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ANNOTATED BIBLIOGRAPHY OF LUNAR PROPERTIES, GEOLOGY, VEHICLES, AND BASES

PART II- VEHICLES, TRAJECTORIES, AND LANDINGS

SPECIAL BIBLIOGRAPHY
SB-61-67

DECEMBER 1961

534 000

Lockheed

MISSILES and SPACE DIVISION

LOCKHEED AIRCRAFT CORPORATION • SUNNYVALE, CALIF.

NOTICE

WORK CARRIED OUT AS PART OF THE LOCKHEED INDEPENDENT RESEARCH PROGRAM.

5-53-61-2

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PART II- VEHICLES, TRAJECTORIES, AND LANDINGS

Compiled by

A. A. BELTRAN, J. B. GOLDMANN and E. E. GRAZIANO

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ABSTRACT

Part II of this three part lunar bibliography is concerned with manned and unmanned lunar probes, their purpose, trajectories, instrumentation, ground support, and landing site selection. Manned vehicle equipment, communications, number of crew, crew requirements, and landings are also covered, as are manned and unmanned space stations. Part I dealt with the physical properties, geology, volcanism, selenomorphology, mineralogy and maps of the moon. Part III will cover fixed and mobile lunar bases, construction problems, lunar surface vehicles, and the methods and feasibility of human habitation. Arctic exploration, including base construction, surface vehicles, clothing and equipment, and environmental effects on man is included because of its applicability to lunar bases and exploration.

INTRODUCTION

The lunar bibliography is divided into three parts: I. Known and Conjectured Properties of the Moon; II. Vehicles, Trajectories, and Landings; and III. Lunar Exploration and Arctic Analogy.

Part II deals with manned and unmanned lunar probes, their purpose, trajectories, instrumentation, ground support, and landing site selection. Manned vehicle equipment, communications, number of crew, crew requirements, and landings are also covered, as are manned and unmanned space stations.

Part I dealt with the moon's motion, gravity, and magnetic fields; temperature, atmosphere, surface features, maps, and mapping techniques; historical geology, volcanism and selenomorphology, mineralogy and internal constitution of the moon, and the possibility of life.

Part III will cover fixed and mobile lunar bases, life support and logistics requirements, lunar buildings and vehicles, construction problems and possible use of lunar materials; and methods and feasibility of human habitation. The Arctic analogy is treated quite extensively because of its direct applicability to the lunar base problem and covers ground transportation, construction, clothing and equipment, environmental effects on man, etc.

A wide variety of reference sources were consulted in this selective compilation, some seemingly unrelated to the subject, due to the wide scope of this bibliography. These sources include the report files and card catalogs of the Lockheed Missiles and Space Company Technical Information Center, the files of the Armed Services Technical Information Agency, the U.S. Geological Survey Library, and the various subject libraries of Stanford University. The indexes and abstract services used include the following:

AEROSPACE ENGINEERING INDEX - 1947 to 1958

AEROSPACE REVIEW (In Aerospace Engineering) - 1959 to 1960

AGRICULTURAL INDEX - Sep 48 to Oct 1961

AIR UNIVERSITY PERIODICAL INDEX - 1953 to June 1961

ANNOTATED BIBLIOGRAPHY OF ECONOMIC GEOLOGY - 1928 to June 1959

ARCHITECTURAL INDEX - 1950 to 1960

ARCTIC BIBLIOGRAPHY - 1953 to 1960

ART INDEX - Oct 1947 to July 1961

ASTIA TAB - Jan 1960 to 1 Nov 1961

ASTRONAUTICS INFORMATION (Jet Propulsion Lab.) - 1960 - 1961

ASTRONOMISCHER JAHRESBERICHT - 1946 to 1959

BIBLIOGRAPHY AND INDEX OF GEOLOGY EXCLUSIVE OF NORTH AMERICA - 1950 to 1959

BIBLIOGRAPHY OF THESIS IN GEOLOGY IN THE U.S. AND CANADA THROUGH 1957

BIBLIOGRAPHY OF SNOW, ICE AND PERMAFROST - 1958 to 1960

BIOLOGICAL ABSTRACTS - 1959 to 1 Oct 1961

BULLETIN SIGNALETIQUE (Monthly Supplement to Astronomischer Jahresbericht) - 1960 to 1961

CHEMICAL ABSTRACTS - 1947 to 1959

CURRENT LIST OF MEDICAL LITERATURE - 1955 to 1959

DOCTORAL DISSERTATIONS - DISSERTATION ABSTRACTS - 1950 to Sep 1961

ENGINEERING INDEX - 1943 to 1960 and Engineering Index Service

GEOSCIENCE ABSTRACTS - 1959 to Sep 1961

INDEX MEDICUS - 1960 to 1961

INTERNATIONAL AEROSPACE ABSTRACTS - Jan to Nov 1961

JOURNAL OF THE BRITISH INTERPLANETARY SOCIETY; Abstracts Section - 1934 to June 1961

METEOROLOGICAL AND GEOASTROPHYSICAL ABSTRACTS - 1950 to June 1961

NUCLEAR SCIENCE ABSTRACTS - 1949 to 31 Oct 1961

PACIFIC AERONAUTICAL LIBRARY UNITERM INDEX TO PERIODICALS - 1958 to 1960

QUARTERLY CUMULATIVE INDEX MEDICUS - 1955 to 1956

SCIENCE ABSTRACTS, Section A - 1930 to Sep 1961

TECHNICAL LITERATURE DIGEST (ARS Journal) - 1952 to Oct 1961

U.S. GOVERNMENT PUBLICATIONS MONTHLY CATALOG - 1945 to Oct 1961

An attempt has been made to represent as many points of view as possible without including every report and article on each specific subject. When a more intensive coverage yielded no new information, the additional items were not included. The resultant work is intended as a key to the universal literature on the physical properties of the moon and its environment; manned and unmanned vehicles for reaching the moon; constructing fixed bases on the moon; lunar surface vehicles and equipment for exploration of the moon; and Arctic bases and exploration. A supplement will be issued early in 1962, which will contain citations not yet verified and additional references uncovered as the literature search continues.

To increase the usefulness of the bibliography, each of the three major parts has been divided into logical sections, and each section has been further subdivided into subject categories. Arrangement within each subdivision is alphabetical by author. A subject index follows Part III. Each part, because of its size, is being issued separately.

CONTENTS

PART II

VEHICLES, TRAJECTORIES, & LANDINGS

SECTION A - GENERAL

479. Baker, N.L.

Lockheed offers satellite and Moon rockets.

MISSILES AND ROCKETS v. 2, n. 11, p. 116-118,

1957.

480. Burke, J.D.

Project ranger: Trailblazer for man on the

moon. GSE v. 2, n. 6, p. 28-29, 1960-1961.

This article relates the three aspects of the Lunar Program: (1) objectives, (2) intended progression of developments and flight experiments, and (3) program management arrangements.

481. Clarke, A.C.

Meteors as danger to space-flight. BRIT.

INTERPLANETARY SOC - J v. 8, n. 4, p. 157-62,

1949.

It is concluded that it is probably not worth while taking any special precautions against meteors for relatively short voyages such as to moon; for space stations or interplanetary rockets, meteors probably represent real danger, but it is one which can be neutralized, or greatly reduced, by simple means; factors tabulated for meteors of various magnitudes are: average number of hits per hour, number of hours between hits, probably of at least one hit per 24 hr.

482. Cross, C.A.

Use of probe rockets. BRIT. INTERPLANETARY

SOC - J v. 16, n. 3, p. 148-62, 1957.

Operation of rockets that are not restricted to closed orbit around earth; establishment of probe rocket in closed orbit about Moon, Mars, and Venus; conditions for their successful accomplishment, and information that might be obtained, considered in each case; prospects for direct investigation of planetary surfaces by remotely controlled landings.

483. Davies, J.G., et al

Observations of the Russian moon rocket

Lunik II. NATURE (Gt. Brit.) v. 184, n. 4685,

p. 501-2, 1959.

Observations made with the Jodrell Bank radio telescope.

484. Davies, M.E.

How good is Lunik III photography? ASTRONAUTICS

v. 5, n. 5, p. 28-29, 1960.

A comparison is made between the Soviet pictures of the back side of the moon, taken from Lunik III, with the earth originated photographs of front side. The primary aim of the Soviet pictures was to record the maximum area of the unseen side without particular regard to quality. The pictures show that the back side of the moon is more monotonous than the front side. According to the Soviet pictures, the image of the moon differs appreciably from a circle. Next step will be to acquire pictures of better resolution. These will be of great scientific importance.

485. Department of the Army, Washington, D. C.

MISSILES AND VENTURES INTO SPACE 1960-1961

REPORT. Pamphlet no. 70-5-9, June 61, 81p.

ASTIA AD-260 820

DESCRIPTORS: *Bibliography, *Guided missiles, Rockets, *Spaceships, Space probes, Satellites, Lunar probes, *Space flight, Directories, Encyclopedias, Conferences, Symposia, Power supplies, Armed Forces, USSR, *Astronautics.

486. Ehricke, K. and Gamow, G.

A rocket around the moon. SCIENTIFIC AMERICAN v. 196, n. 6, p. 47-53, 1957.

It is predicted that the moon will be reached within 5 years. Orbits and techniques of launching the moon vehicle are described. Equipment and the safe return to earth thereof is also considered. This popular article is fully illustrated by diagrams showing possible orbits. One possible experiment would be to drop a small atomic bomb on the moon and collect some of the dust kicked up by the explosion to bring back to earth.

487. Evans, G.R., Compiler

LUNAR PROBES AND LANDING, AN ANNOTATED BIBLIOGRAPHY. Lockheed Aircraft Corp., Missiles and Space Division, Sunnyvale, Calif. Rept. no. SB-61-24.

This paper is concerned primarily with lunar probes, lunar landings, design configurations, and materials applicable to spaceships, covering the period from January 1959 to the present.

488. Gatland, K.W.

Exploration of the moon. II-The robot explorers. SPACEFLIGHT v. 2, p. 212-219, 1960.

Discussion of the new developments in space probes, covering the operation steps involved in taking and transmitting the Lunik III photographs. A speculation is made on the probable design of the final stage of the Lunik I probe, problems to be solved in landing instruments on the moon in working order, and techniques developed in this respect. Features of the proposed British MIGRANT lunar soft-landing probe are described. Experiments considered by the NASA lunar working group are noted. A small caterpillar tractor, the Soviet-proposed "tankette-laboratory"--i.e., which, having been deposited on the moon by the last stage of the carrier rocket, would begin to explore on its own account, is noted.

489. Gold, T.

Space research in relation to the moon and the nearer planets. ROYAL SOCIETY. PROCEEDINGS PART A v. 253, p. 487-491, 1959.

Space Research Discussion, London, 1958. A discussion of the techniques of space research, in the light of some major problems related to the solar system which still await solution. Space experiments involving landing on, or close approach to, the major planets will prove of immense value, and may yield quite unexpected results --- comparable with the recent discovery of the Van Allen radiation zone.

490. Heaton, D.H.

Step by step...to the moon. SAE JOURNAL v. 69, n. 5, p. 91-93, 1961.

A discussion of lunar projects - some ready for production, others still in the planning stage - is presented.

491. Hibbs, A.R., (ed)

EXPLORATION OF THE MOON, THE PLANETS, AND INTERPLANETARY SPACE. Jet Propulsion Lab. Rept. no. 30-1, 30 Apr 59, 120p. (Contract NASw-6). ASTIA AD-215 689

A survey was undertaken of possible objectives in a program of exploration of the moon, the planets, and interplanetary space. This was combined with a survey of the feasibility of engineering developments which would be required by such an exploration program. The basis on which the study was conducted is described and a review of current knowledge is presented about the moon, the planets, and interplanetary space, giving a brief summary of the results of the study on the feasibility of a program for the exploration of space. A program of lunar and interplanetary flight is described and the necessary development activities are outlined to support the exploration program. The time scale covered extends from 1959 through 1964.

492. Hibbs, A.R.

The national program for lunar and planetary exploration. ENGINEERING AND SCIENCE v. 24, n. 8, p. 14-18, 1961.

Plans are discussed for the next decade of lunar and planetary exploration to be carried out under the direction of the Jet Propulsion Laboratory, Pasadena, California.

493. Hunter, M.W.

THE COST OF LUNAR TRAVEL. SAE, International Congress & Exposition of Automotive Engineers, 1961, Detroit, Mich, 9-13 Jan 61. Preprint 302II. 9p.

Discussion of rough cost estimates for lunar transportation systems. Direct-operating costs and development costs are combined into a total cost curve and presented graphically as a function of tonnage delivered. The cost for conventional chemical propulsion would appear to be extremely high. Improvement can be obtained by going to high-energy recoverable systems and then, for greater improvement, to nuclear recoverable rockets.

494. Hunter, M.W.

Round trip to the moon for $600. SAE JOURNAL v. 69, p. 85-87, 1961. Abridged.

Evaluation of direct operating costs, and launch and development costs for travel to and from the moon.

495. Jensen, J.

Satellites. AERONAUTICAL ENGINEERING REVIEW v. 15, n. 9, p. 44-47, 1956.

Problems connected with: (1) earth satellite launching, (2) unmanned space flight (the moon rocket) and (3) manned space flight are discussed. The biggest problem is accuracy of direction and speed which must be within 2.5°

495. (Cont'd)

and 1%, for the satellite, and 0.5° and 1% for the moon rocket if the flights are to be successful. Another problem is that of tracking, and for manned or moon rockets, that of braking. Atomic energy could produce fast streams of ions which would be efficient over long periods of time for control or braking, though insignificant for initial thrust. Uses are suggested such as weather or time observatories, navigation control or radio-TV relay.

496. Jet Propulsion Lab. C

SPACE PROGRAMS SUMMARY NO. 37-8,

VOLUME II, 15 JANUARY - 1 MARCH 1961

(U). Divs. 12/1, 12/2, 12/3, 12/4.

1 Apr 61, 149p. (Contract NASw-6).

ASTIA AD-324 126. CONFIDENTIAL REPORT

DESCRIPTORS: Lunar probes, Booster rockets, Space capsules, Moon, Landing impact, Communications systems, Space probes, Nuclear propulsion, Electric propulsion, Ion rockets, Data transmission, Atmosphere entry.

497. Jet Propulsion Lab., Calif. Inst. of Tech., C

Pasadena. SPACE PROGRAMS SUMMARY NO. 37-9.

VOLUME II, 1 MARCH - 1 MAY 1961 (U).

1 June 61, 108p. (Contract NASw-6).

ASTIA AD-324 546. CONFIDENTIAL REPORT

DESCRIPTORS: *Lunar probes, *Space probes, Spaceships, *Satellite vehicles, Instrumentation, Research program administration, Space capsules, Reliability, Guidance, Control systems, Satellite attitude. Moon, Landing impact, Propulsion, Design, Tests, Rocket motors, Solar cells, Booster rockets, Space flight, Satellite vehicle trajectories, Mars, Venus, Electric power production, Telemeter systems, Command systems, Communication systems, *Satellite vehicle research, Electronic equipment.

498. Kaplan, J. and Hagen, J.P.

The satellite: What it is, how it works,

what it may bring. U.S. NEWS & WORLD REPORT

v. 43, n. 16, p. 106-109, 1957.

498. (Cont'd)

An interview with Joseph Kaplan, chairman of the U.S. National Committee for the IGY, giving his views on the Soviet satellite and its importance and on possibilities for space travel. John P. Hagen, director of Project Vanguard, tells of the advantages of sending a rocket to the moon, and of what the U.S. hopes to learn from our satellites.

499. Koelle, H.H.

LONG RANGE PLANNING FOR SPACE TRANSPORTATION SYSTEMS. National Aeronautics and Space Administration, Washington, D. C. Rept. no. TN D-597, Jan 61.

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 affecting 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.

500. Kolcum, E.H.

Lunar drive may cost under $20 Billion.

SPACE TECHNOLOGY v. 4, n. 3, p. 40-41, 1961.

Washington - Crash program to beat Russia in landing a man on the moon, including all supporting research and development, may cost less than $20 billion instead of the $40-billion estimate made two months ago. The total figure includes a number of vehicle and payload projects that already were on the schedule but that now have been incorporated into the Apollo manned lunar landing program because they will contribute background information to the mission. Among them are at least 20 scientific satellites and probes, and all advanced launch vehicles.

501. Levantovskiy, V.I.

BY ROCKET TO THE MOON. Aerospace Technical Intelligence Center, Wright-Patterson Air Force Base, Ohio. Translation no. MCL-879,

501. (Cont'd)

pt. 2, p. 237-443, Apr 60.

ASTIA AD-258 843

Research is presented on projected travel to the moon and other planets. The following areas are covered: (1) Flight to the moon--plans and reality; technical feasibility of such an expedition, interplanetary stations, certain plans for expeditions, and flight of unmanned automatic rockets. (2) investigation of the moon and outer space: matter in the universe; the relief, physical conditions, and methods of scientific investigations of the moon; and the moon as an intermediate station. (3) Interplanetary flights: interplanetary trajectories of pulsed rockets, the first artificial planets, trajectories of continuous-thrust rockets, role of man in space flight, use of sounding rockets, interplanetary expeditions, and conquering space. The second and third Soviet cosmic rockets are also discussed, and a bibliography is presented.

502. Mars, moon, venus landings proposed in five year space exploration plan. WESTERN AVIATION v 39, n. 9, p. 21-23, 1959.

Jet Propulsion Laboratory proposal of a twelve point space exploration program to the National Aeronautics and Space Administration which would climax with a soft landing on Venus in March, 1964, to ascertain whether or not there is life on this planet.

503. Newell, H.E.

NASA and space. BULLETIN OF THE ATOMIC SCIENTISTS v. 17, p. 222-229, 1961.

Survey of the NASA program for research by means of satellites, sounding rockets, space probes, and manned vehicles. Attention is given to lunar and planetary research programs. A schedule of projected launchings is presented, and data concerning launch vehicles used by NASA are tabulated.

504. Ordway, F.I., III, and Wakeford, R.C.

Man on the Moon?--probes due first.

504. (Cont'd)

MISSILES AND ROCKETS v. 3, n. 4, p. 69-74, 1958.

Studies by K. A. Ehricke and others on important aspects of lunar flight; navigation problems; possibility of establishing satellite around moon; present work on moon rocket project; two approaches concerning placing vehicle in vicinity of moon; Russian moon programs; automatic landing; moon conditions; H-bombs on moon; moon bases.

505. Ordway, F. I., III, and Isbell, B.S.

United States space carrier vehicle and spacecraft developments. ASTRONAUTICA ACTA v. 7, Fasc. 2-3, p. 103-134, 1961.

Review of U.S. achievements in space research to date, and of projected satellites, lunar and interplanetary probes, and orbiting observatories. Extensive tables of descriptive data and firing histories are presented for carrier vehicles and Mercury capsules.

506. Palmore, J.I., III.

Lunar impact probe. ARS JOURNAL v. 31, p. 1066-1073, 1961. (Also issued as ARS Paper 1587-60, 28p.).

Discussion of the need for, and the problems associated with, obtaining information about the surface of the moon by means of the high-velocity impact of a lunar probe. The impact problem is studied by first analyzing the origin of the forces resisting penetration, then adding these forces to predict the resultant transient force response appearing as compression waves at a sensing station in the probe removed from the initial impact face. From this response, which is transmitted to the earth for analysis, detailed clues to the surface structure may be found. An analysis of possible lunar surfaces restricts the design of the probe. Major restrictions are placed on the shape of the probe by the extremes involved in impact at 7,700 ft. per sec. The suitability of cones and paraboloids for distinguishing different surfaces is discussed in detail. Equations are developed, and computations based on them are made for different probe geometries. Properties of various lunar surface materials and probe structural materials are tabulated.

507. Petrov, V.P.

Soviets certain they'll be first on moon.

MISSILES AND ROCKETS v. 4, n. 10, p. 50-58,

1958.

Long-standing, deeply scientific studies of space travel lend strength to beliefs of leaders and citizens.

508. Ranger 2 launch precedes '62 schedule of

three instrumented lunar landings. SPACE

AGE NEWS v. 4, n. 7, p. 4-8, 1961.

A news report on the Ranger Program and Surveyor Outlook. A general appraisal of the problems, and a prediction that man will not reach the Moon until 1967.

509. Ruppe, H.O. and Barker, C.L., Jr.

Lunar circumnavigation. INSTITUTE OF RADIO

ENGINEERS. TRANSACTIONS. MILITARY ELECTRONICS

v. MIL-4, n. 2-3, p. 163-169, 1960.

A short survey on the mechanics of the free flight part of circumlunar flight is presented. This survey is by no means complete and many refinements have been listed but not explained. Other important fields such as attitude control have been left out completely. It must be stressed that for exact computations of trajectories, special studies covering the astronomical constants and computational methods are mandatory. The launch vehicle, space capsule, environment and its control, onboard power supply, communications, and methods of space navigation and propulsion are but a few of the topics which need treatment if completeness is desired. Other areas requiring attention are the Earth communications links for both data transmission and vehicle control as well as the major item of payload recovery particularly when that payload is man!

510. Saturn C-3 approved to launch Apollo B.

SPACE TECHNOLOGY v. 4, n. 3, p. 40, 1961.

