin of the forces may be due to an interaction of a magnetic moment in the satellite with the geomagnetic field although this is not yet confirmed.

JUNO II SUMMARY PROJECT REPORT
Volume I (EXPLORER VII Satellite)

Unclassified Rpt., NASA TN-D-608, July 1961, 356 pages, with illustrations.

Research Projects Division

ABSTRACT

This volume covers those phases of the JUNO II program dealing with the EXPLORER VII earth satellite. Subjects covered include selection of the experiments carried, special considerations for the launching vehicle, composition of the flight unit package, performance of the booster and upper stages during and after the firing, tracking operations, and orbital performance. Design and construction of the EXPLORER VII mechanical system (skin, structure, antenna reel, and antennas), electronic system (telemetry), and electrical system (networks, and battery and solar cell power system) receive extensive coverage including illustrations, charts, and diagrams. An analysis of the environmental requirements, the thermal design developed, the prototype tests to check the design, and actual flight thermal performance data are included. A chapter is devoted to prototype and flight unit testing. Each of the scientific experimenters, in separate chapters, describes the aim of his experiments, discusses the design, construction, and performance of the apparatus used, reports some of the findings and presents a preliminary evaluation of them. An appendix describes the JUNO II launching vehicle.

JUNO II SUMMARY PROJECT REPORT
Volume II (The S-46 Satellite)

Unclassified Rpt., NASA TN D-608, 1961, review draft, 290 pages, illustrated.

Research Projects Division

ABSTRACT

This volume covers those phases of the JUNO II program dealing with initiation, planning, design, and construction of the S-46 payload and the unsuccessful attempt to place it in orbit about the earth. Subjects covered include the objectives of the S-46 project, system parameters, special considerations for the launching, structure of the flight unit, performance of the booster and upper stages during and after the firing, and the tracking operations. Design and construction of the S-46 mechanical system, transmitter, telemetry, electrical networks, and battery and sollar cell power system are covered. The thermal design is also treated. One chapter is devoted to testing of components, modules, assemblies, prototype payloads, and actual flight units; applicable test procedures and specifications are included. The last chapter covers the State University of Iowa radiation experiment in the areas of history, instrumentation, apparatus fabrication, instrument calibration, apparatus operation during flight, and the results of the flight. The report has 157 illustrations, charts and diagrams, and 11 tables.

A LUNAR SUBSURFACE SAMPLING DEVICE

Unclassified Report, DLM-TN-86-60, May 10, 1961, 34 pages, illustrated

ABSTRACT

The purpose of this report is to present the latest concept for a lunar subsurface sampling device in one document for easy reference during future work on this project. The major features of this concept were included in an AOMC Report No. RCS ORDXM-C-1004, "A Lunar Exploration Program Based Upon Saturn Booster Systems," (C) dated 1 February 1960.

The concept presented is designed for operation with the lunar roving vehicle only. The device to be used with the stationary package embodies entirely different features and is not discussed in this document.

VI. PROPULSION SYSTEMS

SOME BASIC FACTORS INFLUENCING THE SELECTION OF PROPULSION SYSTEMS FOR SPACE MISSIONS

Unclassified Rpt., MTP-M-RP-61-9, April 6, 1961, 15 pages, no illustrations.

By
Joseph C. King

ABSTRACT

This report presents a general discussion of the propulsion aspects of space mission planning. The more important characteristics of present and anticipated propulsion systems are outlined, and the relationships between propulsion system characteristics and mission requirements are discussed. The expected space missions are grouped into several broad classes, roughly according to energy requirements. The major conclusion reached is that the high-energy missions (beyond Mars, for example) should be accomplished at very high levels of specific impulse, indicating the use of ion rockets under the present outlook for propulsion technology development. The situation is less clearly defined for the lower-energy missions, so propulsion system selections must be made on an individual basis. Some of the more important factors to be considered in such selections are discussed. The report concludes with a forecast of the applications for various propulsion systems in the advanced propulsion era (beginning in the latter part of this decade).

NUCLEAR ROCKET STAGES INCREASE SATURN'S PAYLOAD CAPABILITY

Unclassified Reprint from "Aerospace Engineering," May, 1961, 5 pages, with illustrations.

By
Willis Y. Jordan, Donald R. Saxton, Paul G. Thomas
Structures and Mechanics Division

ABSTRACT

Nuclear rocket stages used in conjunction with the SATURN space vehicle would offer attractive payload performance gains over the all-chemical SATURN for direct space missions. Although the theoretical performance of SATURN chemical/nuclear configurations increases as the nuclear engine power level increases, practical limitations on vehicular length would tend to limit reactor power to something less than the theoretical optimum performance value. Through the use of orbital refueling operations, SATURN-based nuclear rocket stages could provide the necessary transportation for attractive manned lunar operations. Such missions could be accomplished by a nuclear rocket vehicle departing from earth orbit with an initial gross weight of about 100 tons and driven by a reactor with a power level of approximately 1000 to 2000 megawatts.

THRUST VECTORING BY SECONDARY INJECTION

Confidential Rpt., MTP-M-S&M-P-61-9, April 14, 1961, 23 pages, illustrated
by Richard K. McSheehy

ABSTRACT

Future research concerning the phenomenon of thrust vector control by secondary injection should be devoted to establishing basic thermodynamic relations to accurately predict the performance of an injectant for a particular application. Previous work is reviewed and summarized. The feasibility of a secondary injection system using a reacting (exothermic) liquid is shown. Such a system would not have the high temperature structural problems of a hot gas injection system, and would be capable of generating larger side forces per pound of secondary fluid than comparable non-reacting liquid injection systems.

THE ELECTRIC ENGINE AS A PROPULSION SYSTEM FOR THE EXPLORATION OF SPACE

Unclassified Paper presented at the International Symposium on Space Age Astronomy, California Institute of Technology, 7 - 9 August 1961, 35 pages, illustrated.

By
Gerhard Heller
Deputy Director, Research Projects Division

ABSTRACT

This paper discusses electric propulsion and its application to the exploration of the solar system, and includes:

(1) A definition of the electric engine,

(2) The history and status of electric engines,

(3) A resume of research and technology problems connected with electric engines,

(4) A discussion of the flight testing of electric engines, and

(5) Missions of advanced spacecraft propelled by electric engines under consideration.