Complete article: Washington - Saturn C-3 launch vehicle proposed by Marshall Space Flight Center (AW June 12, p. 58) has been approved by the National Aeronautics and Space Administration as the vehicle to launch the Apollo B circumlunar spacecraft. Maj. Gen. Don R. Ostrander, NASA launch vehicles director, said the C-2 is "rather marginal" for the mission, and the agency wants to start development early next year on the C-3. The new Saturn consists of a cluster of two Rocketdyne F-1 engines as booster, four Rocketdyne J-2 engines as a second stage, and six Pratt & Whitney LR-115 engines as third stage. NASA meanwhile has narrowed the list of prospective bidders for the J-2 stage to Aerojet-General Corp., Douglas Aircraft Co., General Dynamics-Astronautics and North American Aviation. They will meet June 21 at Marshall for a bidders conference. Proposals will be due Aug. 1. Contract for the stage will be awarded Oct. 1. Gen. Ostrander also said NASA is planning to seek industry proposals for the S-1 Saturn first stage to accelerate its availability. The stage has been built by the government at the Marshall facility. After an announcement by Rep. Overton Brooks (D.-La.), chairman of the House space committee, NASA confirmed it was considering a site at Michoud, La., as a possible Saturn construction facility. The site, near New Orleans, is a former Army ordnance plant. NASA said it is inspecting sites throughout the country as potential Saturn construction facilities. The agency plans to assign the selected facility to a contractor.

511. Schneiderman, D.

JPL's plan to explore space. AIRCRAFT AND MISSILES v. 3, n. 9, p. 21-23, 1960.

Ranger research space vehicle being developed by Jet Propulsion Laboratory to explore Moon and planets with instruments and relay information obtained back to Earth; scientific bus consists of hexagonal structure which mates to vehicles that launches it and upon command separates and flies through space; instruments are geared to obtain survey of radiation fields in space and factors that influence them; moon mission, Mars and Venus.

512. Shepherd, L.R.

Basic principles of astronautics. BRIT. INTERPLANETARY SOC - J v. 14, n. 1, p. 37-44, 1955.

First of series of articles intended primarily for scientifically trained newcomer; elementary account of principles of rocket flight in gravitational

512. (Cont'd)

fields given, leading up to assessment of magnitude of task of flying to moon and lesser task of setting up orbital rockets.

513. Smith, D.E. and Smith, A.E.

Around the moon. FLIGHT v. 78, n. 2701,

p. 941-943, 1960.

This article discusses the various aspects of lunar probes, satellites, and trajectories, and reviews Russian and American achievements in this field to date. A description of the launch vehicle, payload, and flight sequence of the Atlas-Able V is given.

514. Stanyukovitch, K.

Trip to the Moon: a Russian view. AVIATION

WEEK v. 61, n. 9, p. 36-38, 1954.

Translation of an article from the Russian publication News, dealing with the problems in a general manner.

515. Stehling, K.R.

From 100-pound to 10-ton payloads: moon

vehicles for today and tomorrow. SPACE

AERONAUTICS v. 30, n. 5, p. 22-23, 200-201,

1958.

A detailed review of the vehicles that will be used in the earlier stages of lunar flight.

516. Stehling, K.R.

Moon vehicles for today or tomorrow. SPACE

AERONAUTICS v. 30, n. 5, p. 22-23, 200-201,

1958.

An outline of the types of vehicle required to carry payloads of 100 lb. to 10 tons to the vicinity of the Moon.

517. Stoller, M.J.

N.A.S.A. looks ahead. SPACEFLIGHT v. 3,

p. 70-77, 1961. Abridged.

Review of America's plans for extending space research and technology over the next 10 years. Areas considered are the solar satellite; spacecraft for lunar, planetary, and interplanetary use; a lunar surface probe; satellite meteorology; manned space flight.

518. Stone, I.

Surveyor lunar spacecraft has varied approaches.

AVIATION WEEK & SPACE TECHNOLOGY v. 74, p. 50,

51, 53, 55, 56. 1961.

Discussion of a proposed lunar surveying craft and its instrument system. Seven of the vehicles are scheduled for soft-landing on the moon during 1963-1966. Propulsion system, terminal guidance, orbital approach, and landing on the lunar surface are discussed.

519. Stuhlinger, E.

LAUNCH VEHICLES FOR LUNAR FLIGHT. ARS,

Semi-Annual Meeting, Los Angeles, Calif.,

9-12 May 60, 14p. Preprint 1115-60.

Discussion of a future exploration program of the NASA, based on the Atlas and Saturn vehicles. A brief review is given of the successful lunar flights up to the present day. Flights designed for the forthcoming years are listed in a table which also includes the carrying capabilities of the vehicles. Another table lists the total masses which the various vehicles can carry to injection into the lunar coasting trajectory, as well as the net payload of scientific instruments which each vehicle can deliver to its target.

520. Taylor, H.

Big moon booster decisions looming. MISSILES

AND ROCKETS v. 9, n. 9, p. 14-15, 1961.

News report: NASA prepared to pick lunar launch site, release specs for Nova-type solid, study liquid Nova proposals.

521. Taylor, H.

NASA realigns to push moon program.

MISSILES AND ROCKETS v. 9, n. 14, p. 14,

1961.

Super management group established to run Apollo called similar to Navy's Polaris direction - but with one major difference; Holmes outlines functional approach to job.

522. The timetable: our pace into space.

PRODUCT ENGINEERING v. 31, n. 37, p. 15-16,

1960.

1960: efforts will be made to achieve the first suborbital flight of an astronaut. And first launchings will be made of the Scout, Delta, and Atlas-Able rockets. 1961: the first manned flight into space will be attempted with Project Mercury; 1961 will also see an attempt to hit the moon with an instrumented payload, and the first launching of the Centaur vehicle, which will have capability of putting 9,000-lb payload into orbit.

523. Turner, R.S.

Takeoff from moon relatively simple.

MISSILES AND ROCKETS v. 9, n. 12, p. 34-35,

68, 1961.

In initial lunar voyage, vehicle will carry fuel for return, other support will be entirely internal

1. Mission Objectives

The purpose of the probes; the experiments to be conducted; the things to be investigated; and decontamination of the probes are treated under this heading.

524. Barabashov, N.P.

Novyi etap izucheniia luny. AKADEMIIA

NAUK SSR. VESNIK v. 30, p. 32-36, 1960.

(In Russian)

Discussion of the exploration of the formation and physical aspects of the moon, by means of cosmic rockets, automatic interplanetary stations, and interplanetary spaceships, which must precede a manned moon flight.

525. Boushey, H.A.

Blueprints for space. AIR. UNIV. QUARTERLY

REV. v. 11, n. 1, p. 16-29, 1959.

Uses of earth circling satellites such as global weather detecting and reporting satellite, reflector type, delayed relay type of communications satellite, retrosatellite, and navigation satellite; military uses; manned outposts in space; problems involved in landing of first human observers on surface of moon and return to earth.

526. Clark, E.

Pioneer indicates restricted radiation.

AVIATION WEEK v. 69, n. 16, p. 30-33,

1958.

Firing of the second Able I Lunar probe to a distance of some 80,000 miles from the earth has provided encouraging preliminary information on lethal high intensity radiation.

527. Clark, E.

Radiation belt explored by Army's Pioneer III probe. AVIATION WEEK v. 69, n. 24, p. 28-31, 1958.

Army's Pioneer III lunar probe made two long instrumented passes through the radiation belt surrounding the earth and provided the most extensive survey of the belt's extent and intensity on a 38 hour six minute trip that carried it 66,654 miles into space.

528. Courtney-Pratt, J.S.

A note on the possibility of photographing a satellite near the moon. J. PHOTOGR. SCI. (Gt. Brit.) v, 9, n. 1, p. 36-55, 1961.

Technical possibilities of photographing vehicle near or on the moon.

529. Eimer, M.

MEASUREMENT OF PROPERTIES OF THE MOON FROM A SOFT-LANDED VEHICLE. Jet Propulsion Laboratory, California Institute of Technology, Pasadena. (Presented at the National IAS/ARS Joint Meeting, Los Angeles, Calif., June 13-16, 1961). American Rocket Society, Inc., New York, N.Y. 61-111-1805.

Some of the measurements of interest for unmanned, stationary vehicles are discussed. Measurements to be made from a stationary lunar laboratory can be categorized as follows: texture, physical properties, petrological analysis, body structure, fields, particles, atmosphere, and ionosphere. With respect to surface material, the first three of these categories correspond to a decreasing scale of examination. At the one extreme, texture is determined from the entire spectrum of surface rubble and porosity. At the other extreme, chemical properties are determined by the various elemental and molecular constituents.

530. Exploring the planets. FLIGHT v. 78, n. 2702, p. 968-970, 1960.

Objectives of the U.S. lunar and planetary exploration programs are outlined.

531. Fensler, W.E., Senior, T.B.A. and Siegel, K.M. Exploring the depth of the surface layer of the Moon from a radar space observatory. AERO/SPACE ENGINEERING v. 18, n. 11, p. 38-41, 1959.

The method given here involves the determination of the power reflection coefficient at different wavelengths; this coefficient is a function of the number and depth of any layers present and of the electromagnetic constants associated with these layers. Using the mathematical formula for the reflection coefficient of a layered structure, these quantities can be calculated from measured values of the power return at different wavelengths. It is suggested that this experiment be carried out by placing a radar-equipped satellite in orbit around the Moon; data on the power reflection coefficient could be telemetered back to earth for analysis. The feasibility of the whole system is discussed.

532. Green, J. GEOPHYSICS AS APPLIED TO LUNAR EXPLORATION: FINAL REPORT. North American Aviation, Inc., Space Information Systems Div., Downey, Calif. Report no. MD 59-277; AFCRL-TR-60-409, 30 June 60, 268p.

A survey of the recent geophysical literature was applied to lunar exploration. Simple combinations of already existing hardware were prescribed to perform specific geophysical tasks on four vehicles. Experiments and surveys were discussed and discussed and described for use in hovering, surface, and subsurface probes. For the hovering and surface surveys, certain morphological features of impacted and volcanic terrains were described. Emphasis was placed on caldera and lava plain features because of the advantages that volcanism offers over impact processes with regard to terrain and mineralization. Comparison curves of geophysical instruments over craters of the two

532. (Cont'd)

opposing mechanisms of origin are compared. The two-curve magnetometer offers much in terrain analysis of the lunar surface. Instrumentation details of television and infrared surveying are detailed. A nested geophone and pulser define a possible system for both surface and subsurface seismic research. For surface and subsurface analysis, specific adaptations of conventional well-logging devices, both horizontal and vertical, are outlined with emphasis on the search for water. Response telemetered from the prescribed instruments, particularly the resistivity log, may be better interpreted by recording during passage of the lunar shadow front. The dry-hole resistivity, neutron-neutron, density, and pulsed accelerator logs are described and endorsed. The pulsed accelerator neutron-gamma system is particularly suited for analysis of elements of high-neutron capture cross section such as boron, chlorine, and sulfur. These elements are enriched in soluble compounds in ocean water on Earth. If defluidization enriched these elements on the surface of the Earth, a similar defluidization process may have enriched them as fumarolic products on the Moon. However, mineralization, if it exists, will probably be concentrated in unknown amounts either in eternally shadowed zones or under dust. Nuclear spectroscopy of the neutron-gamma reaction type is amenable to volume analysis in distinction to surface analysis techniques and can provide an indication of the nature of the material in fissures and under dust. Ice may conceivably be detected by this technique. Four instrumented vehicles, two hovering and two soft-landed, are described for the performance of specific missions. For the Atlas hovering vehicle, available for 32½ minutes of hovering, 68 pounds (30 kg) of instruments are detailed; for the Saturn hovering, available for 46 minutes of hovering, 131 pounds (59 kg) of instruments are prescribed; for the Atlas soft-landed vehicle, 550 pounds (247 kg) of instruments are described; and for the Saturn soft-landed, 1360 pounds (617 kg) of instruments. The equipment common to all four vehicles includes television and infrared cameras and electronics, shift registers, encoders, analog-to-digital converters, programmers, command receivers and decoders, power supplies, telemeters, and wiring and structure. In addition to this common unit, the Atlas hovering contains a gamma-ray scintillometer, and two-curve magnetometer; the Saturn hovering contains the Atlas instruments plus a gravimeter, a mass spectrometer and a radar altimeter. Both surface vehicles contain the common unit just mentioned, together with a landing control programmer, instrumentation programmer, radioactive and sonic shielding, and electromangetic devices for extender probes. The surface Atlas vehicle also contains a micrometeorite detector, discriminated gamma log, neutron-neutron log, resistivity log, temperature log, nested geophone, magnetometer, and density log. The Saturn surface vehicle contains all the Atlas instruments except the neutron-neutron log. In addition, the Saturn contains a pulser to accompany the geophone, proton-gamma and neutron-gamma accelerator log, mass spectrometer, drilling rig, lubricant, and batteries for drilling. The sites for location of these vehicles are detailed on a lunar map on which are specified geological and geophysical features of interest.

533. Greenfield, S.M.

ON LUNAR AND PLANETARY EXPERIMENTS.

Rand Corp. Rept. no. P-1535, 29 Oct 58,

9p. Also In Proceedings of the Lunar and

Planetary Exploration Colloquium v. 1, n.

3, 29 Oct 1958.

A report to the Lunar and Planetary Exploration Colloquium by the Subcommittee for Lunar and Planetary Experimentation. Numerous possibilities for lunar and planetary experiments are outlined, and the suggested experiments are organized into three main categories. The paper is concerned mainly with the issue of contamination (biological, chemical, and radioactive). The experiment categories are organized so that the experiments not involving contamination are given priority.

534. Greenwood, S.W.

Reconnaissance orbits. AERONAUTICS v. 44,

p. 32-35, 1961.

Discussion of solar, lunar, and planetary reconnaissance satellite orbits. Various missions are compared, and NASA projects for the next decade are reviewed.

535. Hibbs, A., Eimer, M. and Neugebauer, M.

Early ranger experiments. ASTRONAUTICS

v. 6, n. 9, p. 26-27, 1961.

Their first and foremost purpose will be to give an extensive, detailed picture of interplanetary plasma.

536. Johnson, M.H., et al SRD

AERONUTRIC, LUNAR RESEARCH FLIGHT STUDIES.

NUCLEAR DETONATION EFFECTS (U). Newport

Beach, Calif. Rept. no. AFSWC TR-59-37 v.2,

15 July 59. SECRET RESTRICTED DATA

537. JPL considers vehicle to return lunar sample to earth for study. AVIATION WEEK AND SPACE TEHCNOLOGY v. 75, n. 5, p. 58, 1961.

Possible mission objectives for Surveyor and Prospector space probes are outlined.

538. Lockheed Missiles and Space Division S
AGENA CAPABILITIES FOR NASA MISSIONS (U). Rept. no. LMSD 446175, 9 Dec 59, 172p.
SECRET REPORT

539. Lockheed Missiles and Space Division S
AGENA REFERENCE DATA FOR NASA (U). Rept. no. LMSD 446253-B, 26 Jan 60, 32p.
SECRET REPORT

Subject: Lunar probes.

540. Lockheed Missiles and Space Division S
PRELIMINARY PROGRAM REQUIREMENTS FOR NASA LUNAR MISSIONS - AFMTC (RANGER, AGENA B, ATLAS VEHICLES) (U). Rept. no. LMSD 447019, 27 June 60.
SECRET REPORT

This Program Requirements Document for the Atlantic Missile Ranger represents the first issue for the National Aeronautics and Space Administration lunar program using the Ranger, Agena B, and Atlas vehicle combination. (U).

541. Lockheed Missiles and Space Division

A PROPOSAL TO STUDY METHODS OF CONDUCTING GEOPHYSICS RESEARCH ON THE MOON. Rept. no. LMSD 48428, 4 Feb 59.

A comprehensive study of selenological literature and research methods is proposed, to determine the experiments that should be carried out in preliminary lunar explorations. The objective is to determine those experiments that are desirable and practical, as opposed to those that are desirable but not feasible for either technical or economic reasons. Five major tasks are proposed: a search and evaluation of the literature; preparation of literature summaries and a bibliography; determination of the selenological data that will probably be required and the methodology of the explorations; delineation of instrumentation-vehicle combinations; and preparation of conclusions and recommendations.

542. Mercier, C.C.

REMOTE PROGRAMMING PROBLEMS FOR SCIENTIFIC EXPERIMENTS ON THE MOON. North American Aviation, Inc., Space and Information Systems Div., Downey, Calif. Jet Propulsion Laboratory, California Institute of Technology, Pasadena. (JPL Contract N-30011, under NASA; Contract NASw-6) 6 Mar 61.

Problems associated with programming remote scientific experiments on the lunar surface are described. Desirable experiments are defined, as are requirements associated with selected instruments to perform the experiments. Considerations of spacecraft payload capability, manipulation requirements, electrical power characteristics, telemetry capacity, duty cycles, and operational constraints such as ground station availability, viewing restrictions, and lunar lighting conditions result in the selection of two spaceborne programmers - one for transit operations, and one for lunar operations. The lunar programmer consists of a master unit and a number of subprogrammers for those experiments requiring a complex or repetitious sequence. Redundancy is provided by a ground-based command system capable of transmitting both manual and complex taped signal. This overriding command capability also provides a desirable degree of schedule flexibility. Alternate programmer philosophies are described along with an operational sequence of a proposed spacecraft concept to perform remote exploration of the Moon.

543. Phillips, C.R. and Hoffman, R.K.

Sterilization of interplanetary vessels.

Earthly organisms can be kept from contaminating the moon and planets, but careful planning will be required.

SCIENCE v. 132, n. 3433. p. 991-995, 1960.

544. Posner, J., (ed)

PROCEEDINGS OF MEETING IN PROBLEMS AND TECHNIQUES ASSOCIATED WITH THE DECONTAMINATION AND STERILIZATION OF SPACECRAFT JUNE 29, 1960, WASHINGTON, D. C. National Aeronautics and Space Administration, Technical note D-771, Jan 61, 57p. ASTIA AD-248 765

A meeting was held of representatives of agencies concerned with the development of space vehicles, including lunar probes, and those investigating decontamination and sterilization procedures. The moon is held by some to be a barren body with no biology of its own, but capable of sweeping up the debris of outer space and preserving it in nooks and crannies from whence it can be recovered and examined. Others contend that simple organic compounds and even life, may have arisen on the moon. It is therefore desirable to avoid contamination of the moon with terrestrial forms of life.

545. Press, F., Buwalda, P. and Neugebauer, M.

A lunar seismic experiment. JOURNAL OF GEOPHYSICAL RESEARCH v. 65, n. 10, p. 3097-3105, 1960.

A feasibility study shows that a lunar seismic experiment can provide significant data on the structure and composition of the moon. The presence or absence of lunar seismicity is an important clue to current tectonic processes that affect the lunar surface. In the first generation of experiments, single detectors are envisaged with the capability of

545. (Cont'd)

recording body and surface waves. Investigation of proposed methods of lunar-seismogram interpretations indicates that these detectors should be sufficient to give a rough outline of lunar seismic geography and to indicate crudely the composition of the moon as well as its main structural features. In the absence of lunar seismicity, the best statistics on the frequency of meteorite impacts indicate that meteorites may provide useful auxiliary seismic sources. In reaching this conclusion, reasonable estimates were made of the efficiency of impact as well as of seismic-wave attenuation. Critical factors in the experiment are instrument lifetime and sensitivity and the nature of lunar microseismic noise.

546. Sagan, C.

Biological contamination of the Moon.

NATIONAL ACADEMY OF SCIENCES. PROCEEDINGS

v. 46, n. 4, p. 396-402, 1960.

Four possible circumstances which could lead to undesirable contamination are discussed.

547. Shlichta, P.J.

Geological exploration of the Moon.

BULL. GEOL. SOC. OF AMER. v. 71, n. 12,

pt. 2, p. 2111, 1960.

On the possibility of geological exploration by instruments carried to the moon by rocket.

548. Singer, S.F.

Interplanetary ballistic missiles; a new

astrophysical research tool. ASTRONAUTICA

ACTA v. 4, Fasc. 1, p. 59-69, 1958.

Evaluation of the feasibility of an H-bomb explosion on the moon. Technical aspects and scientific benefits of this operation are discussed.

549. Singer, S.F.

Scientific problems in Cislunar space and their exploration with rocket vehicles. In INTERNATIONAL ASTRONAUTICAL CONGRESS, AMSTERDAM, 1958-PROCEEDINGS. Springer Verlag. Vienna, 1959, p. 904-13. Also in ASTRONAUTICA ACTA v. 5, n. 2, p. 116-125, 1959.

Discusses scientific measurements which can be carried out in the "cislunar" region between the earth and the moon. Stress is placed on such problems as the space distribution and intensity of cosmic rays, auroral particles, and other corpuscular radiations some of which might be responsible for the magnetic storm producing ring current. The moon's magnetic field is discussed, as well as measurements of the lunar atmosphere and lunar tidal bulge.

550. Vaucouleurs, G. de

The moon and planets. BULLETIN OF THE ATOMIC SCIENTISTS v. 17, p. 214-217, 1961.

Discussion of the techniques for the observation of the moon and planets from the earth, balloons, rocket probes, and satellites, and of the types of experiments which could be carried out with probes and satellites. Preparatory studies, both theoretical and experimental, which are necessary for such a program are pointed out.

2. Specific Vehicles & Missions
a. U.S. Vehicles

551. Burke, J.D.

The Ranger spacecraft. ASTRONAUTICS

v. 6, n. 9, p. 23-25, 1961.

It will not only carry scientific apparatus for exploring the moon and solar plasma interacting with earth, but also embody key engineering experiments on lunar and interplanetary space-vehicle design.

552. Cummings, C.I.

Ranger in the lunar program. ASTRONAUTICS

v. 6, n. 9, p. 22, 1961.

A description and evaluation of Ranger in the U.S. unmanned lunar exploration program.

553. Douglas Aircaft Co. S

FLIGHT TEST REPORT FOR MISSILE S/N 130 (U).

Div. 12/1, 12/2, 12/4, 30/3. Rept. no.

SM-35540, 16 Feb 59, 42p. (Contract

AF 04(645)65). ASTIA AD-320 749.

SECRET REPORT

Subject Headings: Guided missiles; Moon; Lunar probes; Space probes; Flight testing; Guided missile trajectories; Rocket propulsion; Control systems; Automatic pilots; Hydraulic systems; Electrical equipment. (U).

554. First details of Ranger III's lunar

instruments. MISSILES AND ROCKETS v. 9, n. 12,

p. 32-33, 1961.

THE BALSA-CUSHIONED Ranger III instrument capsule will use its own retrorocket to slow its speed to under 150 miles an hour when it impacts the moon.

554. (Cont'd)

NASA has released first details of the spherical capsule, scheduled to be launched early next spring as the first U.S. effort to hard-land instrumentation on the moon.

555. Four Ranger vehicles to be added to unmanned lunar probe. AVIATION WEEK AND SPACE TECHNOLOGY v. 75, n. 10, p. 28, 1961.

Four Ranger spacecraft will be added to the National Aeronautics and Space Administration's unmanned lunar exploration program in an effort to obtain high-resolution television pictures of the moon's surface in support of the Apollo manned lunar program.

556. Glaser, P.F. and Spangler, E.R. Payload design for a lunar satellite. ELECTRONICS v. 33, n. 44, p. 63-67, 1960.

The Able-5 lunar satellite is the largest and most sophisticated of the NASA/USAF Able series of space probes. Measuring nearly nine feet between paddle tips and nearly five feet between fore and aft antennas, it weights approximately 390 pounds.

557. Hibbs, A.R. The national program for lunar and planetary exploration. JOURNAL OF GEOPHYSICAL RESEARCH v. 66, p. 2003-2012, 1961.

NASA-sponsored description of the following spacecraft undergoing design and development at Jet Propulsion Laboratory: (1) the Ranger lunar exploration craft, now being assembled; (2) Mariner, a Venus fly-by craft in the design stage; and (3) Surveyer, a craft for the soft landing of scientific instruments on the moon.

558. Hughes to build NASA's surveyor spacecraft. MISSILES AND ROCKETS v. 8, n. 5, p. 65, 1961.

Cost, weight, and payload equipment are briefly discussed.

559. Lunar satellite. THE AEROPLANE & ASTRONAUTICS v. 99, p. 638-640, 1960.

Discussion of the launch history, objectives, and design of the Pioneer Moon-probe. Requirements to be met in order to establish the probe in a close-orbit around the moon are considered, and the probe design is discussed. The spacecraft itself is a 39-in.-diam., 387-lb. aluminum alloy sphere equipped with four solar-cell "paddles." Although considerably larger, externally it is not unlike the 142-lb. Earth satellite Explorer VI. It is spin-stabilized. The spacecraft is instrumented to obtain the following measurements of the cislunar environment: (1) radiation measurements, (2) some indication of a lunar magnetic field, however weak it might be, (3) the action of gaseous "cloud" plasma floating through space, (4) micrometeorite activity, and (5) solar flare effects. The system of tracking stations established around the world are considered.

560. Luskin, H. The Ranger booster. ASTRONAUTICS v. 6, n. 9, p. 30-31, 73-76, 1961.

Atlas D-Agena B vehicle, proven out in other programs, provides the thrust, guidance and control needed for five Ranger lunar missions.

561. Mason, J.F. Ranger: first of a line of space travellers. ELECTRONICS v. 34, n. 31, p. 20-21, 1961.

To the Electronics industry, the importance of the first Ranger space shot is the release of design details of the craft that will be almost standard for a long generation of spacecraft. The hexagonal-shaped configuration will carry standard, or close to standard, electronics and other instrumentation on many missions, the National Aeronautics and Space Administration says.

562. 1958 NASA/USAF SPACE PROBES (ABLE-1)

FINAL REPORT. VOL. 1 - SUMMARY. NASA Memo.

n. 5-25-59W, June 59, 84p.

Three NASA/USAF lunar probes of Aug 17, Oct 13, and Nov 8, 1958 are described; details of program, vehicles, payloads, firings, tracking, and results; principal result was first experimental verification of confined radiation zone of type postulated by J. A. Van Allen and others.

563. Pioneer VI designed for moon orbit.

AVIATION WEEK AND SPACE TECHNOLOGY v. 73,

n. 11, p. 56-59, 1960.

Pioneer VI lunar orbiter is programmed to course around the moon in a tight path with approximately 5,700 lunar apogee and a 3,800 mile lunar perigee, and a period of about 16 hr. Satellite will be 39 in. in diameter, with nozzles extending 8 in., at opposite ends of the spin axis, from the internal, multiple-start propulsion system used for trajectory midcourse correction and for injection of the satellite into orbit.

564. Project Ranger. FLIGHT v. 80, n. 2734,

p. 145-148, 1961.

This article describes the spacecraft and the scientific experiments it is designed to carry.

565. Project surveyor. AEROPLANE AND ASTRONAUTICS,

THE v. 100, n. 2573, p. 151, 1961.

The capabilities, cost, booster, weight, and design of the Surveyor are briefly reviewed in this article.

566. Ranger I is most sophisticated U.S. spacecraft.

MISSILES & ROCKETS v. 9, p. 14, 15, 1961.

Discussion of the main design features, trajectory, and mission of the Ranger I lunar spacecraft. The eight scientific experiments aboard the Ranger are considered. Most of these concern the study of the nature and activity of cosmic rays, magnetic fields, radiation, and dust particles in space. One of the experiments explores the possibility that the earth carries with it a comet-like tail of hydrogen.

567. Space Technology Laboratories, Inc.

1958 NASA/USAF SPACE PROBES (ABLE-1)

FINAL REPORT. VOLUME 1. SUMMARY.

18 Feb 59, 84p. NASA Memo 5-25-59W,

Vol. 1.

The three NASA/USAF lunar probes of Aug 17, Oct 13, and Nov 8, 1958 are described. Details of the program, the vehicles, the payloads, the firings, the tracking, and the results are presented. Principal result was the first experimental verification of a confined radiation zone of the type postulated by Van Allen and others.

568. Stambler, I.

Ranger: first U.S. moon impact vehicle.

SPACE AERONAUTICS v. 35, n. 2, p. 45-50,

1961.

A detailed description of the Ranger series, slated to place the United States' first impact payloads on the lunar surface.

569. U.S. moon rocket Pioneer IV. CURRENT

SCIENCE v. 28, n. 3, p. 100, 1959.

The U.S. four-stage Juno II rocket was launched on March 3, 1959 from the Cape Canaveral missile test center (Florida). It carried a 13.4 lb gold plated space probe, Pioneer IV. At 22.24 hours GMT on March 4, the space probe by-passed the moon at a distance of 37,771 miles from it. This is more than 17,000 miles further away than was planned. Data were received on the telemeter by Jodrell Bank and the Goldstone tracking stations until March 6. By then it had gone 406,020 miles from the earth and was travelling at 3899 mph.

b. Russian Vehicles

570. Beresford, S.M. and Sheldon, C.S.
First Soviet moon rocket. HOUSE REPORTS ON PUBLIC BILLS, 86TH CONGRESS. Report of committee on Science and Astronautics (Committee paper 33). Washington 31 Aug 59, 41p.

571. Besprimernyi Nauchnyi Podvig.
RADIO p. 3, 4, 1959. (In Russian)

Brief discussion of the Soviet Lunik III moon probe, its intended use, and the information obtained.

572. Blagonravov, A.A.
Description of the first space station photographing the moon. Bijl, H.K., ed. In SPACE RESEARCH. N.Y., Interscience, p. 1109-1113, 1960.

A description is given of the interplanetary automatic station of the Soviet Union which photographed the reverse side of the moon and made other scientific observations. The cosmic rocket was launched 4 October 1959. The program which coordinated the orbital position of the vehicle with the telemetering system and with the photographic equipment is discussed. The position of the camera while photographing the reverse side of the moon is shown.

573. Clark, E.
Soviets plan series of lunar vehicles.
AVIATION WEEK AND SPACE TECHNOLOGY v. 71, n. 15, p. 28-29, 1959.

Lunar probe launched by the Soviet Union on the second anniversary of Sputnik I was the third in a planned series of vehicles that apparently will explore the

573. (Cont'd)

neighborhood of the moon before either planetary probes or manned orbital flights are attempted.

574. Exclusive from Russia! Design details of the Lunik. PRODUCT ENGINEERING v. 30, n. 5, p. 15-17, 1959.

Describes the three-stage, 352,000 lb vehicle (designated CH-10) used to achieve escape velocity on 2 January 1959, launching and tracking methods. Exhaust velocities of 9,348-10,000 ft./sec. were obtained from tungsten carbide lined engines.

575. Fahey, J.A. USSR lunar probes will orbit close to surface. MISSILES AND ROCKETS v. 5, n. 2, p. 22, 1959.

Plans call for a supply of fuel in the Sputnik for controlling the orbit. Small speed changes will be used to alter an elliptical orbit, to change the plane of orbit, and to decrease time of passage across the unilluminated surface of the moon.

576. First flight to the moon. JPRS R (Series) 746-D. Washington, 1 June 60. (OTS 60-31250).

Concerns the first flight by U.S.S.R.

577. First flight to the moon, USSR. JPRS (Series) 2553. Washington. Priroda no. 10,1959, 24 Apr 60, 16p. (OTS 60-11536).

578. FIRST PHOTOGRAPHS OF THE FAR SIDE OF THE MOON. Moscow, Akademiia Nauk SSSR, 1959, 33p. (In Russian); INFORMATION ON SOVIET

578. (Cont'd)

BLOC INTERNATIONAL GEOPHYSICAL

COOPERATION. Dec 59, 26p.

An elegant publication issued in remarkably short time after the successful photography (relayed by TV) of the lunar backside on October 4, 1959 showing photos obtained in close proximity to the moon by Soviet Automatic Interplanetary Station. The details of construction, orientation, transmission and navigation, (orbits) etc. of the satellite and features of the invisible side of the moon are described in the text and nicely illustrated.

579. Griffiths, H.V.

Observations of Lunik I. OBSERVATORY

(Gt. Brit.) v. 80, n. 919, p. 235, 1960.

On 40 minutes reception of signals from Lunik I.

580. Kayser, L.T. and Kölle, D.E.

Die 3 kosmische Rakete der UdSSR (Lunik III).

RAKETENTECHNIK UND RAUMFAHRTFORSCHUNG v. 4,

p. 23-25, 1960. (In German)

Description of the third Soviet cosmic rocket, including the instrumentation and flight path, as well as some data obtained by Lunik III.

581. Krasovskii, V.I.

Results of scientific investigations made

by Soviet Sputniks and cosmic rockets.

ASTRONAUTICA ACTA v. 6, n. 1, p. 32-47, 1960.

A survey is given of the results of Soviet investigation carried out by means of cosmic rockets and artificial satellites and in connection with it, hitherto unpublished information is given on measurements in the upper atmosphere and cosmic space. The density of the atmosphere was found higher than expected. The density was greater by day than by night, greater in the Polar than in the equatorial regions. Atmospheric ions were determined with a spectrometer. Upper atmosphere above 250 km showed an atomic structure. Intensities of cosmic rays were found to be a function of geomagnetic latitude. Hard ionized particles showed essential qualitative and quantitative

581. (Cont'd)

differences between the equatorial and the polar zones. Powerful flux of the electrons was discovered in the upper atmosphere. Anomalies within the geomagnetic field were observed. The photo effect in the photomultiplier registered x-rays of energy of tens and hundreds dev. The piezo-electric elements registered micrometeors. It was established that the magnetic field close to the surface of the moon does not exceed 50-100γ.

582. Launching of a cosmic rocket toward the Moon

(from TASS announcements). PRIRODA n. 1:

I-IV. Jan 59. (In Russian)

On January 2, 1959, the USSR launched a multistage rocket toward the Moon. The final stage of the rocket, which weighed 1,472 kg without fuel, was provided with a special container which contained instrumentation for the following investigations, viz: determination of the Moon's magnetic field, radiation intensity and variation of intensity of cosmic rays, determination of lunar radioactivity, etc. For observations on the flight of the final rocket stage it contained a radio transmitter, broadcasting on 19,997 and 19,995 mHz telegraphic messages 0.8 and 1.6 seconds long, a radio transmitter on a frequency of 19,993 mHz broadcasting scientific data, a transmitter with a frequency of 183.5 mHz used for measuring parameters of motion and broadcasting scientific data, and special apparatus for making a Na cloud. The course of the rocket and the nature of the signals transmitted for approximately 3-hour intervals from 0300 h (moscow time) January 3 to 10:00 h January 5, 1959 is described. The cosmic rocket went into the periodic orbit of an artificial satellite on January 7-8, 1959.

583. Lunik II--the Russian moon rocket.

CURRENT SCIENCE v. 28, n. 9, p. 359, 1959.

A short note on the successful Russian launching of the Moon rocket Lunik II, which landed on the Moon almost to the minute according to schedule. The rocket was launched on the afternoon of Saturday, September 12, 1959. The final stage of the rocket hit the Moon at 00 hours, 2 minutes, 24 seconds (Moscow time) on Monday morning, September 14, 1959. Launching details and the rocket radio signalings are reported. The rocket impact on the Moon as observed from different observatories is described.

584. Lunik III: the Russian third moon rocket.

CURRENT SCIENCE v. 28, n. 10, p. 393, 1959.

A brief note on the third Russian cosmic rocket launched on October 4, 1959. The multi-stage rocket put into orbit an "automatic interplanetary station"

584. (Cont'd)

which, after circling the moon, returned toward the earth and is now orbiting the earth. The significance of this feat for interplanetary exploration is emphasized and its launching and operation details are given.

585. Lunik III model. MISSILES AND ROCKETS v. 5, n. 45, p. 36, 1959.

Model of Soviet automatic interplanetary station, in photo released by Tass. It's believed to be the type which photographed the moon's far side.

586. Mikhailov, A.A. Pervaia karta obratnoi storony luny. AKADEMIIA NAUK SSSR. VESTNIK v. 31, p. 39-42, 1961. (In Russian)

Brief description of the instrumentation in the soviet moon rocket, Lunik III, and of the information obtained. A map of the far side of the moon is included.

587. Mikhailov, A.A. THE REVERSE SIDE OF THE MOON. Aerospace Technical Intelligence Center, Wright-Patterson Air Force Base, Ohio. Translation no. MCL-853 of Pravda p. 6, 16 Nov 60, 29 Mar 61, 4p. ASTIA AD-258 839

DESCRIPTORS: Moon, Photographs, Lunar probes.

588. Orbitnik I. RIVISTA AERONAUTICA p. 1973-1984, 1959. (In Italian)

Survey of available data on the Soviet Lunik III moon rocket, its objectives, and the information obtained.

589. The other side of the moon. SPACEFLIGHT v. 2, n. 5, p. 130-137, 1960.

Paper presents full text of announcement carried in Soviet press on Oct 27, 1959, concerning third Soviet Space probe which photographed hidden side of moon. English translation from "Soviet News."

590. Petrovich, G.V.
Investigation of moon with rocket apparatus, U.S.S.R. (Issledovanie Luny Raketnymi Apparatami). AKADEMIIA NAUK SSSR. VESTNIK p. 3-22, 1959. (In Russian). JPRS 3118,. Washington, 29 Mar 60, 32p.

Discussion of the Soviet moon exploration program with details of the objectives, launching procedures, instrumentation used, and results obtained. Included are tables providing data on the artificial earth satellites Sputniks I, II and III, and on cosmic rockets Luniks I, II and III.

591. Soviet moon rocket. JOURNAL OF SCIENTIFIC AND INDUSTRIAL RESEARCH. (India) SECT. A v. 18, n. 10, p. 453, 1959.

A short paper on the launching to the moon of the second Russian space rocket Lunik II. Lunik II reached the moon at 2 hours 32 minutes 24 seconds I.S.T. on September 14 after a flight of about 34 hours. The paper gives information about the launching details and the equipment carried by the rocket. The Russian launching of an automatic interplanetary space station on October 4 is also reported. This space station was built to permit the study of the 40% of invisible territory of the moon, and supply new information on outer space.

592. Soviets reveal more details on Lunik design. PRODUCT ENGINEERING v. 30, n. 7, p. 22-23, 1959.

Lunik 3-stage vehicle now reported to weight 332,000 lb. Two light-weight high-thrust boosters each weighed 4,862 lb., including 4,488 lb. propellent, said to be same as used for U.S. Thiokol rockets. Booster burned for 10 sec.

592. (Cont'd)

providing 112.2 lb./ton/sec. thrust. Failure to hit Moon is now attributed to crudeness of mechanism to cut third-stage burning (had tolerance of ±0.1 sec.)

593. Third Soviet cosmic rocket. PRIRODA n. 11, p. 3-15, 1959. (In Russian)

A detailed account of the third cosmic rocket released by the USSR on October 4, 1959, is presented. With the aid of diagrams and photographs the author discusses the construction, instrumentation, energy supply, orientation, etc., of this cosmic rocket which is designed especially to photograph the Moon, the trajectory and orbit of the lunar satellite, the photographing and transmission of the images and the principal features of the dark side of the moon as revealed by the photographs of the satellite.

594. Vernov, S. N., et al

Radiation measurements during the flight of the second moon rocket. SOVIET PHYSICS - DOKLADY v. 5, n. 1, p. 95-99, 1960. (English trans. In ARS JOURNAL v. 31, n. 7, p. 967-70, 1961).

The present paper gives a partial account of the results of preliminary processing of measurements taken at 9000 to 120,000 km from the center of the earth, and in the vicinity of the moon, beginning at 40,000 km from the surface of the moon. (1) data concerning the spatial location of the outer radiation belt; (2) composition of the earth's outer radiation belt; (3) The search for increased radiation in the vicinity of the moon; (4) measurement of cosmic rays.

3. Design, Materials, & Construction

595. Britain's part in space exploration.

AEROPLANE v. 96, p. 553-555, 1959.

Describes a proposal by the British Interplanetary Society for a Moon-probe vehicle.

596. Brothers, A.J., et al

U. S. MOON PROBE DEMONSTRATES USE OF TITANIUM-ALLOY SOLID-ROCKET MOTOR CASE. Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. External pub. no. 740. Rept. on Welded Titanium Case of Space-Probe Rocket Motor, 3 Sep 59, 17p. (Contract NASw-6; Continuation of Contract DA 04-495-ORD-18; ORDCIT Proj.) ASTIA AD-234 176

The high strength-to-weight ratio of titanium alloys suggests their use for solid-porpellant rocket-motor cases for high-performance orbiting or space-probe vehicles. The paper describes the fabrication of a 6-in.-diam, 0.025-in.-wall rocket-motor from the 6Al--4V titanium alloy. The rocket-motor case, used in the fourth stage of a successful JPL-NASA lunar-probe flight, was constructed using a design previously proved satisfactory for Type 410 stainless steel. Conclusion: The weight saving realized by substitution of the 6Al--4V titanium alloy was 2.8 lbs., or a weight reduction of approximately 34% from the heat-treated Type 410 stainless-steel motor-case. This increased performance, which could be translated into greater payload weight or an increase in the potential maximum velocity of the payload, was used to extend the permissible launching time, therefore increasing the feasibility of a successful flight. Without the increased capability provided by use of the titanium-alloy-motor case, this flight mission would not have been attempted.

597. Brothers, A.J.

Welded titanium-case for space-probe

rocket motor. WELDING JOURNAL v. 39,

n. 3, p. 209-214, 1960.

The high strength-to-weight ratio of titanium alloys suggests their use for solid propellant rocket motor cases for high performance orbiting or space probe vehicles. The paper describes the fabrication of a six inch diameter 0.025-in wall rocket motor from the 6Al-4V titanium alloy. The rocket motor case used in the 4th stage of the successful JPL-NASA lunar probe flight was constructed using a design previously proven satisfactory for Type 410 stainless steel. The nature and scope of the problems peculiar to the use of the titanium alloy which affected an average weight saving of 34% are described.

598. Clement, G.H.

The moon rocket. FRANKLIN INSTITUTE.

JOURNAL Monograph No. 2, p. 14-24, 1956.

Orbits and weight considerations of moon rockets are considered at some length. At present 950,000 lbs at takeoff would be required to get 650 lbs near the moon so that 50 lbs of scientific instruments could be landed safely to operate for a month or so.

599. Duerr, F.

Preparing Ranger for operations.

ASTRONAUTICS v. 6, n. 9, p. 28-29,

54, 56, 1961.

Efficient space-vehicle design, smooth and timely program coordination, adequate backup testing, and complete systems qualification demand and get scrupulous attention to detail.

600. Happe, R.A.

Materials in space. ORDNANCE v. 45,

p. 578-580, 1961.

Discussion of the environmental effects on materials in space. The discussion refers to problems related to the Ranger vehicle which is being developed to land an instrument package on the moon. The Ranger vehicle is discussed, and the effects of the space environment on inorganic compounds, pure metals and alloys, and organic polymers are considered.

601. Jäger, M.

Der Griff zum Mond. FLUG-REVUE p. 8-11,

1958. (In German)

Discussion of the progress in space exploration covering problem areas in building and launching a moon rocket.