THE PLASMA JET AS AN ELECTRIC PROPULSION SYSTEM FOR SPACE APPLICATION

Unclassified Paper presented at the ARS 14th Annual Meeting, 16 - 20 November 1959, Washington, D.C., 28 pages, illustrated.

By
Gerhard Heller
Deputy Director, Research Projects Division

ABSTRACT

The advantages of electric propulsion systems for space navigation are discussed. The plasma jet is suited for missions between the earth and the moon. A supply mission is described between a 500-kilometer orbit and a manned space station outside the Van Allen belts at 6.6 earth radii. The mission includes the delivery of a cargo of 40,000 pounds in the upper orbit. A tilting of the orbital plane by 28 degrees is part of the flight plan. The plasma jet used as a propulsion system has a thrust of 70 pounds and a specific impulse of 1000 seconds. A period of 17 days is required for the trip from the 500-kilometer orbit to the space station; the return trip takes 5 days. The plasma jet as a propulsion system for space vehicles can be used for transfer between orbits, change of orbit plane by tilting and precession, position control of satellites, attitude control, "high thrust" maneuvers for planetary missions with an ion drive as main propulsion system.

SPACE MISSIONS FOR ION PROPULSION SYSTEMS

Unclassified Paper presented at the Sixth Annual Meeting of the American Astronautical Society, New York, 18 - 21 January 1960, 14 pages, illustrated.

By
Dr. Ernst Stuhlinger
Director, Research Projects Division

ABSTRACT

Chemical propulsion systems will receive strong competition from nuclear rockets, arc engines and electrostatic (ion) engines in space missions. This paper discusses only ion propulsion systems, with specific impulses up to 20,000 seconds. Descriptions, weights, performance data and illustrations are given for the following vehicles powered by ion propulsion systems:

1. Communications satellite with precise orbital control
2. Space station traveling between low and high orbits
3. Lunar ferry
4. Mars probe (unmanned)
5. Manned Mars ship
6. Jupiter and Saturn probe
7. Deep space probe

SOME PROBLEMS IN IONIC PROPULSION SYSTEMS*

Unclassified Paper, IRE Transactions on Military Electronics, 7 pages, illustrated

By
Dr. Ernst Stuhlinger & Robert Seitz
Research Projects Division

ABSTRACT

Some of the problems and applications of ionic propulsion systems are discussed. Three different systems' optimization criteria are considered: the maximization of the initial acceleration of a space vehicle; the minimization of the total-mass-to-payload-mass ratio; and the minimization of the propellant mass required to refuel the vehicle. The production, acceleration, and neutralization of singly ionized cesium ions is also discussed in limited detail. A hot tungsten contact-catalyst type of ion source is assumed and some experimental results with such a source are reviewed. Finally, a simplified treatment of the space charge neutralization of a positive ion beam in the region behind the space vehicle is presented. In this treatment, the positive-ion beam is replaced by an infinitely long cylinder of uniformly distributed positve charge. Electrons are emitted from an annular filament encircling the perimeter of the beam. It is shown that this approximation leads to radial oscillations of the electrons through the positive column.

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* Winner of the M. Barry Carlton Award of the IRE as the outstanding PGMIL technical paper of 1960.

VII. SPACE VEHICLE DESIGN

SATURN S-II/S-IV DYNA SOAR LAUNCH VEHICLE FEASIBILITY STUDY (U)

Confidential Rpt. MTP-M-F-61-4, March 10, 1961, 200 pages, with illustrations.

Coordinated & Edited By
David M. Hammock & Dale L. Hannaford

ABSTRACT

(U) This report presents the results of a feasibility study on the use of the SATURN S-II and S-IV stages modified for use as the DYNA SOAR launch vehicle.

(U) The study covers the vehicle structure, propulsion, aerodynamics, control, separation, performance, and abort design areas and the program plan and costing for typical DYNA SOAR schedules.

(U) The conclusions are that the vehicle is particularly attractive from the operational and cost standpoints when used as a DYNA SOAR launch vehicle. The summary of the report gives a concise presentation of the vehicle system and costs.

PRELIMINARY NUCLEAR/SATURN (C-4) LUNAR VEHICLE STUDY

Confidential (Restricted Data) Rpt., MTP-S&M-F-61-17, September 8, 1961,
81 pages, illustrated

Coordinated By
Nuclear Systems and Application Section, Future Projects Design Branch

ABSTRACT

This report summarizes the results of a preliminary investigation of nuclear/SATURN C-4 class lunar vehicles. The report presents a summary description of the nuclear stage, nuclear propulsion system characteristics, mission and performance data, nuclear radiation shielding considerations, and schedule and costing data.

Preliminary results indicate that the primary vehicle configuration consisting of a four (F-1) engine booster, four (J-2) engine second stage, and a NERVA nuclear rocket third stage has a net escape payload capability, after correcting for the nuclear stage's coasting and starting transient, aftercooling flow, and biological shielding, which appears adequate to perform the direct manned lunar landing and return mission. In addition to the primary C-4/nuclear vehicle, other configurations were investigated including higher thrust chemical second stages and/or PHOEBUS nuclear third stages which indicate a growth potential of 20 percent.

The schedule studies indicate that this vehicle is a very attractive backup to the selected primary mode of operation.

SATURN C-2 PHASE I PRELIMINARY DESIGN REPORT

Confidential Rpt., MNN-M-S&M-F-1-60, August 3, 1960, 124 pages, illustrated

By
D. M. Hammodk, E. E. Engler, J. A. McAnulty, R. G. Reichert, J. H. Laue

ABSTRACT

This report presents the results of the Phase I preliminary design study of the SATURN C-2 vehicle. The vehicle design was investigated for two first stages; i. e., a modified cluster tank (modified C-1 booster) and a single tank design. Second-stage diameters of 220 inches and 260 inches were studied. Dynamic loads, stage separation dynamics, mass characteristics, various structural arrangements, and second stage propulsion parameters were investigated. Line drawings and mass characteristics for two, three and four stage versions, and for a nuclear third stage, are given in the appendix. Results of the stage propellant optimization studies are reported.