602. Lampert, S., et al S

A STUDY OF REQUIREMENTS FOR IN-FLIGHT

STRUCTURAL DATA FOR MISSILES AND SPACE

VEHICLES. PART I. TRAJECTORIES,

ENVIRONMENTS, STRUCTURAL CONSIDERATIONS

(U). Aeronautronic Systems, Inc., Glendale,

Calif. Rept. no. WADC TR-59-478, pt. 1;

Rept. no. 59WCLS-3378, Aug 59, 240p.

(Contract AF 33(616)5928) ASTIA

AD-315 205. SECRET REPORT

Descriptors: Guided missiles*; Hypervelocity vehicles*; Satellite vehicles*; Lunar probes*; Instrumentation; Structures; Flight instruments*; Re-entry aerodynamics; Aerodynamic heating; Aerodynamic data*; Measurement.

603. Lockheed Missiles and Space Division.

PROPOSAL FOR A DESIGN STUDY OF A LUNAR-LANDING CAPSULE. Rept. no. LMSD 288830, 15 Feb 60.

The major problem in the design will be the control of weight. Technical aspects of the study will be trajectory analysis, guidance and control, the retro-propulsion system, communications, capsule design,* Areas affecting capsule design are separation, landing, data acquisition and transmission, environment and materials selection, and general physical arrangement and installation. *power supply, ground handling and checkout, and reliability analysis.

604. Lockheed Missiles and Space Division

PROPOSED DESIGN STUDY PROGRAM FOR LUNAR SOFT-LANDING SPACECRAFT. VOLUME I - TECHNICAL PROPOSAL. Rept. no. LMSD 288632, 6 June 60.

A program is proposed to study the design of a soft-landing spacecraft with the mission of scientific investigation of a limited area of the moon in 1963-64 as part of the NASA Lunar Exploration Program. The study will cover the flight range from injection, through midcourse correction and terminal maneuver phases, to the operation on the lunar surface. Major areas of study include propulsion, guidance, communications, trajectory, and spacecraft design. No extensive developmental efforts are contemplated in any of these areas. The postulated design is toroidal with the main retrorocket in the center of the toroid. Some 200 to 400 lbs would be available for communications, power supply, and experiments.

605. Petrovich, G.V.

INVESTIGATION OF THE MOON WITH ROCKET APPARATUS. USSR. Washington, Joint Publications Research Service, 1960, 30p.

This publication was prepared under contract by the UNITED STATES JOINT PUBLIC PUBLICATIONS RESEARCH SERVICE, a federal government organization establishment departments.

605. (Cont'd)

The applicability of this article is from the description of the shape of the vehicles, weights of the various parts and in some cases types of materials used.

606. Stehling, K.R.

Landing on moon. SPACE/AERONAUTICS v. 33, n. 2, p. 42-45, 1960.

Review of design requirements and problems involved in "hard" and "soft" lunar impacts; application of liquid and solid propellant rocket engines and special requirements for descent control, shock absorption, and radio transmission.

607. Stone, I.

Ford subsidiary speeds space study.

AVIATION WEEK v. 68, n. 1, p. 51, 53, 55-56, 1958.

Work on lunar probe projects by Aeronutronic Systems Ltd.

608. Wolff, F.L.

Target Luna. SPACE AGE v. 1, n. 2, p. 24-27, 1959.

Drawings which show how an astronautics artist worked with engineers in the development of a lunar probe proposal.

4. Propulsion

609. Aerojet designs 5-stage moon vehicle.

SPACE TECHNOLOGY v. 1, n. 2, p. 17, 1958.

Solid Senior rockets developed for Polaris, infrared homing guidance are features of proposal to USAF.

610. All-solid craft urged for moon trip.

MISSILES AND ROCKETS v. 7, n. 24, p. 35-48, 1960.

Big pitch for the all-solid concept is simplicity and high production rate with relatively low costs.

611. Baker, N.L.

"Unsophisticated" Juno II may orbit sun.

MISSILES AND ROCKETS v. 4, n. 21, p. 25-28, 1958.

'Souped-up' Jupiter will fire all four stages in sequence for 220-seconds to reach lunar vicinity in 34 hours after December 5 lift-off.

612. Camac, M.

Plasma propulsion of spacecraft.

ASTRONUATICS v. 4, n. 10, p. 31-33, 113-115, 1959.

Near earth missions, such as placing stationary satellite in orbit, call for specific impulse ranges natural to plasma jet systems; flight parameters for round trip to lunar orbit; possible methods of achieving specific impulses for missions contemplated within gravitational field of earth; development of thrust devices, divided into non-conducting gas, electrostatic acceleration devices (ion rockets), and neutral plasma devices.

613. Carton, D.S.

Mimimum propulsion for soft moon landing of instruments. In COMMONWEALTH SPACE-FLIGHT SYMPOSIUM, 1959. 38p. Also College of Aeronautics, Cranfield, England, Note no. 94, July 59.

Examines some of the problems involved in landing 100 lb. instruments on the Moon: trajectories, external ballistics, rocket engine performance, propellants, combustion chamber and nozzle design, etc. Scaling rules have been derived to permit assessment of the relative merits of pressurization and turbo-pumps, selection of optimum tank and combustion chamber pressures, expansion ratios, etc. Scaling constants are given for one solid and six liquid propellants.

614. Demetriades, S.T.

Applications of propulsive fluid accumulator systems to orbital, lunar and interplanetary missions. AIRCR. ENGNG. v. 32, n. 382, p. 369, 1960.

Suggestion of means of accumulating gasses for use in propulsion from extraterrestrial bodies.

615. Dobrin, S.

Propulsion for Moon-landing maneuvers. MISSILE DESIGN AND DEVELOPMENT v. 5, n. 3, p. 24-25, 1959.

616. Giannini, G.

Electrical propulsion in space.

SCIENTIFIC AMERICAN v. 204, p. 57-65,

1961.

Discussion of the various types of propulsion systems which are under investigation for space vehicle applications. Systems considered are nuclear turboelectric, solar turboelectric, solar voltaic, nuclear-thermal, chemical-thermal, electric-thermal (arc jet), electromagnetic (plasma jet), and electrostatic. Special attention is given to the latter three. Each system is fully explained and illustrated. A table giving data for different types of vehicles on an Earth-Moon trip is presented, showing gross, propellant, engine, and payload weights, and specific impulse, thrust, thrust duration, and trip time, Difficulties involved in the development of various propulsive systems are considered, and future prospects and applications are examined.

617. Gin, W. and Piasecki, L.R.

SOLID ROCKETS FOR LUNAR AND PLANETARY

SPACECRAFT. American Rocket Society.

ARS Paper 1462-60, 6p., also in JPL

Technical release 34-158, 28 Oct 60, 16p.

ASTIA AD-246 978

A survey of the presently scheduled missions for automatic, instrumented spacecraft to explore the Moon and the nearby planets shows a variety of propulsion maneuvers which can be provided by solid-propellant rocket motors. The reliance on the current and expected capabilities of solid rockets is demonstrated by their scheduled use for several forthcoming missions. The increase of propellant specific impulse and propellant loading fraction through development will permit increasing amounts of useful payload to be carried. Staging the motors for certain applications is shown to have considerable merit. Problems unique to the employment of solid rockets in spacecraft are reviewed. These include the requirement for long-term storage in the space environment, with consideration for temperature extremes, hard vacuum, and meteoroid hazard; ignition and maintenance of stable and efficient combustion at low chamber pressure; and special operational problems caused by the spreading of the exhaust plume, the attenuation and distortion of communication signals by exhaust products, and the need for biologically sterile spacecraft on impact trajectories.

618. Jaffe, L.D. , et al C

ELECTRIC SPACECRAFT FOR PLANETARY AND INTERPLANETARY MISSIONS (U). Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

Technical memo no. 33-43, 15 Mar 61, 19p.

(Contract NASw-6) ASTIA AD-324 504

CONFIDENTIAL REPORT

Descriptors: *Spaceships, *Electric propulsion, Thermionic emission, Turbines, Ion rockets, *Nulcear propulsion, Space probes, Satellite vehicles, Lunar probes, Space Flight.

619. Lehrer, S. C

SOFT LUNAR LANDING RETRO PULSION (U).

Thiokol Chemical Corp., Reaction Motors Div. Technical Planning Rept. 88, 1 Aug 60.

CONFIDENTIAL: RMD PROPRIETARY INFORMATION

The purpose of this report is to outline the technical recommendationsof RMD regarding retro propulsion for the Soft Lunar Landing (Project Super Ranger) mission. Since it is intended as a prelude to a thorough study, only one conclusion is warranted at this time: that earth-storable hypergolic combinations (hydrazine and hydrazine derived fuels) offer the ultimate in reliable liquid retro propulsion for this application. (U).

620. NASA details space missions, needs.

SPACE TECHNOLOGY v. 2, n. 3, p. 8-10, 1959.

Fourteen satellites, six probes programmed by end of 1960; propulsion projects for space outlined.

621. Stehling, K.R.

Lunar landing problems. INTERAVIA v.

15, p. 1428-1430, 1960.

Discussion of the propulsion problems of a lunar soft landing mission. A rocket system is considered for use in the slowdown for the soft landing, since no other braking forces are available. The characteristics of a rocket retro-system are studied, assuming an ideal system. It is concluded that a composite propulsion system is ideal for a soft landing, and that a solid rocket should be used to cancel out about 90% of the approach velocity, with some simple hypergolic or monporpellant liquid system used for trimming the residual velocity, maintaining attitude control, and final touchdown maneuvers. The characteristics are described of a hypothetical propulsion system for landing a net instrument package of about 200 lbs. on the lunar surface. Information of the Surveyor program is included.

622. Thompson Ramo Wooldridge Inc., Cleveland, Ohio.

MISSION ANALYSIS FOR ELECTRIC PROPULSION

SYSTEMS (FINAL REPORT). Engineering Report

4114; WADD TR 60-533, June 60.

A comprehensive analytical investigation to determine regions of applicability of electric propulsion systems has been accomplished. Various missions have been examined and the performance available from electric propulsion systems has been compared to the performance available from chemical systems. New methods for calculating both continuous and impulsive thrust requirements have been generated. The influence of Earth oblateness, lunar attraction and other perturbations affecting the orbital plane of a satellite have been considered. The study has determined the thrust requirements for coplanar orbital transfer, change of orbital inclination, rotation of the line of nodes, and change of orbital eccentricity. The capabilities of electric propulsion systems for establishing the "stationary orbit," and an orbit that is continuously exposed to the Sun, and for accomplishing lunar, Mars and Venus missions have been delineated. A preliminary approach for the design of electric propulsion systems using a criterion of minimum energy expenditure is presented Finally a concept is presented that combines both the arc jet and ion engines to obtain an effective specific impulse in the range of from 1500 to 3000 sec.

623. Wrobel, J.R. and Breshears, R.R.

LUNAR LANDING VEHICLE PROPULSION REQUIRE-
MENTS. ARS, Semi-Annual Meeting, Los Angeles,
Calif., May 9-12, 1960. Preprint 1121-60, 16p.
Also JPL Technical Release n. 34-66, 1 May 60,
16p. ASTIA AD-236 389

NASA-sponsored solutions to the equations of motion of a lunar soft-landing vehicle, descending vertically under power, for the case of constant gravity. A propulsion-system-mass scaling function is formulated for the retro-stage. The thrust level, which results in maximum usable payload on the moon, is determined as a function of the required vehicle-velocity decrement, propellant exhaust velocity, vehicle gross mass, and propulsion-system mass. Curves are presented from which the payload penalty of off-optimum thrust operation may be determined for any chosen propulsion scheme. The results of the analysis indicate that for liquid-propellant systems the optimum thrust-to-initial-mass ratio is between 4 and 7 lunar g. For solid-propellant systems, this ratio may be increased to the acceleration tolerance of the payload.

624. Yaffee, M.

Ranger lunar impact planned for 1961-62.
SPACE TECHNOLOGY v. 3, n. 3, p. 46, 1960.
Also in AVIATION WEEK v. 72, n. 17, p. 26-27,
1960.

Spherical solid propellant retrograde rocket would ease landing of NASA instrument capsule on moon.

5. Guidance

Under this heading are grouped reports and articles on midcourse and terminal guidance, soft landing guidance and control, attitude stabilization, and recovery.

625. About Pioneer; Air Force changing guidance cutoff. MISSILES AND ROCKETS v. 4, n. 18, p. 11, 1958.

In the third Air Force try with the lunar probe, the guidance system will be changed from accelerometer cutoff to doppler cutoff.

626. Bement, H.I.
Lunar guidance. ASTRONAUTICS v. 5, n. 9, p. 24-25, 77-79, 1960.

Significant lunar missions for near future are lunar impact, orbiting the moon, and soft landing; accurate terminal guidance will profit from broad capabilities of optical-inertial system.

627. Buchheim, R.W.
LUNAR INSTRUMENT CARRIER - ATTITUDE STABILIZATION. Rand Corp. Research Memo. RM-1730, 4 June 56, 25p.

An estimate of the magnitudes of various attitude disturbances acting on a moon rocket. Such disturbances include initial misalignment, initial pitch and yaw rates, solar radiation torque, and the gravitational gradient of the earth. In addition, vehicle design restrictions are indicated.

628. Campbell, J.P.
DOPPLER VELOCITY FOR SPACE GUIDANCE. General Precision Lab., Bimonthly interim engineering rept. no. 4. Rept. no. A18-4, WADC TN 58-328,

628. (Cont'd)

Nov 58, lv. (Contract AF 33(616)5487)

ASTIA AD-205 350

Contents: Ascent and terminal guidance: Ascent phase; Terminal phase; Attitude measurement; Sensors. A guidance system for moon landings: Landing and control requirements; Proposed system configurations; Additional considerations. Cooperative Doppler systems: Possible configurations for cooperative Doppler measurement in the earth-moon vicinity; Measurement of Doppler shifts in optical spectra; Nature of optical spectra of the stars and planets; Spectrometric techniques for measuring Doppler shifts in optical spectra.

629. Darlington, S.

Guidance and control of unmanned soft landings on the moon. PLANETARY & SPACE SCIENCE v. 7, p. 70-75, July 1961.

A guidance and control scheme is described, which may be appropriate for early unmanned soft landings on the Moon. The principal components are: a precision launch phase guidance system; a preset direction and attitude control; main and vernier retrorockets of the solid fuel, fixed impulse type; a range only, pencil beam radar, nonsteerable relative to the air frame; and means for firing the retrorockets at preset radar ranges to the Moon's surface. No means are included for measuring the errors in the burning of the main retrorocket, and yet the vernier is so used that the effects of the errors are largely suppressed.

630. de Fries, P.J.

ANALYSIS OF ERROR PROGRESSION IN TERMINAL GUIDANCE FOR LUNAR LANDING. George C. Marshall Space Flight Center, Huntsville, Ala. Rept. no. MM-M-G&C-1-60, 20 July 60. Also issued as NASA TN D-605, July 61, 29p. and in JOURNAL OF THE ASTRONAUTICAL SCIENCES v. 8, n. 1, p. 18-27, 1961.

A lunar descent scheme with n periods of engine on-off is investigated. Each period may have a different thrust level but it is constant for the length of

630. (Cont'd)

the period. The engines are ignited by altitude and cut off by velocity signals. Five groups of errors are considered: ignition altitude (Δs), velocity change (Δu), thrust level (ΔF), lunar gravitation (Δg), and initial approach velocity (Δw_0). Equations are derived that allow the computation of the influence of any given error occurring during any one of the n periods on the final velocity at touchdown. It is concluded that it is principally advantageous to break up the descent into on-off periods. Also it is inferred, with relation to guidance, that the problem of descent rests with the very last period of braking. The upper periods can always be handled with constant thrust and rather crude instrumentation, whereas the instrumentation for the last period depends upon the required softness of the landing which also determines whether variable thrust is necessary.

631. de Fries, P.J.

HORIZON SENSOR PERFORMANCE IN MEASURING ALTITUDE ABOVE THE MOON. National Aeronautics and Space Administration, Washington, D. C. Rept. no. TN D-609, July 61, 20p. ASTIA AD-259 497

A space vehicle approaching the Moon can determine its altitude above the surface by measuring the diameter of the apparent lunar disk with a horizon sensor and computing the distance with the knowledge of the lunar radius. Two basic errors are involved in this process: an error introduced by measuring the chord of the lunar sphere, and an error introduced by computing with an inaccurately known lunar radius. The error in measuring breaks up into two: one is purely instrumental (electronic gear); the other one stems from the properties of the target, the Moon, which is not an ideal sphere but has elevations and depressions referenced to the ideal "sea level." An error analysis is carried out considering these factors. The accuracy with which the altitude can be determined is resolved as a function of altitude.

632. de Fries, P.J. (ed)

UNMANNED LUNAR LANDING WITH SATURN S-V STAGE. George C. Marshall Space Flight Center, Huntsville, Ala. Rept. no. MTP-G&C-61-12, 15 Jan 61.

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

632. (Cont'd)

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.

633. Frye, W.E. S

LUNAR INSTRUMENT CARRIER. POWERED FLIGHT GUIDANCE (U). Rand Corp., Research Memo RM-1729, 4 June 56, 29p. (Contract AF 33-(038)6413) ASTIA AD-112 400. SECRET REPORT

634. Gates, C.R.

TERMINAL GUIDANCE OF A LUNAR PROBE. Jet Propulsion Lab., California Institute of Technology, External Publication no. 506, 14 May 58, 16p. (Contract DA 04-495-ORD-18) ASTIA AD-262 023

The problem of guiding a lunar probe to a zero-velocity or soft landing on the moon is discussed. A self-contained guidance system is proposed, and measurement instruments and accuracies, guidance computer transfer functions, and the magnitude and control of impulse required in the terminal maneuver are treated. It is concluded that guidance is in two stages, lateral guidance at a point some 5,000 miles above the surface using optical and inertial sensors, and braking along the path near the surface of the moon using a radio altimeter as an error sensor, is feasible. Existing components and techniques are adequate to perform these functions; aside from weight reduction, no new developments are needed.

635. Gazley, C., Jr., and Masson, D. J.

Recovery of circum-lunar instrument carrier.

In 9th INTERNATIONAL ASTRONAUTICAL CONGRESS, BARCELONA, 1957- PROC. Springer Verlag, Vienna, 1958. p. 137-146. Also Rand Corp., Rept. no. P-1119, 19 Aug 57, 20p.

The possibility of the physical recovery of a circum-lunar vehicle widens the scope of scientific investigations possible for a vehicle with lunar capabilities. While a very high guidance capability is necessary to impact such a recoverable vehicle within a given area on the earth's surface, only moderate accuracy is required to effect just a return to earth. Radio tracking during return would enable prediction of the probable impact point. Ultimate recovery could be accomplished through a radio beacon and overflight search. While the penitration of the earth's atmosphere involves more severe decelerations and heating than in the case of the recovery of a scientific satellite, the magnitude of the deceleration poses few structural difficulties and the use of a vaporizing surface for heat absorption does not require an excessive weight penalty.

636. Gordon, H.J.

A STUDY OF INJECTION GUIDANCE ACCURACY AS APPLIED TO LUNAR AND INTERPLANETARY MISSIONS.

Jet Propulsion Laboratory, California Institute of Technology, Pasadena. Rept. no. TR 32-90, 15 May 61.

This report discusses studies performed to determine the accuracy of a typical inertial guidance system as applied to future lunar and interplanetary missions. Errors in guidance systems are described, and analytical techniques for converting these into injection and target errors are presented. The statistics of injection, target, and midcourse-maneuver errors are briefly developed. The determination of midcourse-maneuver fuel requirements is the primary purpose of the study. One of the important results of this analysis was an evaluation of the effect of "parking orbits" (circular satellite coast periods) on injection-guidance accuracy. These parking orbits will be necessary for practical space missions of the near future in order to satisfy various geometrical constraints in an efficient manner. The technique for calculating the injection errors and the effect of the parking orbit on these errors are described.

636. (Cont'd)

The results of studies of several specific trajectories are presented, illustrating the degree of accuracy to be expected for practical deep-space missions of the immediate future. Parking orbits do not necessarily reduce guidance accuracy, and in fact, there is an optimum coast arc.

637. LaFond, C.D.

Guidance adequate for soft-landing.

MISSILES AND ROCKETS v. 9, n. 9, p. 38,

1961.

The only limiting factor in achieving soft lunar landing velocities of less than 20 feet per second is the state of the art of sensors. If sensor accuracy can be improved (or if those employed prove to be better than is currently assumed) velocities of less than 10 ft. per second are possible. Under a recent subcontract to the Jet Propulsion Laboratory, scientists at Space Technology Laboratories, Inc., have completed a paper study of a terminal guidance system for such a landing. Results of this study were presented here last week at Stanford University during the First National Guidance, Control and Navigation Conference, sponsored by the American Rocket Society.

638. Landing a rocket on the Moon.

AERONAUTICS p. 128-129, 1957.

Application of an analogy to simulate a rocket falling vertically on the moon, and to test the performance of individuals making such a landing by manual control.

639. Mears, C.M. and Peterson, R.L.

MECHANIZATION OF MINIMUM ENERGY AUTOMATIC

LUNAR SOFT LANDING SYSTEMS. Society of

Automotive Engineers. SEA 61-302A, 110p.

Nondimensional parameters are developed and plotted for use in rapid analysis of soft-landing system concepts. With the aid of these charts, optimum soft-landing systems are discussed. The systems automatically control and reduce vehicle energy remaining after main-stage retro-thrust to zero at the landing surface, with an expenditure of a minimum amount of stored energy. Mechanizations of some practical automatic landing systems are presented and

639. (Cont'd)

compared with an optimum system in terms of energy consumption and ability to tolerate wide ranges of initial vehicle velocities and positions.