Among other things, it was recommended that the operational SATURN C-2 vehicle should have the following nominal characteristics:

a. First stage with a 260-inch diameter, single-tank structure, and eight gimbaled H-1 engines.

b. Second stage with 260-inch diameter and four 200K-thrust oxygen-hydrogen engines.

c. Third stage with four 20K-thrust oxygen-hydrogen engines and 220-inch tank diameter.

d. Fourth stage, when used, a modified CENTAUR stage with the same engine as the third stage.

This report documents the presentation made to Dr. von Braun and the Division Directors on June 3, 1960, and includes most of the supporting data of the study.

THE SHIELDING OF SPACE VEHICLES

Unclassified Rpt., MTP-M-RP-61-12, May 16, 1961, 46 pages, illustrated.

By
J. Warren Keller

ABSTRACT

In this paper, the biologically important types of radiation fields to be encountered by the astronaut are reviewed briefly and the problems encountered in shielding against each are discussed. An effort is made to point out large uncertainties in the input data and shield calculations and to indicate areas where refinements are most immediately needed.

The shielding data given in this paper are drawn from a number of sources and are not meant to be definitive. They may prove useful, however, on a "best available data" basis, for making rough estimates of shielding needs for future manned vehicles.

UNCERTAINTIES IN SPACE RADIATION SHIELDING CALCULATIONS

Unclassified Paper from Research Projects Division presented at the ARS Space Flight Report to the Nation, New York, October, 1961, 32 pages, illustrated.

By
J.W. Keller

ABSTRACT

One of the most imposing problems confronting manned space flight programs is that of shielding astronauts from the harmful effects of radiation environments to be encountered in space. Although the data on the various radiation phenomena could hardly be called definitve at this time, efforts are being made to assess shielding problems.

In this paper an effort is made to point out and evaluate the magnitude of large uncertainties existing in the environmental data and shielding calculations, and to indicate needs for data refinements amd additional inputs. Among the items of environmental data considered are the absolute intensities, spatial distribution, energy spectra, and temporal variations in the Van Allen belts and solar cosmic radiation. Uncertainties in the methods of calculation currently being used are discussed including the handling of secondary radiation production.

MICROMETEORITE DISTRIBUTION NEAR THE EARTH

Unclassified Rpt., MTP-M-RP-61-2, February 1, 1961, 18 pages, illustrated.

By
Henry L. Martin

ABSTRACT

This report discusses the concentration or impact frequency of micrometeorites in space near the earth; their minimum mass distribution; their penetration into aluminum and steel; the 95% probability of no penetrations; and erosion depths.

SOME THERMAL PROBLEMS OF THE SATURN PAYLOADS ON THE MOON

Unclassified Rpt., MNN-M-RP-4-60, July 25, 1960, 28 pages, illustrated.

By
Billy P. Jones & Gerhard Heller

ABSTRACT

A preliminary analysis of the thermal aspects of SATURN payloads designed for soft landings on the moon for the purpose of scientific exploration are presented. The major factors contributing to the thermal design are discussed and the major problems defined.

It is demonstrated that it is technically feasible, although difficult, to protect payloads of this class from the lunar temperature environment.

THERMAL RADIATION INCIDENT ON NON-SPINNING EARTH SATELLITE

Unclassified Rpt., MTP-M-S&M-P-61-13, 28 pages, illustrated
by Frank E. Swalley

Equations are derived, using vector analysis, which predict the amount of thermal radiation received by a non-spinning earth satellite. The heating depends on the intensity of the radiation and the view factor between the object and source. To determine the length of the exposure to the various heat sources, relations are developed which give the points of ingress and egress of the earth's shadow and the location of the twilight line. As an illustration, the method is applied to a cylinder with flat or hemispherical ends and the results of the numerical integration of the view factors for the flat ends are presented.

SATURN C-1, BLOCK II DESIGN CRITERIA

Confidential Rpt., MTP-M-S&M-E-61-2, May 12, 1961, with revisions, illustrated

Design Integration Unit

ABSTRACT

This document presents, in one volume, the major design criteria for the SATURN Block II Vehicles and will serve as the basis for design of these vehicles.

This document is preliminary and of necessity incomplete; as more defined parameters develop, additions and revisions will be prepared. Available data are being presented at this time to ensure that design effort can develop.

Preliminary criteria, such as configurations, mass characteristics, trajectories, aerodynamic and structural loads which affect the entire vehicle are contained in the Flight Mechanics Section. Criteria, such as aerodynamic heating and pressure differentials applicable to individual stages, are shown in the S-I Stage and S-IV Stage Sections.

RECOVERY SYSTEM DEVELOPMENT

Unclassified Paper from IRE Transactions on Military Electronics, February 1, 1960, 5 pages, illustrated.

By
R.M. Barraza & W.G. Huber

ABSTRACT

The design and development of a recovery system involves extensive studies and tests to determine the best configuration for each specific application. Thought should be given to using off-the-shelf, well proven components where applicable in any new recovery system design. This will reduce the development cost and yield higher system reliability. In discussing the design and development of recovery systems, the overall problem can be broken down to include considerations of structural integrity of the vehicle; i.e., deceleration loads it can safely withstand; re-entry heating; practical end conditions of velocity and altitude at which recovery system sequence can be initiated with reliable operation; efficiency of system, i.e., weight and space requirements of the system for the amount of braking force developed; flotation equipment if required; and locating devices.

This paper discusses these considerations in detail and their application to present and future booster and payload recovery systems being developed by the U.S. Army Ballistic Missile Agency.

ON THE ECONOMY AND TECHNIQUES OF LARGE BOOSTER RECOVERY

Unclassified Rpt., DSP-TN-17-58, Dec. 15, 1958, 15 pages, illustrated
by H. H. Koelle

ABSTRACT

The question of booster recovery for large space-flight operations, which becomes very important with increasing vehicle size and firing rates, is discussed in detail. Such parameters as initial vehicle requirements, recovery cost, booster rotation time, and various correction factors are defined and explained. Simple approximation formulae are derived and evaluated for an arbitrarily selected orbital flight mission. Recovery schemes based on parachutes, wings, turbojets, and combinations thereof are evaluated numerically.

MERCURY BOOSTER RECOVERY

Unclassified Rpt., MTP-M-S&M-TSR-60-1, November 30, 1960, 46 pages, illustrated.

R.M. Barraza & J.C. Glover

ABSTRACT

This report outlines the results of past efforts toward recovery of a REDSTONE booster, and the areas where further study is desirable.

Recovery of the booster includes deceleration devices, water entry, water handling and retrieval, safety aspects, and retardation of salt water damage.

The report shows that the approach taken is one that will reward the government with an early retrieval of a large booster for inspection if the present program is followed to completion. This will give an opportunity of answering a number of questions which have developed during theoretical investigations of the economics of booster recovery from sea water.

The parachute deceleration system is capable of retarding a falling booster to a water entry velocity within the structural capability of the booster.

The open sea retrieval trials on the REDSTONE booster were successful to the degree that Naval personnel involved indicated they could recover larger boosters in the same manner.

Sea water immersion tests on the booster with minimum washdown and passivation are recommended prior to a detailed study of a returned booster, with refined techniques to be developed from results of inspection.

DIFFUSION OF GASES THROUGH MATERIALS

Unclassified Rpt., October 25, 1960, 21 pages, illustrated
by W. A. Riehl, W. C. Looney, and S. V. Caruso

ABSTRACT

It is well known that many gases will diffuse slowly through engineering materials. The diffusion rate is dependent not only upon temperature and pressure differential but also on the nature of the gas and material. Other factors being constant, diffusion rate is inversely proportional to the square root of the molecular weight of the gas. Hydrogen is the lowest molecular weight gas and is being considered widely as a propellant for chemical and nuclear rocket propulsion. For these reasons, primary attention has been placed on determination of the rate of diffusion of hydrogen through materials. Although considerable research has been reported on the mechanism of diffusion, almost all of this work was devoted to studies on pure materials. Very little experimental information is available on engineering materials.

After initial attempts to determine diffusion coefficients by measurement of pressure losses in a sealed container were unsuccessful, a method based upon mass spectrometric determination of gases diffusing through a membrane of the test material into a vacuum was developed. Accuracy and precision of this method were verified by comparison of experimental and literature values for the diffusion coefficient of hydrogen through palladium.

EFFECT OF SPACE ENVIRONMENT ON THE EXTREME PRESSURE QUALITIES OF LUBRICANTS

Unclassified Rpt., October 25, 1960, 41 pages, illustrated
by J. G. Williamson and E. E. Nelson

ABSTRACT

The wear characteristics and load-carrying capacities of a petroleum oil and a synthetic oil, with various extreme pressure compounds added, were studied under boundary lubrication conditions at reduced atmospheric pressure and in an inert atmosphere. Results of this work indicated that the lubricating properties of the oils tested were not changed when operating in an atmosphere of nitrogen. However, the lubricating qualities of the petroleum-based oils were drastically reduced when subjected to an absolute pressure of twenty microns of mercury. The lubricity and load-carrying capacity of the synthetic based lubricants were only slightly reduced at the lower atmospheric pressure. This work has shown that the loss of lubricants by evaporation is not the only problem associated with the reduction of atmospheric pressure, but that deterioration of wear characteristics and load-carrying capacity of lubricants can occur at environmental pressure higher than where evaporation would become a serious problem.

THERMAL FATIGUE TESTING, ARPA PROJECT 92-59

8550-9360-303

Unclassified Final Report, Structures & Mechanics Division, September, 1960, 14 pages, illustrated.

By
R.P. Wagner, J.H. Hess, C.E. Cataldo

ABSTRACT

There is a relationship between the number of thermal cycles a restrained metallic material can withstand before failing and the plastic strain induced during each cycle. The constant relating these parameters for a given temperature range can be determined in the laboratory by measuring the temperature at which a sample exerts no load upon its restraining members during heating and the "no-load" temperature during cooling. The plastic strain induced during each cycle can then be calculated using this temperature differential value, coefficient of thermal expansion data, and sample length.

A thermal cycling device was developed to determine the relationship between the number of thermal cycles to failure and the plastic strain induced during each cycle. The value of this constant relationship for 6061-T6 aluminum, cycled between -220°F and +500°F, was determined to be approximately 14.0×10^{-3}.

EFFECTS OF HIGH VACUUM CONDITIONS UPON THE FATIGUE PROPERTIES OF METALS, NASA PROJECT HS-175

Unclassified Final Report, Structures & Mechanics Division, September 30, 1960, 19 pages, illustrated.

By
B. McPherson, C.A. Navarette, C.E. Cataldo

ABSTRACT

An investigation to determine the influence of reduced pressures on the fatigue properties of several metals at room temperature indicated that, by the reduction of oxygen, the fatigue properties of some metals can be improved. Fatigue life under vacuum conditions may be ten times greater than at corresponding stress levels in air. Increased fatigue properties in reduced pressures depend upon the oxygen affinity of the particular metal. By the elimination of oxide film formation on crack walls or the reduction of oxygen diffusion of the crack front, the rate of crack propagation can be substantially reduced by vacuum conditions.

ULTILIZATION OF PIGMENTED COATINGS FOR THE CONTROL OF EQUILIBRIUM SKIN TEMPERATURES OF SPACE VEHICLES

Unclassified ABMA Paper for Aerospace Finishing Symposium, 12 February 1960
37 pages, illustrated.

By
Gene A. Zerlaut

ABSTRACT

The ease of application and the ability to tailor-make solar absorptivity-emissivity ratios, α/ϵ, have made the use of pigmented coatings very attractive for many present and future space vehicle applications. The utilization of painted surfaces as a means of affecting temperature control of space vehicles, and the possible deleterious effects of space environment upon the optical and radiometric properties are discussed. Other means of affecting temperature control and their advantages and disadvantages are outlined. Possible specialized pigmented coatings for satisfying future needs are also discussed.

A BRIEF REVIEW OF THE ABMA ABLATION MATERIALS PROGRAM

Unclassified Paper, DSN-TM-7-60, 12 May 1960, 6 pages, with illustrations.

By

Dr. W.R. Lucas & J.E. Kingsbury

ABSTRACT

This paper presents a brief review of the step-by-step progress in the experimental development of ablating materials for hyperthermal environment. Test methods and the parameters controlling the effectiveness of ablating materials are discussed. It is shown that the effectiveness of ablation materials is controlled not only by the composition and orientation of material but also the conditions of the test. Thus, there is not a generally applicable ablation system.