640. Radar designed to control lunar landings. AVIATION WEEK AND SPACE TECHNOLOGY v. 74, n. 2, p. 93-95, 1961. Also in SPACE TECHNOLOGY v. 4, p. 34-35, 1961.

A description is given of a radar system that could take command of a Centaur or Nova vehicle during the last ten minutes of its flight and give accurate commands to its retrorockets so that the vehicle could make a soft landing on the Moon.

641. Raimond, J.J., Jr. The first tour around the moon. HEMEL EN DAMPKRING v. 58, n. 3, p. 57-71, 1960. (In Dutch)

An article about Lunik III since October 4, 1959, launched at Aral'sk near the Caspian Sea. A description of the rocket is given according to information collected by a collaborator of the Bendix Aircraft Corporation. Some information about calculation of the trajectory made by G. Gamow and K.A. Ehrike are given in a fig., the author mentions also the calculation made in Holland by J.M.J. Kooy in collaboration with J. Berghuis using the "Bull Nederland" computer. Lunik III started its trajectory over the Northern Hemisphere and continued its way to the moon in a trajectory situated in a plane perpendicular to the plane described by the moon trajectory. Two figs. giving the trajectory of Lunik III are described and explained clearly.

642. Rosen, B.M. Determining lunar mission guidance requirements. SPERRY ENGINEERING REVIEW v. 12, n. 2, p. 27-33, 1959.

Trajectory analyses used to specify cutoff parameter accuracies; discussion of cutoff parameters and choice of typical values for lunar impact mission; midcourse guidance is offered as means for relaxing stringent guidance requirements.

643. Rousculp, P.J. and Pope, W.S.

A television system for a soft landed lunar vehicle. In NATIONAL TELEMETERING CONFERENCE, SANTA MONICA, CALIF., MAY 23-25, 1960. PROCEEDINGS. p. 131-134.

The Missile Division of North American Aviation Inc., has proposed an unmanned vehicle, the Lunar Prospector, to be soft-landed on the moon. This vehicle will be equipped with instrumentation to gather and return data to the earth. A television system has been proposed for use in altitude sensing, in the guidance and control system for landing, and in the exploration operations after landing.

644. Schroeder, W. and Pittman, C.W.

A guidance technique for interplanetary and lunar vehicles. PLANETARY AND SPACE SCIENCE v. 7, p. 64-69, 1961.

The problem of guiding an extraterrestrial vehicle during its launch phase by means of a closed loop control system, using a large digital computer in real time, is discussed. Equations are derived from fundamental physics, from which the computer can determine the desired burnout conditions during flight. Steering equations are then derived, by means of which the vehicle will be guided to these burnout conditions in an efficient manner. Compared to the technique of guiding the vehicle to a trajectory determined before the flight, this method has the advantages that it is simple and flexible, and it can accommodate a wider range of vehicle performance perturbations. The accuracy of the guidance technique is demonstrated by results from simulated flights to Venus.

645. Williams, F.L., Ruppe, H.O. and Reichert, R.G.W.

How high the moon's?

SAE JOURNAL v. 69, n. 5, p. 82-84, 1961.

An economical approach to lunar flights by orbital operations which would utilize recoverable launch vehicles is discussed.

646. Wingrove, R.C. and Coate, R.E.

PILOTED SIMULATOR TESTS OF A GUIDANCE SYSTEM WHICH CAN CONTINUOUSLY PREDICT LANDING POINT OF A LOW L/D VEHICLE DURING ATMOSPHERE RE-ENTRY. National Aeronautics and Space Administration, Washington, D. C. Technical note D-787, Mar 61, 36p. ASTIA AD-253 418

Also available from NASA, Washington 25, D.C., as NASA Technical note D-787.

The guidance system for maneuvering vehicles within a planetary atmosphere which was studied uses the concept of fast continuous prediction of the maximum maneuver capability from existing conditions rather than a stored-trajectory technique. In the method of display and control used, desired touchdown points are compared with the maximum range capability and heating or acceleration limits, so that a proper decision and choice of control inputs can be made by the pilot. A piloted fixed simulator was used to demonstrate the feasibility of the concepts and to study its application to control of lunar mission re-entries and recoveries from aborts. The regions of entry conditions leading to control-sensitivity problems corresponded to trajectories which skipped up to the edge of the atmosphere. The simulation was also used to define the ground areas that would be attainable during typical entries using this method of guidance control for a vehicle with moderate lifting capability (lift-drag ratio of 0.5).

6. Flight Paths & Trajectories

In addition to lunar and cislunar flight paths and trajectories, the literature on orbits and impact point is also covered.

647. Aeronutronic Systems, Inc. Glendale, Calif. C

(CLASSIFIED TITLE). Publication no. C-365.

Semifinal rept. July 58-Feb 59, 1v.

(Contract AF 33(616)6005). ASTIA AD-313 608.

CONFIDENTIAL REPORT

DESCRIPTORS: Lunar probes*; Orbital flight paths*; Moon; Earth; Astronautics.

648. Almar, I. and Balaza

Approximate method of plotting the orbit of a space rocket passing near the Moon.

HUNGARIAN ACADEMY OF SCIENCES. MATHEMATICAL INSTITUTE. PUBLICATIONS v. 4, p. 129-147, 1959.

Derivation of equations and construction of nomograms assuming: (1) rocket starts in free flight outside atmosphere; (2) plane of orbit makes small angle with ecliptic and passes through ecliptic when close to Moon; (3) Moon describes circular orbit around Earth.

649. Angelitch, T.P.

On the trajectories of lunar projectiles.

VASIONA v. 7, p. 5-7, 1959. (In Serbo-Croat)

650. Benedikt, E.T.

Collision trajectories in three-body problem. J. ASTRONAUTICAL SCIENCES v. 6, n. 2, p. 17-24, 30, 1959.

Determination of collision trajectories passing through centers of celestial target bodies, is regarded as one of basic problems of Astroballistics; by applying transformation due to T. LEVI-CIVITA, it is possible to regularize collision trajectories, and to obtain conditions which position and velocity of missile must satisfy so that trajectory of missile passes through center of body: practical applicability tested on case of circumlunar trajectories.

651. Berman L.J.

OPTIMUM SOFT LANDING TRAJECTORIES, PART 1: ANALYSIS. Massachusetts Institute of Technology, Cambridge. Air Force Office of Scientific Research. Rept. no. AFOSR 519, 30 Mar 61.

To achieve landing of a rocket vehicle from a space orbit with zero relative velocity at touchdown, a variational calculus solution is obtained for the thrust program for minimum propellant consumption. The simplifying assumptions of no atmospheric forces and a uniform (i.e., flat-Earth) gravitational field are made. These assumptions are appropriate for the lunar landing of a moderately high-thrust rocket. The results of the variational solution are interpreted to provide an appreciation of the physical nature of the requirements established by different initial conditions, as specified by initial altitude and velocity vector. Representing the initial conditions parametrically by an equivalent energy altitude and the actual altitude, five different regimes are identified and the corresponding thrust programs described.

652. Blitzer, L.

Lunar-solar perturbations of an earth satellite. AMERICAN JOURNAL OF PHYSICS v. 27, n. 9, p. 634-645, 1959.

The influence of the sun and moon on the orbit of a near satellite of the earth is investigated, and it is shown that the principal effect is a precession

652. (Cont'd)

of the orbit plane about the pole of the ecliptic, analogous to the precession of the equinoxes. The precessional rate increases with orbit size and eccentricity and decreases with orbit inclination to the equator. For orbits close to the earth the lunar-solar precessional motion is only about 10^{-4} that due to the earth's oblateness. Radial perturbations resulting from the attractions of the sun and moon are similarly extremely small, being of the order of one meter. The induced radial oscillations exhibit twice the frequency of the satellite's orbital motion around the earth, analagous to the twice daily motion of the tides. To second-order terms in the orbit eccentricity the expressions derived herein are in exact agreement with the astronomical treatments for the special case of the perturbations of the moon's orbit due to the sun.

653. Brereton, R.

Three steps to the moon. SPACE WORLD

v. 1, n. 10, p. 32-35, 60-61, 1961.

Discussion of a new orbital technique that will ease the problems of moon transport.

654. Brumberg, V.A.

Orbits of artificial moon satellites. SOVIET

ASTRONOMY--AJ v. 5, n. 1, p. 95, 1961.

The aim of the present paper is to investigate the motion of satellites of the moon by numerical integration, for certain special examples. This procedure not only yields an accurate ephemeris for the satellite, but gives a good idea of the evolution of the orbits considered over a sufficiently large number of revolutions. From a mathematical viewpoint, the problem consists in the integration of the equations of motion of a point of infinitely small mass, moving in the moon's gravitational field, and experiencing perturbations induced by the asphericity of the moon and the attraction of the earth and sun.

655. Bryson, A.E. and Ouellette, G.A.

Optimum paths to moon and planets. ASTRONAUTICS

v. 3, n. 9, p. 18-21, 80, 82, 1958.

Space ships will follow trajectories designed to make most of fuel used, gravitational forces and relative motions of planets; transfer made by means of Hohmann ellipse involvestwo impulses, one at beginning and one at end,

655. (Cont'd)

path itself being ellipse tangent to both orbits, with gravitational center at one focus; diagrams of optimum paths; use of fuel in braking; disadvantage of Hohmann ellipse transfer is long waiting period at Mars for correct angular relationship.

656. Buchheim, R.W.

ARTIFICIAL SATELLITES OF THE MOON. RAND Corp. P-873; RAND RM-1941, 14 June 56, 69p. ASTIA AD-133 021. Also In SEVENTH INTERNATIONAL ASTRONAUTICAL CONGRESS, PROCEEDINGS p. 587-634, 1956.

A discussion of the requirements for establishing an artificial satellite of the moon. Such problems are considered as general orbit properties, limiting orbit parameters, transporting the satellite to the moon, and its visibility on orbit.

657. Buchheim, R.W. and Lieske, H.A.

Lunar flight dynamics. AIR UNIVERSITY QUARTERLY REVIEW v. 10, n. 3, p. 74-103, 1958.

This paper presents a brief survey of the general subject of lunar flight with particular reference to flight trajectories, including discussion of the general nature of the trajectory problem, classes of trajectories, initial conditions, and sensitivities to initial conditions. The associated subjects of orientation control and launching requirements are also introduced.

658. Buchheim, R.W.

MOTION OF A SMALL BODY IN EARTH-MOON SPACE. RAND Corp. Research Memo RM-1726, 4 June 56, 91p. ASTIA AD-123 557

A presentation of analytical relations and numerical data that may be useful in studies of trajectories of unpowered vehicles in the region of space dominated by the gravitational fields of the earth and moon.

659. Clarke, A.C.

Dynamics of space-flight. BRIT.

INTERPLANETARY SOC - J v. 8, n. 2,

p. 71-84, 1949.

Subject divided into three sections; motion of body in earth's gravitational field, problem of lunar voyage, and true interplanetary journeys; no particular form of propulsion presupposed; table shows theoretical velocities needed for various typical journeys, and estimates of what these values may be in practice.

660. Clarke, V.C., Jr.

DESIGN OF LUNAR AND INTERPLANETARY ASCENT

TRAJECTORIES. California Institute of

Technology. Jet Propulsion Laboratory,

Pasadena. Technical Report No. 32-30,

July 60, 16p.

This report is primarily concerned with the near-Earth or "ascent" portion of lunar and interplanetary trajectories. Of particular interest is the matching of the powered flight and the coasting phases To achieve a suitable match, consideration of vehicle-related engineering constraints, payload, and geometrical and energy requirements imposed by the extraterrestrial trajectory is essential. The geometrical constraints and trajectory shaping are treated in detail. To satisfy these constraints, direct ascent and parking-orbit types of trajectories are investigated and compared. Advantages and disadvantages of each are noted. The superiority of the parking orbit type is illustrated. It is shown that this type has consistently greater payload capability and also provides a convenient method of launch-time delay compensation. Finally, injection of locations of (ARS JOURNAL v. 31, n. 4, p. 576, Apr 1961) Mars and Venus trajectories using parking orbits are mapped.

661. Dedebent, G. and Schereschewsky, P.

On the possibility of observing the hidden

face of the Moon. ACADEMIE DES SCIENCES.

COMPTES RENDUS v. 248, p. 3530-3532, 1959.

(In French)

Orbits for lunar probes.

662. Detre, L.

OPTICAL OBSERVATIONS ON THE OCCASION OF THE LANDING OF THE SOVIET MOON PROBE LUNIK II (Bericht Ueber Optische Beobachtungen Anlaesslich der Landung der Sowjetischen Mondrakete Lunik II). Royal Aircraft Establishment (Gt. Brit.). (translated by J. W. Palmer). Library trans. no. 922 from Mitteilungen der Sternwarte der Ungarischen Akademie der Wissenschaften, 1960. Nov 60, 6p. ASTIA AD-248 602

On the night of 13th September, 1959, which was exceptionally clear in Hungary, an expanding dark spot on the moon, near the crater Autolycus, was observed by several astronomers at two independent observatories, between the times 21h 02m 30s and 21h 07m UT. Traces of a similar phenomenon were found on photographs taken at the same time at Uppsala. The co-ordinates of the dark spot (+0.03 +0.45) agree well with those given for the impact point of Lunik II, which hit the moon at 21h 02m 24s UT.

663. Dluzhnevskaya, O.B.

ON PHENOMENA OBSERVED AT THE INSTANT OF IMPACT OF THE SECOND SOVIET COSMIC ROCKET ON THE MOON. (O Yavleniyakh, Nablyudavshikhsya v Moment Padeniya Vtoroi Sovietskoi Kosmicheskoi Rakety na Lunu) Royal Aircraft Establishment (Gt. Brit.). (tr. by J.W. Palmer). Library Trans. no. 938 from Byulleten' Stantsii

663. (Cont'd)

Opticheskogo Nablyndeniya Iskusstvennykh

Sputnikov Zemli 4:1-6, 1960. Feb 61, 8p.

ASTIA AD-253 914

The Astronomical Council of the U.S.S.R. Academy of Sciences has received various accounts of phenomena observed by a number of people when the Lunik hit the surface of the moon. All observations are analysed and summarised in a table. The positions of the observed phenomena are indicated on the map of the moon.

664. Eggleston, J.M. and McGowan, W.A. C

A PRELIMINARY STUDY OF SOME ABORT TRAJECTORIES

INITIATED DURING LAUNCH OF A LUNAR MISSION

VEHICLE (U). National Aeronautics and Space

Administration, Washington, D. C. Technical

memo. X-530, Apr 61, 27p. ASTIA AD-322 826

CONFIDENTIAL REPORT

Also available from NASA, Wash. 25, D. C., as NASA Technical memo. X-530.
DESCRIPTORS: *Space flight, Moon, *Atmosphere entry, Re-entry aerodynamics, Launching, Mechanics, Control, Flight paths, Mathematical analysis, Recovery, Manned, Safety, *Spaceships, *Satellite vehicles, *Satellite vehicle trajectories, *Orbital flight paths.

665. Egorov, V.A.

Certain problems of moon flight dynamics.

RUSSIAN LITERATURE OF SATELLITES, PART 1.

N.Y. International Physical Index, Inc.,

p. 115-174, 1958.

A very detailed article on the various best possible trajectories for achieving different results with regard to a vehicle flight to the moon.

666. Egorov, V.A.

Nekotorye voprosy dinamiki poleta k lune. AKADEMIIA NAUK SSSR. DOKLADY p. 46-49, 1957. (In Russian)

Discussion of dynamics of the flight to the moon, including such problems as the necessary speed, trajectory shape, orbit around the moon, and landing on the moon.

667. Egorov, V.A.

Some problems relating to dynamics of flight to moon. In INTERNATIONAL ASTRONAUTICAL CONGRESS, BARCELONA, 1957-PROC. SPRINGER VERLAG, VIENNA, p. 478-82, 1958. Also In USPEKHI FIZICHESKIKH NAUK v. 63, n. 1a, p. 73-117, 1957. (In Russian)

The strict requirements concerning the accuracy of initial data mean that in order to realize a close flight around the moon and particularly a close flight with a slightly oblique entrance into the atmosphere of the earth, it is necessary that the passive segment of the trajectory should be corrected by means of an auxiliary engine. For trajectories hitting the moon and those for distant flight around the moon, the accuracy requirements are moderate enough, hence a flight along these trajectories may probably be realized without correction at the passive segment as soon as the rockets attain the speed of the order of the parabolic speed.

668. Flying to the Moon. ENGINEERING v. 184, p. 642-643, 1957.

Extensive abstracts of two Russian papers: "Problems in the dynamics of lunar flight," by V. A. Egorov deals with computer calculations of free orbits, the effects of initial errors and the conditions required for capture by the Moon. "Some variation problems connected with the launching of artificial satellites of the Earth," by D. E. Okhotsimskii and T. M. Eneev investigates the most economical flight path and thrust programme.

669. Gedeon, G.S. and Dawley, R.E.

The influence of launching conditions on the orbital characteristics. JET PROPULSION v. 28, n. 11, p. 759-760, 1958.

The relationship between the apogee and perigee altitudes and the burnout conditions are obtained from the equations of motion of a satellite orbiting in a vacuum around a spherical nonrotating Earth. This relationship is presented on a composite chart. It can be seen from the chart that for high reliability in achieving an orbit, high excess velocities are favorable.

670. Gold, L.

Earth-Moon rocket trajectories. FRANKLIN INSTITUTE. JOURNAL v 266, n. 1, p. 1-8, 1958.

Analysis of the three-body problem using an approximation of an adiabatic limit which considers the earth and the moon as essentially stationary during rocket flight. Emphasis is placed on setting forth the formalism and deducing some immediately obtainable findings. Properties such as flight times and landing velocities are found.

671. Goldbaum, G.C. and Gunkel, R.J.

Comparison of two- and three- dimensional analysis of earth-moon flight. 15p. In AMER. ASTRONAUTICAL SOC. PROC., N.Y. 1958, 521p. (Papers presented before Western Regional Meeting 18-19 Aug 58, Palo Alto).

Data show that basic trends can be established with an idealized two-dimensional system, but must be expanded to include the effects of the angle between the planes of the trajectory and the lunar orbit as well as the errors in launch azimuth angle. Cognizance of combined errors is important before feasibility can be definitely established. In general, the following errors in trajectory parameters can be tolerated for lunar impact: (1) 200 to 315 fps in the magnitude of launch velocity, (2) approximately 0.49 degree in direction of the launch velocity, or (3) about 1 degree in launch azimuth. Combined errors can

671. (Cont'd)

reduce any one tolerance considerably, e.g., an error of minus 0.2 degree in launch flight path and azimuth angles will reduce the permissible error in velocity to less than 110 fps if lunar impact is to be achieved.

672. Gontkovskaya, V. and Chebotarev, G.A.

The motion of the space probe LUNIK III.

SOVIET ASTRONOMY--AJ v. 5, n. 1, p. 91-105,

1961.

Four orbits are considered for artificial satellites of the moon. The motion of the satellites is investigated over a considerable time-span. The principal results of the numerical integration are presented in Tables 3-7 and Figs. 3-5.

673. Gradecak, V.

Solar and lunar perturbations of satellite

orbit. 8p. In AMER. ASTRONAUTICAL SOC.

PROC., N.Y. 1958, 521p. (Papers presented

before Western Regional Meeting 18-19 Aug

58, Palo Alto).

Theory of solar and lunar perturbations is applied to a satellite orbit. It is assumed that the orbital plane of the satellite is co-planar with the Moon-orbit. It is also assumed that, initially, the satellite orbit is a true circle, becoming elliptical due to the above mentioned perturbations. The results show that the perturbative influence of the sun is small whereas the lunar effect is much larger because of the proximity of the Moon. A cycle of 8.87 years is discernible during which the moon causes a periodic disturbance in eccentricity and the perigee point of the satellite orbit. By combining the solar and lunar influences the joint effect of perturbations is obtained.

674. Gröbner, W. and Cap, F.

The three-body problem of earth-moon-spaceship.

In INTERNATIONAL ASTRONAUTICAL CONGRESS, 10TH.

674. (Cont'd)

1959, 24p. Also In ASTRONAUTICA ACTA

v. 5, n. 5, p. 287-312, 1959. (In English)

The solution of the astronomical n-body problem using Lie series is discussed and the known algebraic integral (conservation of momentum, conservation of angular momentum, conservation of energy) are reproduced. After solving the two-body problem, the closed solution for the three-body problem is given. Two alternative methods for numerical computations are provided in sufficient detail for immediate programming. Work has begun on several more advanced problems, including the computation of orbits in the approximate five-body problem (one small mass in the field of four moving large masses); it is being carried out at Innsbruck University under the sponsorship of General Motors, U.S.A.

675. Groves, G.W.

On tidal torque and eccentricity of a satellite's orbit. ROYAL ASTRONOMICAL SOCIETY, MONTHLY NOTICES OF THE v. 212, n. 5, p. 497-502, 1960.

A hypothesis is made whereby it can be shown that tidal dissipation within the Earth must increase the eccentricity of the Moon's orbit.

676. Gunkel, R.J. and Shuttle, E.H.

Trajectories for direct vehicle transfer from moon to earth. In INTERNATIONAL ASTRONAUTICAL CONGRESS, 11TH. 1960, 11p. Also In AIRCRAFT ENGINEERING v. 32, n. 382, p. 364, 1960.