VIII. SPACE VEHICLE PRODUCTION

EXPLORING THE USE OF MODULES IN VERSATILE TOOLING SYSTEMS

Unclassified Rpt., M-F&AE-IN-61-6, May 27, 1961, 11 pages, illustrated
by R. V. Hoppes

ABSTRACT

The unique context of space vehicles places a serious responsibility on manufacturing, of which tooling is a major and important segment. There is a definite need for new concepts and principles in tooling which can be succinctly stated as follows:

1. Frequent change of space vehicle configuration and diameter can cause major re-tooling repeatedly, costly and time consuming.

2. Man in space and the limited number of vehicles per design demand the utmost in reliability.

3. The immensity of prospective vehicles precludes the use of conventional tooling approaches.

The only possible solution seems to lie in versatile, modular tooling complexes, within which several vehicle sizes and configurations can be fabricated.

A FABRICATION STUDY TO COMPARE TITANIUM AND ALUMINUM STRUCTURES

Unclassified Rpt., M-F&AE-IN-61-27, Aug. 16, 1961, 12 pages
by J. Trust

ABSTRACT

A study was accomplished in support of Centaur Project to determine the adaptability of titanium with reference to its fabrication qualities for tanks. This study includes titanium's characteristic capabilities for welding, forming, machining, milling, and cleaning as compared to aluminum and stainless steel.

Although the cost of titanium is considerably higher than aluminum and stainless steel, the predominant index for consideration of its use is the specific weight savings and the strength-to-density ratio.

VERTICAL POSITION WELDING OF ALUMINUM ALLOY FOR SPACE LAUNCH VEHICLE APPLICATIONS

Unclassified Rpt., M-F&AE-MTP-61-20, April 8, 1961, 14 pages, illustrated
by Daniel M. Daley

ABSTRACT

A study was conducted to determine and describe the problem areas and to develop preliminary information on techniques for vertical position welding. During this study both 2014-T6 and 5456-H343 were welded, using the automatic MIG welding process in thicknesses of 1/8" and 1/4". As a result of this preliminary study, it was determined that vertical welding is practical for space launch vehicle applications. However, more work and study must be done to obtain better control of fitup between parts, weld machine settings and weld tooling that will insure reproducible, high quality welds that can meet the standards needed for the large diameter tanks of future space launch vehicles.

AUTOMATIC FUSION WELDING OF SPECIALLY DESIGNED ALUMINUM ALLOY STRUCTURES

Unclassified Rpt., M-F&AE-IN-61-2, May 24, 1961, 12 pages, illustrated
by S. J. Paek

ABSTRACT

A program was initiated to investigate problem areas and establish preliminary data relative to fusion welding of mechanically milled, ribbed aluminum alloy 5456-H343 in thick sections. This study revealed that mechanized fusion welding is readily accomplished. However, it must be emphasized that a pronounced narrowing of the weld bead occurs, due to varying heat dissipation, when the arc passes over the intermittent ribbing. Although this condition does not seriously impair the mechanical properties of the joint, it does fall out of the range of standards as acceptable for space launch vehicles. As a result, a considerable effort is required with the objective to utilize a mass sensing device to precede the arc and adjust the current to compensate as required.

SPINFORMING SATURN TANK BULKHEADS

Unclassified Rpt., M-F&AE-MTP-61-15, Feb. 28, 1961, 19 pages, illustrated
by J. Cresap and P. H. Schuerer

ABSTRACT

This report presents the techniques developed by this agency to produce 105" diameter Saturn bulkheads using a process which combines flat blank machining with power shear spinning.

Specialized equipment for the operation was developed and embodies the use of a 10-foot capacity boring mill equipped with hydraulic, template controlled, roller attachment and spinning mandrels. Rear bulkheads produced by the process have been evaluated and found acceptable for missile use.

This is an interim report outlining procedures presently used. Refinements in techniques are being made and will be incorporated in subsequent reports.

USING HIGH ENERGY TO FORM MATERIALS

Unclassified Rpt., M-F&AE-IN-61-26, April 7, 1960, 34 pages, illustrated
by Earl A. Hasemeyer

ABSTRACT

Scientists and engineers in the missile and space industry have been fascinated by the potential of high energy forming. This report is intended to describe the present state of the art, as well as the research and development effort being expended by this Agency.

Many companies have established facilities for high energy forming and others are purchasing components made by this method. Some questions on physical and metallurgical phenomena remain unanswered, but continuing research is steadily removing these mysteries.

CHEMICAL CLEANING OF SATURN COMPONENTS

Unclassified Rpt., M-F&AE-MTP-61-12, March 20, 1961, 12 pages, illustrated
by F. J. Beyerle

ABSTRACT

This report presents a study of the methods employed and the results obtained in cleaning Saturn components to the cleanliness requirements of ABMA-PD-C-472a (MSFC-SPEC-110) specification.

The process includes the use of high pressure spray techniques to eliminate non-volatile hydrocarbons and solid, insoluble particles from Saturn LOX and fuel surfaces.

The process is in the experimental stage and is being continually improved to arrive at the desired end results.

RECOMMENDATIONS CONCERNING ALIGNMENT OF THE PRATT & WHITNEY AIRCRAFT LR-119 ROCKET ENGINE

Unclassified Rpt., MTP-M-QUAL-61-18, May 25, 1961, 47 pages, illustrated
by E. S. Hendricks

ABSTRACT

This report presents the various recommendations made by Quality Division concerning alignment of the Pratt & Whitney Aircraft LR-119 Rocket Engine. Quality Division's participation to date, with regard to this subject, is given. This includes recommendations made with respect to Pratt & Whitney Aircraft and Douglas Aircraft Company engine alignment procedures. Comments pertaining to alignment of the Pratt & Whitney LR-119 Engine as given in a trip report by the writer are also included. Detailed comments to Pratt & Whitney Aircraft preliminary engine alignment report are made as well as detailed comments with respect to engine alignment procedures and specifications as presented by the Vehicle Mechanical Design Integration Working Group. A discussion of engine alignment procedures and equipment used by Rocketdyne, Chrysler Corporation and this Agency during the Redstone, Jupiter and Saturn Programs, along with some mention of difficulties encountered, is presented. A discussion of geometric versus dynamic thrust vector determination is presented along with a bar graph showing displacement between geometric and dynamic thrust vectors for 68 Jupiter S-3D Rocket Engines.

INSPECTION PROVISIONS FOR GOVERNMENT INSPECTION AGENCIES

Unclassified Rpt., QEB Nr. 1, April 19, 1961, 14 pages
by Quality Division

ABSTRACT

Quality Engineering Bulletin #1 sets forth those principles of inspection which MSFC has found, through experience, to be necessary to assure the receipt of product of acceptable quality. It instructs the inspecting agency performing service for MSFC in the detailed requirements in certain areas. It calls for an organized, detailed, inspection plan based on the contractor's quality assurance plan, which is to be followed in detail throughout the life of the contract. It further requires a monthly report describing the work performed and the general quality program at the manufacturer's plant, listing problem areas and suggestions for improvement. It provides for training of the inspection agency personnel as necessary and establishes lines of communications.

QUALITY ASSURANCE PROVISIONS FOR SPACE VEHICLE SYSTEM CONTRACTORS

Unclassified Rpt., QEB Nr. 2, Revision A, June 15, 1961, 31 pages
by Quality Division

ABSTRACT

Quality Engineering Bulletin #2 establishes criteria for a contractor's quality assurance program when the contract calls for a long-term manufacturing operation of large scale such as for a complete stage of a vehicle. The requirements are generally in keeping with good policies established by MIL-Q-9858, and most contractor systems meeting the MIL-Q-9858 requirements will also be acceptable under this document with only minor changes. The program calls for a quality assurance plan covering all aspects of quality from the design phase through purchasing, receiving of purchased items, inspection, build-up and fabrication, to final acceptance and shipping. It further calls for a monthly status report which enables MSFC to evaluate the program and take corrective action as required. The bulletin establishes training requirements and channels of communication.

INSPECTION SYSTEM PROVISIONS FOR SUPPLIERS OF SPACE MATERIALS, COMPONENTS AND SERVICES

Unclassified Rpt., QEB Nr. 3, August 15, 1961, 6 pages
by Quality Division

ABSTRACT

Quality Engineering Bulletin #3 explains the requirements which must be met concerning a contractor's program of inspection and quality control when performing services on contracts of a short term or on task order type blanket contracts. It requires that the contractor have a plan of inspection and quality control which must be approved by MSFC, and it requires that he not present to the government for acceptance any material which has not been subjected to his system and which he knows to be of poor quality. Channels of communication are stated and the assistance of MSFC is provided for as needed.

FINAL ACCEPTANCE TEST REPORT MR-1

Unclassified Rpt., MM-M-SAR-2-60, Sept. 12, 1960, 114 pages, illustrated
by Systems Analysis and Reliability Division

ABSTRACT

The final acceptance tests performed on Mercury-Redstone No. 1 are described in this report. Tests performed assured that all systems, sub-systems, components, and the related support equipment perform satisfactorily to accomplish the assigned mission.

Three alignment problems discovered during testing were either waived or corrected, after which alignment of the entire vehicle was certified for flight.

Measurements on the booster and GSE indicated that the resistance from GSE to Capsule in the Mayday circuit is 0.7 ohms or slightly less. Although the circuit in the capsule is fused at 10 amperes, it is switched by a 2 ampere capacity relay contact. Blowing of this will prevent completion of the abort sequence. It is recommended that a diode be added to the capsule circuitry, as considered previously by the Space Task Group, in all subsequent Capsules.

Based upon results obtained from the analyses performed, MR-1 is accepted for flight preparations, with the exception of the Capsule. Problems involving the Capsule were referred to the Space Task Group for corrective action.

FINAL ACCEPTANCE TEST REPORT SATURN S-I-1

Unclassified Rpt., IN-M-QUAL-61-7, Sept. 18, 1961, 41 pages, illustrated
by Quality Division

ABSTRACT

This report describes the final verification tests performed on Saturn S-I-1 immediately prior to launch preparations and the minimum pressure, fit and alignment tests performed on the dummy upper stages.

Test results revealed that the systems which were complete are ready for launch preparations even though all discrepancies were not resolved due to lack of scheduling time. Special attention should be given at Launch Operations Directorate to the cooling thermostats since they operate erratically. A design change to the cooling system is necessary and is scheduled for SA-3. The measuring discrepancies will be cleared when transducer replacements become available, and when the vehicle is positioned vertically.

The control system was in a non-flight condition due to unavailability of the flight control computer and the mechanical feedback servo-valves. Therefore, complete control system verification should be made at the Launch Operations Directorate.

QUALITY ENGINEERING SURVEY OF ASTRONAUTICS DIVISION, GENERAL DYNAMICS CORPORATION, SAN DIEGO, CALIFORNIA

Unclassified Rpt., IN-M-QUAL-61-6, May 1961, 26 pages
by Quality Division

ABSTRACT

A survey of the Quality Control System of General Dynamics/Astronautics, San Diego, California was conducted in May of 1961 by Quality Division of George C. Marshall Space Flight Center with active participation by the NASA Western Operations Office. The purpose of this survey was to determine the adequacy of the Quality Control System at General Dynamics/Astronautics, with both Air Force and Contractor quality control activities being considered.

The Quality Control System conforms to the requirements of MIL-Q-9858, and, although in many respects it is satisfactory, the following serious deficiencies were noted:

1. Complete Vehicle and GSE Systems Electrical Schematics are nonexistent. These are of prime importance for proper understanding and efficient checkout of space vehicles.

2. Vital tests are entirely omitted from the vehicle checkout phase.

3. Meeting of pre-determined schedules is given precedence over shipment of flight ready vehicles to the firing site. Much final assembly, correction of deficiencies, and checkout is actually planned for the launch facility.

4. Serious deficiencies in the Contractor's quality control program include (a) insufficient engineering level coverage and (b) mere witnessing of tests rather than active participation.

5. Serious deficiencies in Air Force quality control program includes (a) insufficient Q. C. personnel, (b) extremely low ratio of engineering to nonengineering personnel, (c) lack of specialization and specialized training, and (d) insufficient authority at all levels. This includes insufficient delegated authority and backing from the Air Force Ballistic Missile Division in Inglewood.