An investigation of possible direct ballistic transfer of transport vehicles from the Moon to landing areas on Earth, with particular attention to the sensitivity of initial condition errors. The importance of such parameters as location of launch site, location of landing area, and departure velocity are discussed. The results indicate that very little control of the velocity vector in magnitude of direction will be required for the early attempts of return flight where the objective is the landing of an instrumented capsule anywhere on the Earth's surface. In later manned return flights, where the object will be to land on a particular area of the Earth, guidance systems of a high degree of accuracy will be required during the powered phase. The most desirable location of the launch site is in the vicinity of the mean central point of the visible disc.

677. Guth, V.

Calculation of the impact point of the carrier rocket of Lunik II. AIRCR. ENGNG. v. 32, n. 382, p. 367, 1960.

Simple method of calculating impact point. Found to be in area of Erathostine.

678. Huang, S.S.

SOME DYNAMICAL PROPERTIES OF NATURAL AND ARTIFICIAL SATELLITES. NASA--Tech Note D-502, Sep 60, 6p.

Some qualitative properties of natural and artificial satellites in solar system that can be understood in terms of restricted three-body problem are discussed; satellite system of Jupiter, Trojan group of asteroids, and behavior of artificial satellites in Earth-Moon-Sun system are considered.

679. Hunter, M.W., Klemperer, W.B. and Gunkel, R.J.

Impulsive midcourse correction of lunar shot. In INTERNATIONAL ASTRONAUTICAL CONGRESS, AMSTERDAM, 1958 - PROC. SPRINGER VERLAG. VIENNA, p. 626-38, 1959.

A review of the interrelation between the initial parameters of a ballistic trajectory from earth to the moon and the probability of a hit elucidates how a modest excess initial velocity over the minimum energy condition can be exploited to reduce the sensitivity of errors in magnitude, but not so well in direction of the actual velocity vecter. This sensitivity to the direction error can be offset by a burst of propulsive impulse applied during the midcourse part of the travel. A method of implementing the optimal timing for such a corrective impulse with a minimum of apparatus on board is described. It may be useful either to ensure a strike with only marginal initial guidance, or to pick out a specified impact area when the initial guidance is just adequate to strike anywhere on the moon. Significant insight into the problem was obtained from two-dimensional machine solutions of somewhat idealized Earth-Moon system trajectories. More accurate three-dimensional calculations designed to take the most important perturbations into account were than carried out to verify the applicability of the conclusions to a real case, and to determine its limitations.

680. Jean, O.

Outlay of trajectories for the Army's Juno I and Juno II program. INSTITUTE OF RADIO ENGINEERS. TRANSACTIONS. MILITARY ELECTRONICS v. MIL-4, n. 2-3, p. 145-157, 1960.

This paper presents a description of the factors associated with establishing trajectories for the Juno I and Juno II program. It gives a description of the following orbital elements: inclination, eccentricity, semi-major axis, right ascension of the ascending node, argument of perigee, and time of perigee passage. Also included is a detailed description of the trajectory arrangement for the Lunar Probe, and a list of the elliptical characteristics for the Explorer VII trajectory.

681. Jones, C.M.

System of coordinates for space. IRE - EAST, COAST CONFERENCE ON AERONAUTICAL & NAVIGATIONAL ELECTRONICS - PROC p, 97-102, 1958.

Proposed system of coordinates for powered space flight specifies reference plane, point of reference, and reference for measuring longitude, for satellite, cislunar, solar, and interstellar space; distances measured in light seconds and velocity by its ratio to speed of light.

682. Kalensher, B.E.

SELENOGRAPHIC COORDINATES. Jet Propulsion Laboratory, California Institute of Technology, Pasadena. Rept. no. TR 32-41, 24 Feb 61, 31p. (Contract NASw-6)

ASTIA AD-255 607

The Moon's triaxial, gravitational potential and its complex, rotary motion (libration) are incorporated in the equations of motion of a space vehicle in the near vicinity of the Moon. A transformation is derived between the

682. (Cont'd)

space-fixed coordinate system, centered in the Moon, in which the vehicle's motion is computed, and a coordinate system fixed in the lunar body; i.e., a coordinate system which rotates with the Moon. Finally, an expression is derived for computing the velocity of the space vehicle in the Moon-fixed coordinate system.

683. Kissell, K.E.

ANALYSIS OF THE ANNOUNCED TRAJECTORY OF

THE RUSSIAN EXTRATERRESTRIAL VEHICLE, MECHTA

I. Air Force Cambridge Research Center,

Bedford, Mass. Rept. on Proj. Space Tract,

Sep 59, 23p. (Proj. no. 1772; AFCRC TN 59-605;

GRDST-8). ASTIA AD-251 314

Tracking data extracted from Soviet newscasts during the post-launch phase of the first Soviet extra-terrestrial vehicle are analyzed. The data are examined to deduce a spatial position at which the vehicle passed closest to the moon at the announced time of 0259 GMT on 4 January 1959. The radial distance from the moon is found to agree closely with the miss distances announced from quick-look and hindsight data reductions. Plots of the probe path are included and criteria for estimating repeat firing dates and times for lunar probes are given. Translations of pertinent Russian newscasts are presented. One set of US tracking data made at Goldstone Lake, California, is compared to the announced trajectory.

684. Kizner, W.

A method of describing miss distances for

lunar and interplanetary trajectories.

Jet Propulsion Laboratory, California Institute

of Technology. PLANETARY & SPACE SCIENCE v. 7,

p. 125-31, 1961.

Miss distances for lunar and interplanetary trajectories can be described by specifying two components of the impact parameter, which is treated as a vector. This is analogous to the use of range and azimuth (or cross range) in specifying the impact point for terrestrial targets. The resulting co-ordinates are very nearly linear functions of the variables of the trajectory near the

684. (Cont'd)

Earth, except in cases where the trajectory is of the minimum-energy type, such as a Hohmann orbit. Applications are given to the theory of guidance and to a method for automatically searching for a trajectory which hits or misses the target in a specified manner.

685. Klemperer, W.B.

Moon-shot with corrections enroute.

OESTERR. INGR. Z. v. 2, n. 6, p. 223-6,

1959. (In German)

Discussion of difficulties in maintaining a missile on trajectory for reaching the moon.

686. Klemperer, W.B. and Benedikt, E.T.

Selenoid satellites. ASTRONAUTICA ACTA

v. 4, n. 1, p. 25-30, 1958.

Lagrangeian solution of restricted three-body problem of constant configuration; five possible positions are inferior and superior conjunction, opposition and two "trojan" positions or sextiles; these positions are computed for symperiodic moon companion of earth and earth companion of sun.

687. Klemperer, W.B. and Benedikt, E.T.

Synodic satellites. ASTRONAUTICS v. 3,

n. 10, p. 28-9, 64, 66, 68, 1958.

Consideration of conditions under which satellite could be established in such orbit that it would remain in equilibrium in constant configuration relationship with both earth and moon; geometry of inertial forces of earth, moon, and synodic satellite following circular motion in restricted 3-body problem.

688. Kooy, J.M.J. and Berghuis, J.

On the numerical computation of free

688. (Cont'd)

trajectories of a lunar space vehicle.

ASTRONAUTICA ACTA v. 6, n. 2/3, p. 115-143,

1960.

With the occasional use of a "Bull Nederland" (Amsterdam) electronic computer, we have been able to carry out numerical investigations on trajectories of moon rockets. To begin with, a three dimensional orbit was worked out, in which the vehicle approaches the moon to within about 11,000 km, and so arriving at a position from which the hidden lunar hemisphere can be observed. Then, after completing a loop, the vehicle returns again to the vicinity of the earth. In this first example, the launching site was chosen on the equator, and during the last stage of the flight, a ballistic speed, just sufficient to bring the vehicle within lunar distance was applied. In a subsequent investigation, the launching site was chosen along a northern latitude (Cape Canaveral), and a hyperbolic speed was applied in the last burn out point. The effects of the application of a retro-rocket in the vicinity of the moon have also been explored. In this way, orbits planned to hit the moon, and also to circumnavigate the moon and return to earth, have been obtained. In all these cases, the lunar and solar disturbances have been taken into account. In addition, the possibility of launching a moon satellite has also been examined and a corresponding orbit has been computed. It appeared that the Kepler motion of such a moon satellite (with respect to selenocentric system of reference, and not rotating with respect to the celestial sky) is strongly influenced by the combined terrestrial and solar disturbances.

689. Kramer, S.B.

Trajectory governs Moon shot's value.

AVIATION WEEK AND SPACE TECHNOLOGY v. 70,

p. 48, 49, 51, 55, 57, 1959.

Discussion of the performance requirements of four types of trajectories for unmanned lunar probes: (1) orbiting the moon several times and (a) not returning to earth or (b) returning to earth or its vicinity; (2) pure impact or hard landing; (3) circumnavigating the moon once and returning to or near the earth; and (4) flying past, close to the moon, without returning.

690. Lanzano, P.

Application of Hill's lunar theory to

the motion of satellites. THE JOURNAL

690. (Cont'd)

OF THE ASTRONAUTICAL SCIENCES

v. 8, n. 2, p. 40-7, 1961.

Hill's Lunar Theory of Celestial Mechanics is applied to the problem of establishing a permanent artifical satellite on a periodic orbit around„a planet. Using a method developed by C. L. Siegel, in his "Vorlesungen uber Himmelsmechanik," the Hill's equations of the Lunar Theory are solved to obtain the coordinates of the periodic trajectory as Fourier series of the time with respect to a rotating system of reference. A recurrent procedure is obtained for evaluating the coefficients of the series in terms of the period of revolution. The Jacobi constant of the motion is also expressed as an infinite power series of the period. The convergence of such expansions can be ascertained for small values of the period. A numerical example for a satellite of Venus is furnished. An error analysis is undertaken by studying solutions of Hill's equations lying in a neighborhood of a periodic orbit and corresponding to the same value of the total energy. The coordinates of such neighboring trajectories are determined as isoenergetic displacements referred to the intrinsic reference formed by the tangent and normal lines at the various points of a periodic orbit. This procedure leads to a differential equation of the Mathieu type whose solution is obtained as a series expansion valid for small values of a parameter.

691. Lass, H. and Solloway, C.B.

Motion of a satellite of the moon. ARS

JOURNAL v. 31, n. 2, p. 220-222, 1961.

The motion of a satellite of the moon depends chiefly on the force fields of the moon, Earth and sun. If one chooses a frame of reference attached to the moon, it can be shown that the force field resulting from the sun can be neglected when compared with Earth's field on the satellite. The effect of the Earth's field is shown to be of the same order of magnitude as is the moon's perturbing field resulting from its oblateness. The distance between Earth and moon will be assumed to be constant, and satellite orbits of small eccentricity will be studied. The averaging process of Kryloff-Bogoliuboff is applied to the equations of motion for an analysis of this restricted three-body problem, which is further complicated owing to the moon's oblateness. It is shown that a nearly circular polar orbit will digress less than 1 deg from a true polar orbit, and that the change in eccentricity of the orbit is less than a factor of e in one half of a year. An integral of the motion is obtained, such that accurate observations of a nearly circular orbit (not necessarily a polar orbit) will yield value of two fundamental constants related to the principal moments of inertia of the moon.

692. Lieske, H.A. S

LUNAR INSTRUMENT CARRIER - ASCENT FLIGHT MECHANICS (U). RAND Corp. Rept. no. RM-1727, 4 June 56, 59p. ASTIA AD-133 041

SECRET REPORT

One of a series of studies on the lunar instrument carrier. The present investigation considers the powered-ascent trajectories for a moon rocket designed with a typical combination of booster stages. Such topics are examined as powered trajectories using a gravity-turn or zero-lift flight program, the ascent path leading to the design transit trajectory to the moon, and the tolerances in the trajectory parameters at booster burnout that will permit a hit on the moon. (U).

693. Lieske, H.A.

LUNAR INSTRUMENT CARRIER-TRAJECTORY STUDIES. Rand Corp., Santa Monica, Calif. Rept. no. RM-1728, 4 June 56, Revised 25 June 58.

This research memorandum summarizes the results of a study of free-flight Earth-Moon trajectories. The two-dimensional ballistic motion of a vehicle from a standard initial altitude above the Earth to impact on the surface of the Moon is described. Trajectories originating at various positions relative to the initial position of the Moon are studied to cover the complete spectrum, including retrograde launching. A design transit trajectory is chosen to examine the effect of small variations of initial parameters on the location of the lunar impact point for use in error studies. A "hit band" of transit trajectories that lead to impact on the Moon is computed by varying initial conditions in the vicinity of the design point. Moon-miss transit trajectories in the vicinity of the design point are studied with reference to establishing artificial satellites of the Moon.

694. Link, F.

On the phenomena of the impact of a lunar projectile. ASTRONOMICAL INSTITUTES OF

694. (Cont'd)

CZECHOSLOVAKIA. BULLETIN v. 11, n. 2, p. 34, 1960. (In French)

Effect of fall of rocket on to dust-covered lunar surface is disclosed theoretically with emphasis on cloud produced.

695. Liu, A.

Normal lunar impact analysis. JOURNAL OF THE ASTRONAUTICAL SCIENCES v. 7, n. 2, p. 35-39, 1960.

If the angle of impact is chosen to be perpendicular to the local lunar surface (i.e., normal impact), for purposes of simplifying terminal guidance of lunar vehicles, then it is possible to show, on the basis of a rocket moving under the gravitational field of the Earth and a circularly moving but massless Moon, that normal impact region is restricted to the leading semi-circle of the visible disc. Further, it is possible to show that higher energy orbits will strike closer to the center of the visible lunar disc than lower energy orbits.

696. Margerison, T.A.

The way to the Moon. NEW SCIENTIST v. 4, p. 1048-1051, 1958.

Discusses alternative orbital paths for a lunar probe.

697. Michael, W.H., Jr. and Tolson, R.H.

EFFECT OF ECCENTRICITY OF THE LUNAR ORBIT, OBLATENESS OF THE EARTH, AND SOLAR GRAVITATIONAL FIELD ON LUNAR TRAJECTORIES. U.S. National Aeronautics and Space Administration. Rept. no. TN D-227, June 60, 37p.

Comparison between lunar trajectories which were calculated by using the classic restricted three-body equations of motion, and lunar trajectories

697. (Cont'd)

(with identical injection conditions) which were calculated by using equations of motion which include terms representing the additional effects. It is found that the oblateness of the earth can modify the trajectories in the vicinity of the moon by several hundred miles or more; whereas, the eccentricity of the moon's orbit and the gravitational gradient of the sun are relatively less important and cause a difference in impact point of no more than one or two hundred miles along the lunar surface.

698. Michael, W.H., Jr. and Tolson, R.H.

THREE-DIMENSIONAL LUNAR MISSION STUDIES.

U.S. National Aeronautics and Space

Administration. Memo no. 6-29-59L, June 59,

38p.

Calculation of some three-dimensional lunar trajectories by integration of the equations of motion of the classical restricted three-body problem of celestial mechanics. The calculation have been used for the analysis of several aspects of lunar flight including requirements for achieving lunar impact and for establishing a close lunar satellite. It is concluded that the allowable errors in initial conditions for lunar missions are strongly dependent on the values of the initial injection velocity and the injection angle. There can be large differences in results obtained from two- and three-dimensional analyses. Some of the accuracy tolerances can be fairly well estimated by use of a two-body analysis. Satisfactory orbits for a relatively close lunar satellite can be obtained with accuracies in the initial conditions approximately equal to those required for lunar impact.

699. Michael, W.H., Jr. and Crenshaw, J.W.

TRAJECTORY CONSIDERATIONS FOR CIRCUMLUNAR

MISSIONS. IAS, Annual Meeting, 29th.,

New York, N.Y., 23-25 Jan 61. Paper 61-35,

22p.

Presentation of some results of preliminary trajectory studies which are useful in the design of nominal trajectories for the circumlunar mission. Part of the paper described the results of a parametric study defining characteristics of trajectories which circumnavigate the moon and return to the atmosphere of the earth with re-entry conditions suitable for manned missions. Injections and midcourse guidance studied include an error analysis and calculation of the effects of guidance corrections at various points throughout two nominal trajectories. Finally, some consideration is given to the effect of the return point at the surface of the earth on the design of circumlunar trajectories.

700. Mickelwait, A.B. and Booton, R.C.

ANALYTICAL AND NUMERICAL STUDIES OF THREE-DIMENSIONAL TRAJECTORIES TO THE MOON. Space Technology Labs. Rept. no. GM-TM-0165-00287; AFBMD document no. 8-10326, 23 Sep 58, 50p. ASTIA AD-216 469. Also In JOURNAL OF THE AEROSPACE SCIENCES v. 27, n. 8, p. 561-73, Aug 60.

Theoretical calculations are presented of lunar trajectories from the point of view of the guidance problem. The guidance problem is one of reducing error at burnout. A conventional 2-dimensional approach is presented and 3-dimensional problems arising from a nonoptimum location of launch sites are analyzed. Machine calculations were made and are compared directly with the approximate solutions. The analytic statement of the required accuracy to impact on the moon's surface is determined and compared with the actual accuracy needed. The accuracy requirements given assume that the launching may be made directly into the plane of the moon. This solution is unsatisfactory for real launch sites which require that the vehicle be launched out of plane or that it be turned into the plane of the moon, an extremely expensive alternative for propulsion. The effect on the necessary guidance accuracy of launching out of the plane of the moon is examined. This 3-dimensional analysis indicates that the velocity accuracy requirements increase sharply as the plane of the trajectory is inclined with respect to the plane of the moon. Accuracy requirements vary greatly for the different launch times. Methods for analytically determining appropriate launch time and azimuths are also given.

701. Mickelwait, A.B.

Lunar trajectories. ARS JOURNAL v. 29, n. 12, p. 905-914, 1959.

The status of three-dimensional lunar trajectories and techniques for treating them analytically are reviewed. The problem of a lunar satellite is treated in detail. This study is framed in the light of equipment limitation and interaction. Curves showing the interrelationship of flight parameters and also miss coefficients are presented.

702. Miele, A.

Theorem of image trajectories in the earth-moon space. ASTRONAUTICA ACTA v. 6, n. 5, p. 225-232, 1960.

Theorem of Image Trajectories in the Earth-Moon Space. The motion of a small vehicle in the Earth-Moon space is considered using the mathematical model of the restricted three-body problem. Two theorems associated with this motion are established: the Irreversibility Theorem and the Theorem of Image Trajectories. The Irreversibility Theorem states that, if a trajectory is physically possible in the Earth-Moon space, the reverse trajectory is not physically possible. The Theorem of Image Trajectories states that, if a trajectory is physically possible in the Earth-Moon space, three image trajectories are also physically possible: (a) the image with respect to the plane which contains the Earth-Moon axis and is perpendicular to the axis of rotation of the Earth-Moon system; (b) the image with respect to the plane which contains the Earth-Moon axis and the axis of rotation of the Earth-Moon system; and (c) the image with respect to the Earth-Moon axis. The first of these image trajectories must be flown in the same sense as that of the basic trajectory, while the other two must be flown in the opposite sense. As a conclusion, the time required for the parametric study of lunar trajectories is reduced considerably, since, once a basic set of trajectories is calculated, three additional sets can be obtained by simple transformations of coordinates.

703. Musen, P.

On the long-period lunar and solar effects on the motion of an artificial satellite, 2. JOURNAL OF GEOPHYSICAL RESEARCH v. 66, n. 9, p. 2797-2805, 1961.

The disturbing function for the long-period lunisolar effects is developed into a series of polynomials in the components of the vectorial elements in the direction to the disturbing body. This development is convergent for all eccentricities and all inclinations. The equations are established for the variation of elements in a form suitable for the use of numerical integration and for the development of the perturbations into trigonometric series with

703. (Cont'd)

numerical coefficients. An application of Milankovich's theory of perturbations leads to the equations for perturbed elements in which the small numerical divisors, the sine of the inclination and the eccentricity, are not present. These new equations, like the equations for canonical elements, have a symmetrical form and a wider range of applicability than the equations for elliptic elements.

704. Musen, P.

ON THE LONG PERIOD LUNI-SOLAR EFFECT IN THE MOTION OF AN ARTIFICIAL SATELLITE. National Aeronautics and Space Administration, Washington, D. C. Rept. no. TN D-1041.

Two systems of formulas are presented for the determination of the long period perturbations caused by the Sun and the Moon in the motion of an artificial satellite. The first system can be used to determine the lunar effect for all satellites. The second method is more convenient for finding the lunar effect for close satellites and the solar effect for all satellites. Knowledge of these effects is essential for determining the stability of the satellite orbit. The basic equations of both systems are arranged in a form which permits the use of numerical integration. The two theories are more accurate and more adaptable to the use of electronic machines than the analytical developments obtained previously.

705. Nelson, W.C.

An integrated approach to the determination and selection of lunar trajectories. JOURNAL OF THE ASTRONAUTICAL SCIENCES v. 8, p. 33-39, 1961.

Presentation of an analytical approach to the determination of lunar trajectories, on the basis of the restricted three-body problem. A technique for relating a geocentric ellipse to a selenocentric hyperbola is developed, which leads to interrelationships of major design areas including guidance and control, propulsion, tracking and communications, and logistics. Particular emphasis is placed on relating vehicle energy to selenographic coordinates for lunar landing and take-off, or for entering and leaving lunar orbits from which the "corridor-ring" concept is developed. An analysis of the optimum point for entering and leaving lunar orbits or for lunar landing and take-off is included.