SATURN MECHANICAL SYSTEMS PRESSURE AND FUNCTIONAL TEST PROCEDURES

Unclassified Rpt., 6 QUAL 2-15, August 28, 1961, 290 pages, illustrated
by R. Baker

ABSTRACT

In order to insure that the mechanical systems of the S-1 stage of the Saturn C-1 Space Vehicle will meet the mission requirements assigned, special test methods and inspection techniques are employed as outlined in the "Mechanical Systems Pressure and Functional Test Procedure Manual." The manual is divided into fifteen sections with each section covering a specific system and assembled into the proper sequence to simplify testing. The methods, specialized equipment, techniques and types of tests were carefully selected so that the tests performed, and the results obtained, would provide maximum assurance of the integrity and functional capability of each system.

CATALOG OF SYSTEM TESTS FOR SATURN S-1

Unclassified Rpt., September 1, 1961, 150 pages

ABSTRACT

This catalog describes briefly and basically each test performed on the Saturn S-I stage. The tests described are, in general, those which require vehicle scheduled time to perform. The catalog is organized so that the tests appear in sequence according to catalog category numbers. The categories defined are as follows:

1. Electrical Networks
2. Measuring, Rough Combustion Cutoff and Fire Detection
3. Telemeter
4. R. F. and Tracking
5. Guidance and Control Systems
6. Mechanical Systems Tests
7. Vehicle Systems Tests

FAR-FIELD NOISE CHARACTERISTICS OF SATURN STATIC TESTS

Unclassified Rpt., NASA TN D-611, August 1961, 48 pages, illustrated
by Wade D. Dorland

ABSTRACT

A far-field survey has been conducted to determine the characteristics of the noise generated by the Saturn static firing tests. Data obtained for the first series of eight tests indicate the noise has high power, broad directivity, a low frequency spectrum, and low efficiency. Initial tests were made firing two engines on the first test and four engines on the second test. These tests produced sound power levels of 0.56 megawatt and 1.6 megawatts, respectively, with low efficiencies of 0.04% and 0.06%. The remaining six tests were made with eight engines. They produced sound power levels ranging from 25 megawatts to 40 megawatts, with an acoustic efficiency of approximately 0.7%. Frequency spectra peaked between 10 cps and 100 cps, with a severe dip at 250 cps and a minor peak at 1000 cps. The effects of impingement on the flame deflector and the dampening of the cooling water make it very difficult to isolate the effects of clustering the engines.

SOUND CONSIDERATIONS CONCERNING THE MSFC WEST AREA

Unclassified Report, October 12, 1961, illustrated
by Test Division

ABSTRACT

Static tests can be conducted in the West Area with a six million pound thrust vehicle with sound pressure levels in the Huntsville Area no greater than those experienced from present Saturn static firings. This conclusion is based on the following:

a. The jet deflector will be oriented away from nearby populated areas.

b. That monitoring of atmospheric conditions will enable tests to be scheduled only during favorable periods, as is now being done for Saturn tests at the Static Test Tower.

SIMULATED SATURN LOX PRESSURIZATION SYSTEM TESTING

Unclassified Rpt., Internal Note TEST 12-61, August 8, 1961, 38 pages, illustrated
by W. J. Halbrooks

ABSTRACT

This report describes the simulated Saturn LOX pressurization system tests conducted at Cell 114, Components Test Section "A". Nine tests were conducted with four heat exchangers operating in parallel, six tests with two heat exchangers operating in parallel, and six tests required only one heat exchanger. The scope of testing included clustered heat exchanger performance tests, pressurizing both LOX and water, LOX tank pressure decay studies, heat exchanger LOX bypass systems, variable LOX orifice valve performance tests, and LOX tank wall and gas temperature studies. Construction and instrumentation of the facility are described, and scheduled modifications are outlined.

These tests indicated that H-1 heat exchangers would operate satisfactorily in parallel. The LOX tank pressure decay observed in test SAT-11 on the Saturn booster was duplicated, and the effectiveness of a "Chinese hat" capped standpipe verified. Feasibility of a LOX tank pressurant control valve was demonstrated.

DESIGN, FABRICATION, AND INSTALLATION OF FIRE CONTROL SYSTEM, SATURN BUILDUP, STATIC TEST TOWER EAST

Unclassified Rpt., Internal Note TEST-1-61, July 14, 1961, 53 pages, illustrated
by William E. Marsalis

ABSTRACT

An important item in the facility buildup is the fire control system. Experience has proven that where a fuel and an oxidizer are present in large quantities, a fire can be disastrous. If the fuel and oxidizer flows can be shut off, the fire can usually be extinguished without great loss. But, if rupture of propellant lines or tankage precludes control of fuel and oxidizer flows, it is virtually impossible to extinguish the fire until the propellants have burned out. In such case, the best that can be expected is to protect the test stand structure during burnout and attempt to prevent a major explosion. With these thoughts in mind, and considering the large quantities of propellants used in the SATURN test vehicle, design and installation of a fire control system were undertaken.

Responsibility for design of the system and for preparation of working drawings was assigned to the Test Stand Design Section, Test Laboratory. General design criteria were to provide the utmost in fire control using all of the water available at the test stand. The water supply system was modified to provide a flow capacity of 40,000 - 41,000 g.p.m. with a minimum pressure of 115 p.s.i. at ground level at the test stand. It was decided that in case of emergency, 6,200 g.p.m. would be used to maintain a protective flow on the flame deflector and 33,800 to 34,800 g.p.m. would be diverted for the fire control system. Of the latter, 1,000 g.p.m. would be used by the off-stand, remotely-controlled fire monitor, leaving 32,800 - 33,800 g.p.m. for the on-stand system.

Responsibility for fabrication and installation of the fire control system was assigned to the Structural and Mechanical Shop Section, Test Laboratory. Where feasible, component parts of the system were prefabricated in the shop and installed as units in the test stand. However, the very nature of the work required that most of the fabrication be done as part of the system installation.

The system was completed in April 1960. Overall cost for design, fabrication, installation, and materials was $103,000.00.