706. Newton, R.R.

Motion of a satellite around an unsymmetrical central body. JOURNAL OF APPLIED PHYSICS v. 30, n. 1, p. 115-117, 1959.

If a central body does not have an inversion centre, the eccentricity of a satellite orbit varies periodically, with low frequency and large amplitude. Thus, unless the satellite is initially in a large enough orbit, it may strike the central body, even in the absence of dissipative forces. Details are worked out for a central body composed of a large spherical mass and a small point mass contained somewhere within it. Application is made to satellites of the moon.

707. Petty, A., et al

LUNAR TRAJECTORY STUDIES. Space Sciences Lab., General Electric Co. Final Rept. July 60 - June 61. Rept. no. AFCRL-507, June 61, 276p. (Contract AF 19(604)-5863). ASTIA AD-261 670

A description of several related IBM-7090 Fortran computer programs is presented to provide a fast, accurate, and systematic procedure for determining initial conditions to the differential equations of motion from tracking data, lunar and interplanetary trajectories in n-body space, and satellite ephemeris compilations.

708. Petty, A. and Jurkevich, I.

LUNAR TRAJECTORY STUDIES AND AN APPLICATION TO LUNIK III TRAJECTORY PREDICTION. General Electric Co., Space Sciences Lab., Philadelphia, Pa. Scientific Report 1; AFCRL-TN-60-1132, July 60. (Contract AF 19(604)-5863). ASTIA AD-247 577

The purpose of the computer program is to solve numerically equations of motion of a vehicle in the Sun-Earth-Moon space. The program has the capability

708. (Cont'd)

of solving the equations of motion in either their entirety or only their perturbative part. These two approaches are known respectively as the Cowell and the Encke methods. For purposes of the present study Cowell techniques were used throughout. The program is characterized by a compromise between speed, accuracy, and flexibility. It utilizes a Runge-Kutta-Gill integration scheme with authentic selection of integration so that the largest integration step possible is taken consistent with a maximum preset error. The program includes the oblateness terms which account for the dipole gravitational field of the Earth. It is further assumed that all flights start at altitudes where air drag can be ignored. To demonstrate the capabilities of the lunar computer program it was applied to two specific problems: The first problem is concerned with accuracy requirements of the initial conditions for achieving impact at a specific point on the surface of the Moon. The problem has been restricted to specific conditions of burnout velocity, altitude, and date without any regard to the site of launch. Such a restriction is necessary because a general treatment of the problem would lead to preparation of firing tables, which is far beyond the scope of this study. The general scheme of computation followed was to design a nominal impact trajectory and then vary each of the six initial conditions separately by a small amount. The resulting deviation from the nominal impact point was taken as a measure of miss. This study indicates that several auxiliary subroutines are necessary to obtain the desired information from the main computer runs. These auxiliary computations were performed on the LGP-30 computer. It is recommended that they eventually be included in the main computer program. The second problem to which the lunar program was applied was the computation of Lunik III trajectory. The input data employed were those released by the Soviet news agency TASS. The procedure was to fit the tracking data around the first apogee following the vehicle's approach to the Moon. It must be strongly emphasized that the accuracy of the available data was quite low. In spite of this, the computed trajectory agreed remarkably well with that predicted by the USSR.

709. Porter, J.G.

Interplanetary orbits. BRIT. INTERPLAN.

SOC. JOURNAL v. 11, n. 5, p. 205-210, 1952.

Discussion concerned with fundamentals of orbit work, mainly with those of earth-moon system deals particularly with some of common fallacies prevalent.

710. Riddell, W.C.

Initial azimuths and times for ballistic lunar

impact trajectories. ARS JOURNAL v. 30, n. 5,

p. 491-493, 1960.

Analytic expressions have been derived that show approximately the launch azimuths and launch times for which a ballistic missile will hit the moon.

710. (Cont'd)

Also shown are the conditions producing the smallest angle of intersection between the missile plane and the lunar plane, and those giving an optimum launch azimuth. The formulas are applicable to missions other than lunar impact.

711. Ruggieri, G.

Considerations on the possible direct observation of the impact point of Lunik II on the moon. COEIUM. (ITAL.) v. 29, n. 1-2, p. 10-2, 1961. (Italian)

Discussion of observations made by the Budapest observatory of the event.

712. Sedov, L.I.

Orbits of cosmic rockets towards the moon. ARS JOURNAL v. 30, n. 1, p. 14-17, 1960. Also <u>In</u> ASTRONAUTICA ACTA v. 6, n. 1, p. 16-31, 1960.

Summary of considerations and computations made which served as basis for choosing flight around trajectory for third Soviet cosmic rocket, making use of strong influence of moon for best solution; tabulation of actual data concerning orbits of three Soviet cosmic rockets; data characterizing flight orbit; projection of orbit of AIS (Automatic Interplanetary Station); photographs obtained from moon.

713. Sedov, L.I.

THE ORBITS OF MOON ROCKETS. Aerospace Technical Intelligence Center, Wright-Patterson Air Force Base, Ohio. Translation no. MCL-877 of FIZIKAI SZEMLI v. 10, p. 241-5, 1960. 23 May 61, 15p. ASTIA AD-259 576

DESCRIPTORS: Moon, Guided missile trajectories, Orbital flight paths, USSR technological intelligence, Launching, Celestial mechanics, Lunar probes.

714. Slabinski, V.J.

Calculating a journey from the earth to the moon. ENGINEERING AND SCIENCE REVIEW v. 4, n. 1, p. 17-20, 1960.

An original method of computing an Earth-Moon trajectory, using a minimum of sophisticated mathematics, is described.

715. Spencer, R.C.

The astronautic chart. INSTITUTE OF RADIO ENGINEERS. PROCEEDINGS v. 48, n. 4, p. 528-531, 1960.

The Astronautic Chart is a nomograph or alignment chart so arranged that a single straight line marks off values of the velocity, mass, mean distance, period, and acceleration of any two-body orbiting system. It is illustrated with numerous examples of orbits of planets about the sun, moons about their planets, and artificial earth satellites. All scales give correct values at the extremities of the minor diameter of the elliptical orbit. In the case of binary stars where the masses are comparable, the scales also give correct values of the total mass, total separation, relative velocity, and relative acceleration.

716. Strughold, H. and Ritter, O.L.

Orbital characteristics of earth and moon satellites as a basis for space medical studies. AEROSPACE MEDICINE v. 32, p. 422-424, 1961.

Discussion of the earth's potential satellite sphere. Data are given which provide a more distinct picture of the gravitational situation in the earth-moon areas. The data include: (1) orbital velocities at 200 km. altitude and at selected intervals above this limit, (2) orbital data at various intervals up to 70,000 km. including the 24-hr. orbit at 36,000 km., (3) orbital velocities and periods of revolution up to the border of the satellite sphere, and (4) orbital velocities and periods of revolution of moon satellites at selected intervals up to 20,000 km.

717. Thompson, G.V.E.

Lunar probe paths for approaching the Moon.

ENGINEERING v. 186, n. 4826, p. 294-295, 1958.

Reference to failure of United States lunar probe, Able I, launched from Cape Canaveral, Fla., August 17, 1958. Factors which must be considered for actual launching of vehicle. Two possible types of orbit near moon which woudl permit obtaining useful information with these instruments.

718. Thuering, B.

Zwei spezielle Mondeinfang-Bahnen in der

Raumfahrt um Erde und Mond. ASTRONAUTICA

ACTA v. 5, n. 3-4, p. 241-50, 1959.

Two special trajectories of capture by moon in space travel around earth and moon; by means of electronic computer Univac-Factronic (Frankfort/Main) Germany, two trajectories of 3-body problem are calculated in restriction to Earth-Moon plane as representatives for "bottleneck" and "capture trajectories"; trajectories characterized by frequent driving around Earth or entire Earth-Moon system, respectively, before passing through narrow pass at Lagrangian libration points L, and L_2 respectively.

719. Tolson, R.H.

EFFECTS OF SOME TYPICAL GEOMETRICAL CONSTRAINTS

ON LUNAR TRAJECTORIES. U.S. National Aeronautics

and Space Administration. Rept. no. TN D-938,

Aug 51, 25p.

The constraints considered in this study are of two types, those resulting from specification of the trajectory characteristics near the earth and those associated with the specification of the approach conditions at the moon. The effects of the constraints are discussed from the standpoint of the limitations imposed by the constraints on the possible launch days during the month and also on the possible launch times during the day for three types of launch trajectories: direct-ascent, coasting-orbit, and parking-orbit launches.

720. Tross, C.

CONTRIBUTION TO ASTRODYNAMICS: LUNAR VEHICLE ORBIT DETERMINATION. Aeronutronic, Newport Beach, Calif. Publication U-703, 15 Feb 60.

The most frequently employed method in orbit determination for satellite, lunar, and interplanetary vehicles is a procedure generally known as Cowell's method, through which the equations of motion are integrated directly to obtain total velocity and position at any epoch. In seeking another procedure which is less demanding of computer time and one with which higher precision over a very long ephemeris can be attained, a procedure known to astronomers as Encke's method was formulated. Further pursuit indicated that Encke's method is very well suited for lunar vehicle orbit determinations. With Encke's method the user may incorporate all desired and significant perturbations. For example, an Encke method which considers the solar, lunar, and terrestrial perturbations can determine the three-day lunar trajectory with only 15 integration steps so that the error at impact on the lunar surface is less than one-half mile. In contrast, the same calculation with Cowell's method required 190 integration steps. In this paper Encke's method is developed and the over-all problem of lunar vehicle orbit determination is discussed.

721. Upton, E., Bailie, A. and Musen, P.

Lunar and solar perturbations on satellite orbits. SCIENCE v. 130, n. 3390, p. 1710-1711, 1959.

Calculations of the solar and lunar effects on highly eccentric satellite orbits show that the sun and the moon may cause large changes in perigee height over extended periods of time. The amplitude and sign of the perigee height variations depend on the orbit parameters and the hour of launch; for a typical orbit and various choices of launch time, the perigee height will either rise or fall at the rate of 1 km/day over the course of several months. These results may be significant in deciding the launch conditions for future satellites with highly eccentric orbits.

722. Vargo, L.G.

Generalization of minimum impulse theorem to restricted three-body problem. BRIT. INTERPLANETARY SOC - J v. 17, n. 5, p. 124-6, 1959.

Relation between path variables in restricted 3-body problem is established which minimizes velocity addition required to cause given change in value of Jacobi integral; result is compared to classical 2-body case and applied to lunar orbit problem of practical significance; theorem is useful as means of analyzing complex interaction of propulsion requirements and 3-body trajectories.

723. Vocel, M.

Impact of rocket Lunik II on the Moon. ASTRONOMICAL INSTITUTES OF CZECHOSLOVAKIA. BULLETIN v. 11, n. 3, p. 206-213, 1960. (In Czech)

Phenomena produced by impact of rocket are examined and discrepancy between theory and observation pointed out.

724. Walters, L.G.

Flight mechanics of Lunar vehicle. In AMERICAN ASTRONAUTICAL SOC. PROC. N.Y., N.Y. p. 3-4, 1958. (Papers presented before Western Regional Meeting 18-19 Aug 58, Palo Alto).

Very brief statement on moon-flight trajectories.

725. Walters, L.G.

Lunar trajectory mechanics. NAVIGATION

v. 6, n. 1, p. 51-8, 1958.

Discussion covering studies of the design and navigational aspects of translunar trajectories. A simple model of the earth-moon system, consisting of a planar representation of the Earth and Moon with each moving in a circular path about their common center of gravity, is used for design purposes. The role played by lunar motion in the guidance mission for a high-energy trajectory is described. It is shown that as the velocity increases toward the design value, the impact point moves up the face of the Moon; for higher values the impact points begin to retreat. The computation associated with the navigation problem is discussed.

726. Walters, L.C.

Problems in space navigation. MISSILES AND

ROCKETS v. 3, n. 4, p. 76-9, 1958.

Determination of translunar trajectory format for Earth-Moon rocket studies; role of lunar motion in guidance mission for high energy trajectory; navigational aspect of translunar trajectory; factor of uncertainty in flight time.

727. Weber, R.J., Pauson, W.M. and Burley, R.R.

LUNAR TRAJECTORIES. National Aeronautics

and Space Administration, Washington, D. C.

NASA Technical note no. D-866, Aug 61, 67p.

ASTIA AD-261 105

Also available from NASA, Wash. 25, D. C. as NASA Technical note D-866. A catalog of coast paths between the Earth and the Moon is presented, accounting for three-dimensional factors but neglecting multibody effects. Flight times, velocity increments, and launch azimuths are given for various positions of the Moon and various injection points in the northern hemisphere. The distance covered during powered flight is found to have an important effect on the mission energy requirements. The effect of flight-path angle at burnout is studied; nonhorizontal burnout is often advantageous. The effect of launching from an Earth orbit, rather than directly from the surface, is discussed. Because precession may cause an unfavorable orientation of the orbital plane, departure from a permanent space station is usually undesirable. The velocity increment necessary to accomplish lunar landings or takeoffs is computed as a function of the thrust-weight ratio and of the desired landing location.

728. Woolston, D.S.

DECLINATION, RADIAL DISTANCE, AND PHASES OF THE MOON FOR THE YEARS 1961 TO 1971 FOR USE IN TRAJECTORY CONSIDERATIONS. U.S. National Aeronautics and Space Administration. Rept. no. TN D-911, Aug 61, 48p.

As a byproduct of the preparation of solar and lunar coordinates for use in trajectory calculations a time history has been obtained of the radial distance and declination of the moon and its phases. Results are intended for use as an aid in the selection of launch dates. Results are presented for the years 1961 to 1971 in a form which permits a rapid approximate determination of the combination of declination and lighting for any calendar date. The information provides a time basis for entering tables of the moon's coordinates to obtain more precise data for use in computing insertion conditions.

7. Instruments and Communications

Included under this heading are references to the literature on earth-moon-earth and earth-lunar probe-earth communications; methods and equipment for transmitting information from lunar probe instruments to earth; instrument packages and specific instruments; telemetering, photographic, TV, and tracking equipment; and power sources and systems for instruments and communications.

729. Anderson, R.E. and French, A.D.

Tracking Pioneer IV beyond moon. INST.

RADIO ENGRS-1959 IRE NAT. CONVENTION REC. v.

7, pt. 5, (Aeronautical & Navigational

Electronics, etc.) p. 152-157, 1959.

Space probe tracking system set up by General Electric Co. at Schenectady, N.Y. to track Pioneer IV described; success of tracking project is attributed to low-noise parametric amplifier which made possible use of comparatively small antennas to attain lunar range performance heretofore available only with larger antennas.

730. Bazykin, V.

Teleperedacha iz kosmosa. KRYL'IA RODINY

v. 11, p. 10-11, 1960. (In Russian)

Discussion of the problems associated with the telemetering of photographic data of the moon, obtained by a moon rocket. The technique used in telemetering is outlined in brief.

731. Blackband, W.T.

Radio communication with a lunar probe.

ROYAL SOCIETY OF LONDON. PROCEEDINGS. SERIES

A v. 253, n. 1275, p. 511-515, 1959.

In the design of a communication system between the lunar probe and the earth the study of the radio noise is of importance. The paper treats the chief sources of radio noise, the variation of the noise with galactic coordinates and the variations of galactic noise with the frequency. A lunar probe might transmit 10 W at a distance of 400.00 km. The signal-to-

731. (Cont'd)

noise ratio could be improved in three ways: 1) increasing the transmitted power, 2) using a larger receiving aerial, and 3) stabilizing the axes of the probe so that a directive transmitting aerial would be carried with its signal beamed toward the earth.

732. Boni, A.

Lunar observation rockets. In SEVENTH INTERNATIONAL ASTRONAUTICAL CONGRESS, ROME, 17-22 SEPT. 1956, PROCEEDINGS. p. 288-296.

Consideration of problems associated with a lunar observation vehicle, and the transmission of observations to earth by TV.

733. Caltabiano, S.

Temperature control considerations for instrumented lunar packages. ASTRONAUTICAL SCIENCES REVIEW v. 3, n. 3, p. 16-19, 1961.

Manned lunar operations are on the horizon. These operations will be preceded by many unmanned soft-landed packages whose primary purpose will be to gather data defining the lunar environment. Control of the equipment temperature of these packages will be one of the primary problems in achieving a reliability level consistent with program goals. SURVEYOR, the first soft-landed lunar package. Equipment temperature limits must be closely maintained if operation for these lengths of time is to be accomplished with any degree of confidence. Temperature control limits will depend on the particular characteristics of the payload components and the individual trade-offs that exist between temperature and reliability. Establishing temperature limits in the design stage is sometimes difficult to accomplish due to lack of reliability test data on each package of the vehicle. However, common elements display certain reliability and performance trends that can serve as a basis for predicting temperature vs. reliability data prior to package tests.

734. Collins, J.J., Johnson, R.W. and Stephens, J.E.

UNMANNED PHOTOGRAPHIC EXPEDITION TO THE MOON, VOLUME I. Instrumentation Lab., Massachusetts Institute of Technology, Master's Thesis.

734. (Cont'd)

Rept. no. T-162, 26 May 58, 137p.

(Contract AF 04(645)-9) ASTIA AD-207 937

The vehicle and equipment requirements to accomplish photographic examination of the normally unseen side of the moon are examined. Trajectory studies were carried out via machine computation to establish a suitable orbit. Equipment designs for vehicle stabilization and for the photographic missions are included and a machine study is presented in some detail.

735. Davies, M.E.

LUNAR EXPLORATION BY PHOTOGRAPHY FROM A SPACE VEHICLE. International Astronautical Congress, 10th, 1959. 12p. Also in AIRCRAFT ENGINEERING v. 31, n. 370, p. 373, 1959.

Design of a spinning panoramic camera which, as the payload of a space vehicle, could photograph the Moon's surface from an altitude of 3000 (±2000) miles. An axial retro-rocket is provided for adjustment of the trajectory, which would be in the form of a figure-of-eight passing around the Moon. During re-entry into the Earth's atmosphere, 40-50 lb of the 400-lb. capsule will be ablated. The point of landing could be predicted within a few hundred miles.

736. Details of Ranger instrumentation.

MISSILES AND ROCKETS v, 9, n. 9, p. 24, 1961.

The lunar landing capsule for Rangers 3, 4 and 5 is expected to contain a seismometer with accompanying amplifier, transmitter, antenna and power supply, a righting mechanism, temperature control system, zeroing motor and automatic calibration system. The zero motor and calibration system are recent additions. The program is still reasonably fluid, and there may be other additions or deletions of equipment before the first capsule launch. Jet Propulsion Laboratory is prime contractor for NASA's Project Ranger, Aeronutronic Division, Ford Motor Co., is capsule contractor, and Hercules Powder Co. will make the retrorocket.

737. Duggan, R.S., Jr.

Selection of optimum parameters for lunar mapping satellite. WESTERN AVIATION MISSILES AND SPACE v. 41, n. 6, p. 6-7, 24-26, 1961.

Discussion of basic philosophy, photogrammetry, satellite systems (guidance, mapping sensors, vertical stabilization, azimuth stabilization, star background, altimeter, intervalometer, central time reference, data recorded for picture identification and data reduction, data transmission to earth, data processing on earth).

738. Electronic payload for Pioneer III.

ELECTRONICS v. 31, n. 52, p. 11-12, 1958.

Payload instrumentation for Army's Pioneer III rocket included Geiger tubes, photoelectric scanner and radio transmitter.

739. Fusca, J.A.

Moon reflectivity described at WESCON.

AVIATION WEEK v. 69, n. 10, p. 64-72.

1958.

The reflection characteristics of the moon as they affect earth-moon-earth communications systems.

740. Hamilton, R.C.

RANGER SPACECRAFT POWER SYSTEM. Jet Propulsion Laboratory, California Institute of Technology, Pasadena. (Presented at the ARS Space Power Systems Conference, Santa Monica, Calif., September 27-30, 1960).

American Rocket Society, New York, N.Y. 1345-60.

Oriented silicon photovoltaic cells provide the basic power source for the

740. (Cont'd)

Ranger spacecraft. An attitude control system positions the spacecraft so that solar radiation impinges vertically on the solar cell panels. Primary silver-zinc batteries provide power during the launch phase, prior to Sun acquisition, and during guidance maneuvers when the solar radiation incident on the photovoltaic cells is inadequate to power the Ranger spacecraft. A power logic switching control draws power from the solar panel unless its output voltage under load becomes too low ($<$23.5 volts) to adequately power the spacecraft, at which time the battery is switched in. A booster regulator senses the nominal 28-vdc system voltage and adds a pulse width modulated ac boost voltage which is rectified and filtered to provide a 31.5-vdc $\pm$1 percent regulated bus voltage. Five functionally separate overload protected static inverters provide multiple output ac and dc voltages as required for communications, attitude control, scientific instruments, data processing, and telemetry. Only two of the 20 output voltages require a secondary feedback loop around the rectifier-filter stage to provide the accurate ($\pm$2 percent) required voltage regulations.

741. Hibbs, A.R.

Ranger instrumentation: Current and new gear included. GSE v. 2, n. 6, p. 30, Dec 1960-Jan 1961.

A description of the types of instrumentation carried by the Ranger vehicle to be used for lunar exploration is given. Some will be adaptations of currently used instrumentation and others will be ruggedized versions of instruments which have been applied to Earth situations only.

742. Instrument package, spacecraft being built for trip to the moon. MACHINE DESIGN v. 32, n. 26, p. 30, 1960.

The instrument package to be dropped on the lunar surface by Ranger is discussed.