PROPOSED TEST FACILITY FOR GROUND TEST OF SPACE SUPPORT EQUIPMENT

Unclassified Report, DLS-TN-19-60, March 9, 1960, 13 pages, illustrated
by Owen L. Sparks

ABSTRACT

This report presents a general plan for a vacuum facility to be constructed at Redstone Arsenal. Some of the major requirements and objectives are outlined but no detailed description of construction, equipment, and costs are included. The purpose of the report is only to "fix" the requirements for such a facility and indicate a general approach to its solution.

IX. FLIGHT OPERATIONS

INTERIM REPORT ON FUTURE SATURN LAUNCH FACILITY STUDY

Unclassified Rpt., MIN-LOD-DL-1-61, May 10, 1961, 45 pages, illustrated
by O. K. Duren

ABSTRACT

Future SATURN launch rates may require full utilization of Cape Canaveral real estate.

This report presents new launch concepts that have been proposed to satisfy high launch rates of the SATURN. The concepts are generally termed "Mobile" and "Fixed." Basically, the "Mobile" concept allows the assembly and checkout of the vehicle in an off-pad facility prior to transfer to the launch pad. The "Fixed" concept allows the completed launch operations to be accomplished on the launch pad. In each case, supporting facilities are integrated in a multi-pad complex.

Charts of cost and operational comparison of each concept are included.

1:20 SCALE MODEL SATURN LAUNCH DEFLECTOR STUDIES

Unclassified Rpt., MTP-M-TEST-61-14, June 13, 1961, 81 pages, illustrated
by C. P. Verschoore

ABSTRACT

Results of a 1:20 scale model Saturn test program concerning launch conditions are contained within this report.

Results reported concern tests conducted with a cluster of eight, 500-pound thrust LOX and kerosene operated engines, with the same configuration as the actual Saturn Booster, in conjunction with a 1:20 scale model of the proposed Saturn launcher pedestal for complex 34, and various angled wedge deflectors.

Contained herein are the results of studies made regarding cluster base region temperatures and pressures during the cluster hold-down period and during the lift-off phase up to an equivalent height of 25 feet for the full-scale Saturn vehicle. Model deflector ablation characteristics in conjunction with deflector geometry and material are included. Also reported are general gas flow patterns as well as overall effects of the launcher during the launching period.

Test results revealed the desirability of a 60° wedge deflector as compared to the 80° wedge deflector. Test information indicated that a wider deflector would be preferable; however, with the 60° deflector, the existing width was considered tolerable.

LUNAR SOFT LANDING STUDY FOR NATIONAL AERONAUTICAL AND SPACE ADMINISTRATION SYSTEMS SUPPORT EQUIPMENT

Unclassified Rpt., DLS-TN-26-59, Dec. 17, 1959, 93 pages, illustrated
by Owen L. Sparks

ABSTRACT

Material in this document is presented in three sections: Section I, Ground Support Equipment; Section II, Manned Lunar Capsule Recovery; and Section III, Lunar Roving Vehicle. It should be pointed out that a majority of the ground support equipment described in Section I has already been developed or has been designed for use in the overall SATURN Vehicle Program. Therefore, most of this section is a proposal only in the sense that it is proposed to use existing SATURN Ground Support Equipment in the Lunar Soft Landing System. However, the information presented in Section II and Section III is based on preliminary design studies only and is submitted as a proposal subject to a complete R&D Program.

Since information presented herein is very general in nature it is not intended for use as final design criteria.

MERCURY REDSTONE MR-4 LAUNCH REPORTS

Confidential Rpts., Published by the Launch Operations Directorate

ABSTRACT

This report is comprised of copies of the launch and flight evaluation reports prepared by the Launch Operations Directorate in support of Captain Virgil Grissom's suborbital flight into space on July 21, 1961. The reports are divided into two categories: (1) Preflight and Quick Look Post Flight Evaluation Reports and (2) Firing Test Reports.

The Preflight and Quick Look Post Flight Evaluation Reports present the status of the vehicle in relation to the scheduled launch time and a preliminary evaluation of the vehicle's performance during flight. All reports are dispatched to a limited need-to-know group of NASA personnel and are prepared "as required" or "on schedule" as their subject titles indicate.

The Firing Test Report contains the plans for the testing and firing of a vehicle by Launch Operations Directorate personnel and details the data collected during this process. It is published in six parts and is distributed as soon as the information is available. Part I, the Index and Test Results, covers data collected during and immediately after the vehicle flight and is distributed approximately seven days after the actual launch. Part II consists of Part IIA, the Instrumentation Plan and Part IIB, the Instrumentation Analysis. A provisional Instrumentation Plan is distributed (to a select, immediate need-to-know, group) approximately four weeks prior to launch date and is followed weekly by up-to-date plans. The final or Consolidated Instrumentation Plan is published one week prior to the vehicle flight. Part IIB details the actual instrumentation coverage obtained during the vehicle flight and is distributed approximately thirty days after the firing. Part III, the Firing Site Weight Report, contains the weight data collected during vehicle testing, erection and countdown. It is published approximately four days after the launch date. Part IV, the Master Operations Schedule details the procedures for the Simulated Flight Test, the launch countdown, and provides the schedule for Prelaunch Preparations and launch day. This part is distributed about two weeks prior to the scheduled launch date. Part V, the Unsatisfactory Condition Reports, contains all the UCRs written against the vehicle and associated equipment at the Launch Operations Directorate.

JUNO II AM-19F FLIGHT EVALUATION OF PROPULSION UNIT AND ASSOCIATED SYSTEMS

Confidential Rpt., MTP-M-S&M-P-61-8, June 2, 1961, 46 pages, illustrated
by Ralph M. Hoodless, Jr. and Norman G. McDonald

ABSTRACT

JUNO II AM-19F was fired from Complex 26, Pad B, Cape Canaveral, Florida, on February 24, 1961, at 1913 hours EST. The propulsion system performance was satisfactory and a velocity cutoff occurred 1.93 seconds earlier than predicted.

The environmental control system performance was satisfactory in maintaining the necessary temperature and pressure for proper functioning of the guidance and control equipment. Tail section environment was also satisfactory.

Immediately after first separation (body installation from power unit), a violent motion of the body installation was observed. This resulted in excessive use of the spatial attitude control system and premature depletion of the supply sphere. During the same period, the launcher rpm dropped and recovered. Because of these deviations, the mission of placing the satellite into orbit was not accomplished.