743. Jet Propulsion Laboratory, Calif. Institute of Technology, Pasadena. SCIENTIFIC EXPERIMENTS FOR RANGER 1 AND 2. Rept. no. TR 32-55, 3 Jan 61, 28p.

This report presents descriptions of the scientific experiments to be carried on the Ranger 1 and Ranger 2 spacecraft. This spacecraft is the first in a

743. (Cont'd)

series designed for the scientific investigation of the Moon, the planets, and interplanetary space. Ranger 1 and Ranger 2 will carry a family of radiation detectors designed to monitor the intensity of charged-particle radiation. A magnetometer will also be carried to determine the interplanetary magnetic field and its relation to particle flux. Other experiments include a telescope sensitive to Lyman-alpha radiation, a cosmic-dust detector, and scintillation counters to investigate the statistics of solar X-rays.

744. Koener, T.W. and Paulson, J.J.

NUCLEAR ELECTRIC POWER FOR SPACE MISSIONS.

Jet Propulsion Laboratory, California

Institute of Technology, Pasadena. Rept.

no. TR 34-230, 5 Jan 61.

The first portion of this paper covers present planning concerning spacecraft secondary power requirements for planetary, interplanetary and lunar exploration. This planning and study is relatively independent of the means of getting the spacecraft to its destination, although electric propulsion must be included for planning purposes. From the power requirements shown and the desired weights, the need of a nuclear power source is clearly indicated. The second portion of the paper covers the use of electric propulsion for the final phases of propulsion to place the spacecraft at its destination. It is shown that the use of electric propulsion results in more than just an improvement. In certain missions, the need for electric propulsion is definite in that presently existing information shows it to be the only system capable of properly achieving the goals. Applying the same principles covered in the first portion of the paper on power and weight, it is evident that nuclear power is required.

745. Lockheed Missiles and Space Division

PROPOSAL FOR A SCIENTIFIC-EXPERIMENT

PROGRAMMER FOR SOFT-LANDING LUNAR

VEHICLES. Rept. no. LMSD 702156,

18 Nov 60.

This proposal describes a programmer designed to control a series of experiments for investigating the surface and sub-surface characteristics of a specific area on the moon.

746. Lunar probe avionics.

AVIATION WEEK v. 69, n. 26, p. 39,

1958.

A transmitter used in Air Force Pioneer I lunar probe intended to transmit back television picture of moon surface. Weighs only $2\frac{1}{2}$ ounces, yet can deliver 50-watts output. Built by Naval Ordnance Test Station engineers. The crystals stabilized transmitter has tank coil around output tube.

747. McGuire, F.G.

Weight of surveyor payload to be doubled.

MISSILES AND ROCKETS v. 8, n. 8, p. 40-41,

1961.

Payload weight of the Surveyor lunar vehicle is being doubled. Nuclear power supplies for the program are now being considered for the first launch in spring of 1963.

748. Malling, L.R.

960-MC lunar transmitter. ASTRONAUTICS

v. 4, n. 5, p. 29-31, 104-105, 1959.

Rocket launched space experiments involve communication links that must operate in initial take-off and powered flight phase and free-flight or coasting phase; use of Microlock technique and design of highly efficient u-h-f (1000-mc) transmitters that will meet specialized requirements of space research vehicles; transmitter block diagram and performance; efficiency and r-f output of three sub-units comprising transmitter tabulated.

749. Moon "sampler" prototype readied.

MISSILES & ROCKETS v. 9, n. 6, p. 32-33,

1961.

Description of a lunar gas chromatograph developed by Aerojet-General Corp. The device, which is designed to be carried by the Surveyor lunar landing craft, will provide information on the composition of nonmineral materials in the lunar surface. Its primary purpose is to determine if terrestrial-type life exists or has existed on the moon.

750. Moose, moth, moon: Complete article.

MISSILES & SPACE v. 7, n. 8, p. 6,

1961.

A remote controlled miniature (8" x 8" x 10") chemistry laboratory geared to detect organic chemicals, such as amino acids, is scheduled for 1963 Surveyor landing on moon in search for evidence of life in space. Samples of lunar soil will be finely ground and heated in a sealed oven. Gases given off will be analyzed in "super sniffer" whose versatility and sensitivity is compared to the nose of the moose and a species of moth with the most delicate sense of smell known to science.

751. Photographs of the Moon's hidden side from

Lunik III. CURRENT SCIENCE v. 28, n. 11,

p. 433-434, 1959.

The first pictures of the hidden side of the Moon taken by the Russian Automatic Interplanetary Station and transmitted to earth were released for publication on October 26, 1959. The photographs were taken with a two-unit camera, each unit of which had a different optical system enabling simultaneous pictures to be taken on two different scenes. The present paper discusses the photographic apparatus, techniques and the timing of the photograph. A reproduction of the picture showing the hidden side of the Moon is also printed. It is now possible to piece together the hitherto unseen lunar objects and those already known, and thereby to determine their selenographic coordinates.

752. Pravda describes space vehicle instrument

package. PRODUCT ENGINEERING v. 30, n. 4,

p. 21-24, 1959.

A lengthy communique in Pravda has described flight, orbit, tracking and instrument package of the Soviet space vehicle launched January 2, 1959, and now orbiting the sun.

753. Rackham, T.W.

Rocket on the moon. SPACEFLIGHT v. 2,

753. (Cont'd)

n. 1, p. 3-6, 1959.

Discussion covering the difficulties of detecting the arrival of a rocket on the moon, as well as possible detection methods.

754. Renzetti, N.A. and Ostermier, B.J.

COMMUNICATIONS WITH LUNAR PROBES.

Jet Propulsion Laboratory, California

Institute of Technology, Pasadena.

Rept. no. TR 32-148, 23 Aug 61.

The tracking and communication capabilities of the Deep Space Instrumentation Facility (DSIF)--a precision system capable of command, telemetering, and positional tracking of space probes for scientific investigations at lunar distances and beyond-briefly described. The DSIF consists of a mobile station and three deep-space stations in California, Australia, and South Africa. The purpose of the Ranger project, the spacecraft, the communications equipment aboard the spacecraft, and the participation of the DSIF in this project are discussed.

755. Rutledge, C.K., et al

PRECISE LONG RANGE RADAR DISTANCE MEASURING

TECHNIQUES. Convair-Astronautics, Rept. no.

AE61-0061, RADC TR 61-70, 13 Feb 61, lv.

(Contract AF 30(602)-2196) ASTIA AD-255 820

An analytical investigation of 200- to 3,000 nautical mile baseline radio tracking systems was conducted. The evaluation considered use of the systems in tracking and guiding earth satellites and lunar spacecraft.

756. Schrader, C.D., et al

NEUTRON-GAMMA RAY INSTRUMENTATION FOR

LUNAR SURFACE COMPOSITION ANALYSIS.

California, University of, Lawrence

Radiation Lab., Livermore, (Presented

756. (Cont'd)

at the National IAS/ARS Joint Meeting,

Los Angeles, Calif., June 13-16, 1961)

American Rocket Society, Inc., New York,

N.Y. 61-108-1802.

The neutron-gamma-ray spectrometer consists of two packages: the neturon source and the gamma-ray detector. At the heart of the source package is a miniature nuclear accelerator utilizing the D-T reaction to produce a pulsed beam of 14-Mev neutrons. The neutrons, upon striking the lunar surface, react to produce gamma rays which are characteristic of the elements present. The gamma rays, in turn, impinge on the detector which consists of an NaI (Tl) scintillator and a ruggedized photomultiplier tube. The scintillation pulses are then stored in a multi-channel pulse height analyzer, and the spectrum is telemetered back to Earth.

757. Scull, J.R.

A SYSTEM FOR LUNAR PHOTOGRAPHY AND DATA

TRANSMISSION. Jet Propulsion Lab., Tech.

release no. 34-142, 28 May 60, 26p.

(Contract NASw-6) ASTIA AD-247 440

At the time the first US lunar photographic vehicle was being developed, data from Explorer IV indicated the presence of high-intensity ionizing radiation surrounding the Earth. As a result, an alternate approach was developed, using a slow scan vidicon television camera in conjunction with 2000:1 bandwidth compression by means of a special 650 gm low power tape recorder. The performance of the prototypes along with the engineering philosophy which led to their development is presented in some detail. Special attention is given to the development of methods for generating, storing and transmitting video information over long distances using low power and subaudio bandwidths.

758. Soviets detail Lunik instruments.

AVIATION WEEK v. 70, n. 3, p. 28, 1959.

Instruments for Russia's moon rocket which the Soviets now say passed within 3100 to 3700 miles of the Moon instead of 4660 miles were housed in container consisting of two thin hemispherical aluminum magnesium alloy shells.

759. Space exploration instrument laden payloads to surpass launching vehicle in cost within decade. WESTERN AVIATION v. 40, n. 12, p. 1H-2, 1960.

A discussion of payload experiments and cost for NASA projects Ranger, Surveyor, Mariner, Prospector, and Voyager is presented.

760. Spaulding, S.W. Television and lunar exploration. J. SOC. MOTION PICT. AND TV ENGRS. v. 69, n. 1, p. 39-43, 1960.

Discussion of a system capable of televising from the moon.

761. Steier, H.P. Challenge to industry: Spaceship telemetry. MISSILES & ROCKETS v. 3, n. 2, p. 105-108, 110, 1958.

Feasibility of telemetering of information between earth and unmanned vehicles orbiting about moon; radio frequency link seen as primary difference between today's telemetering schemes and those needed for space flight; presentation of basic design data gathered by H. Scharla-Nielsen which are necessary to examine what happens to space telemetry signals between transmitting antenna and receiver.

762. Steree color TV system may guide moon robot. ELECTRONICS v. 34, n. 41, p. 30-32, 1961.

Robot vehicle for exploration of the moon's surface was demonstrated by Airborne Instruments Laboratory at the American Rocket Society convention held this week in New York City. Among design problems of such vehicles is selection of a tv system to transmit visual data. Sensitivities in the image-orthicon range would be required in lunar areas illuminated by starlight,

762. (Cont'd)

which is dimmer than earthlight. These tubes need protection for general operation on the moon-when they will also be exposed to sunlight and earthlight.

763. Vogelman, J.H.

Propagation and communication problems

in space. INSTITUTE OF RADIO ENGINEERS.

PROCEEDINGS v. 48, n. 4, p. 567-569, 1960.

The problems of propagation and communications arising from landings on the Moon, Venus, or Mars are treated in terms of the characteristics required for the communication system to achieve data transfer between parties on the surface of these bodies and the communications problems arising in the transfer of information from these bodies back to the Earth. Consideration is given to Doppler shift, Faraday rotation, tracking and stabilization of antennas, and ground network requirements. The problems of communications between vehicles in space in terms of signal acquisition and antenna orientation and tracking are described.

8. Launchings and Lunar Landings

Under this heading are grouped references to the literature concerned with selection and development of launch sites; ground support equipment; launchings; lunar launch sites and escape velocities; and lunar landings and landing site

764. Air Force Missile Test Center, Patrick Air Force Base, Fla. ATLANTIC MISSILE RANGE TEST ACTIVITY REPORT (U). Rept. no. MT 60-3319, Mar 60, 59p. ASTIA AD-316 396 SECRET REPORT S

Not releasable to Foreign Nationals.

Descriptors: Guided missiles*; Surface to surface; Surface to air; Air to surface; Underwater to surface; Satellite vehicles*; Space probes*; Lunar probes*; Flight testing.

765. Alexander, G. Cape Canaveral to expand for lunar task. AVIATION WEEK AND SPACE TECHNOLOGY v. 75, n. 5, p. 28, 1961.

766. Balsa shell will cushion moon capsule's landing. MACHINE DESIGN v. 33, n. 21, p. 6, 1961.

When the Ranger spacecraft streaks nearly a quarter of a million miles to the moon next year, it will end the trip by impacting a small ball-shaped capsule on the lunar surface. The sphere will automatically set up shop and radio lunar-structure data back to earth. The capsule, designed by Aeronutronic Div., Ford Motor Co., will contain a seismometer to record moon quakes, temperature-recording devices, and numerous other instruments. At a distance of 20-25 miles above the moon, it will be detached from the Ranger spacecraft and a retro-rocket will slow it to less than 150 mph prior to impact. Ranger will continue traveling at 5000 mph into the surface. Measuring 25 in. OD, the outer shell consists of a thick layer of balsa wood. Inside this covering is a 12-in. survival sphere that contains instruments.

766. (Cont'd)

The inside sphere is surrounded by a flotation fluid that will help distribute impact loading. The fluid also allows the sphere to right itself in a vertical position in response to the moon's gravity. Once it lands, the lunar sphere will gather and transmit messages for several months, even though temperatures on the moon will vary from -250°F at night to 220°F in the day.

767. Beller, W.

Armour study indicates maria may be best bet for lunar landings. MISSILES AND ROCKETS v. 8, n. 25, p. 34-35, 1961.

Bare rock of craters or deep dust of moon's lowlands could be alternatives; volcano slopes, crater floors or mountain-girt plains ruled out by loose dust hazard.

768. Beller, W.

Russian map shows moon's far side may be best for landing. MISSILES AND ROCKETS v. 8, n. 21, p. 40-41, 1961.

769. Cape expansion to cost $500 million. MISSILES AND ROCKETS v. 9, n. 10, p. 15, 44, 1961.

NASA expects to spend well over $500 million on the just-ordered expansion of Cape Canaveral as a launch site for moon expeditions. Biggest construction items at the beefed-up facility will be six new launch pads--three for Saturn C-3 and three for the Nova booster, a control and assembly building for the Saturn C-3, a blockhouse-type building for Nova, a complete cryogenic facility for manufacturing and storing liquid propellants, a building to assemble and check out the Apollo spacecraft, special facilities for dynamic testing, and a bio-medical building to house moon expedition crews. In addition, there will be a whole host of minor support buildings. Construction and preparation of sites will begin this spring with perhaps the heaviest expenditure of funds to come in Fiscal 1963. All of the construction will be completed and ready for use by 1966. Some $60 million of the half-billion-dollar layout will go to purchase of land.

770. Chincarini, L.

Regions of the Moon adduced to be more suited to the descent of space-ships. ASTRONAUTICA v. 6, n. 1, p. 26-28, 1958. (In Italian)

771. Cleaver, A.V.

Calculation of take-off mass. BRIT. INTERPLANETARY SOC.-J v. 9, n. 1, p. 5-13, 1950.

Theoretical mathematical discussion using for illustration, case of "Earth-Moon-Return to Earth" voyage, with landing at lunar destination.

772. Curchack, H.D. and Van Der Linden, R.E.

BALLOON FOR SOFT IMPACT LANDING. Diamond Ordnance Fuze Labs., Washington, D.C. DOFL rept. no. TR-863, 29 Aug 60, 26p. (Proj. no. TN3-9101) ASTIA AD-243 693

The top of a balloon striking a flat rigid surface would be cushioned by the gas within the balloon, and the feasibility of using this effect to cushion a load in high-velocity impacts was investigated. A one-dimensional analysis of the impact was made assuming that the balloon is of moderate dimensions (from 3 to 30 ft in diameter), that the impact velocity is either the moon escape velocity or 500 fps, and that the only force decelerating the top of the balloon is supplied by gas within it. Results indicate the system is not feasible for impact velocities as high as the moon escape velocity, but that the system may be feasible if the impact velocity is reduced through use of retrograde rockets to about 500 fps.

773. Denison, F.

The Ranger lunar capsule. ASTRONAUTICS

v. 6, n. 9, p. 32, 1961.

What looks like a beach toy will deliver a sterile seismometer and related equipment to the moon's surface to open a new phase in lunar exploration and probing of the solar system's secrets. The lunar capsule is a Ranger spacecraft subsystem developed by Aeronutronic, a Div. of Ford Motor Co., under a subcontract from the Jet Propulsion Laboratory. The capsule is carried to that immediate vicinity of the Moon by the Ranger "bus." The distance to the Moon is then automatically measured; and, when a predetermined altitude above the lunar surface is reached, the capsule separates from the bus and brakes itself by means of a retrorocket to allow a survivable landing.

774. Eastman, F.

NASA studies lunar landing projects.

AVIATION WEEK AND SPACE TECHNOLOGY v. 72,

n. 8, p. 31-33, 1960.

Soft lunar-landing systems for Atlas-Centaur and Saturn boosters and gas cushion techniques to absorb the impact of instrumented hard landings are under study by the National Aeronautics and Space Administration.

775. Eggers, A.J.

Lunar landing and earth recovery. In

AMER. ASTRONAUTICAL SOC. PROC. N.Y., N.Y.

1958. p. 19.(Papers presented before Western

Regional Meeting 18-19 Aug. 1958, Palo Alto).

Very brief statement on requirements for lunar landing.

776. Esgar, J.B. and Morgan, W.C.

ANALYTICAL STUDY OF SOFT LANDINGS ON

GAS-FILLED BAGS. NASA Technical rept. no.

R75, 1960, 58p.

Procedure is valid for bags of various arbitrary shapes and applicable to planetary or lunar landings for sinking speeds that are small compared to sonic velocity of gas within bag; for landing on earth at speeds consistent with normal parachute descent, merits of four bag shapes were evaluated with and without gas bleed from bags.

777. Gallagher, A.E. and Ingelse, A.O.

Drop tests prove out inflatable lunar

decelerators. SPACE AERONAUTICS, Pt. 1,

v 36, n 5, p. 69 & 71, 1961.

For soft landings on the moon and planets, a pneumatic decelerator system has been developed that provides the stability and shock absorption required for a space payload. A model, scaled to simulate the actual forces of a landing on the moon, has been put through an extensive drop test program.

778. Greenwood, S.W.

Lunar probe launchings. AEROPLANE

& ASTRONAUTICS v. 97, n. 2503, p. 321,

1959.

Paper concentrates on mechanics of problem involved in launching Moon probe and factors affecting selection of favorable times for such launchings; question is examined whether launching of lunar probes can be associated with phases of Moon.

779. Gulf site considered for Nova.

AVIATION WEEK AND SPACE TECHNOLOGY v.

75, n. 5, p. 33, 1961.

A launching site on the Texas gulf coast for Nova and other large boosters is being considered.

780. Hawkes, R.

Hughes unveils lunar landing mockup.

AVIATION WEEK AND SPACE TECHNOLOGY v. 74,

n. 8, p. 70-71, 73, 1961.

The full-scale mockup is Hughes Aircraft Co.'s entry into the Surveyor spacecraft competition. The 11-ft. Surveyor will soft land about 750 lb. on the moon; about 30% of the payload will consist of instruments and the supporting devices needed to make them work. Launch is tentatively scheduled between 1963-1966.

781. Inflatable paraglides undergo drop-tests

for moon landing. WESTERN AVIATION v. 41,

n. 10, p. 15, 1961.

Tests with towed flex-wing gliders are part of a study which also includes experimental drops of capsules with inflatable paraglides.

782. ITT Laboratories, Ft. Wayne, Ind. C

FIRST QUARTERLY REPORT. ITT-6032, QR-1,

July 59. CONFIDENTIAL REPORT

Subject: Lunar landings. (Not available for abstracting).

783. Landing of lunar vehicles studied.

AVIATION WEEK AND SPACE TECHNOLOGY v.

74, n. 25, p. 62-65, 1961.

This article briefly discusses a report which was prepared for the First International Conference on the Mechanics of Soil-Vehicle Systems, in Turin,

783. (Cont'd)

Italy. The problems of lunar and planetary landings are given.

784. Lang, H.A.

LUNAR INSTRUMENT CARRIER - LANDING FACTORS.

Rand Corp. Rept. no. RM-1725, 4 June 56,

36p. ASTIA AD-112 403

One of a series on a possible rocket to the moon. This report considers the problems of landing the instrument package portion of the rocket on the moon's surface in good operating condition. This will require that the instrument package come to rest in an upright position so that its aerial can function properly. Factors governing successful landing are: nature and crushing strength of the surface, and the weight, velocity, shape, strength, and angle of impact of the instrument package. This report emphasizes landing situations for a vehicle decelerated by a braking rocket prior to impact. A penetration spike on the forward point of the instrument package can be used to increase the prospects for a successful landing. Unconventional landing possibilities are briefly considered.

785. Lieske, H.A. S

LUNAR INSTRUMENT CARRIER-LAUNCH TIME

TOLERANCE (U). Rand Corp., Research

Memo RM-1994, 4 Oct 57, 29p. (Contract

AF 33(038)-6413) ASTIA AD-144 304 SECRET REPORT

An investigation is made of the allowable tolerances on the instant-of-launch of the lunar instrument carrier. To determine the launch-time tolerance, one method used assumes the ascent trajectory program (path angle versus powered flight time) to be continuously reprogrammed as a function of launch time and results in trajectories for which the approach velocity is normal to the surface of the moon. Another method considered assumes a fixed ascent trajectory program and leads to hits which are distributed over the visible face of the moon. (Unclassified Abstract)

786. London, H.S.

Comments on "anisotropy of escape velocity from the moon". THE JOURNAL OF THE ASTRONAUTICAL SCIENCES v. 8, n. 1, p. 28, 1961.

Calculations based on Jacobi's integral of the restricted three-body problem lead to the conclusion that an anisotropy of not more than one-sixth of one percent exists between the near and far sides of the Moon.

787. "Lunar probe."

FORTUNE v. 47, n. 5, p. 153-156, 1958.

Photographs show just what the terrain is going to look like to the first men who come in for a landing on the moon.

788. Martin, E.D. and Howe, J.T.

ANALYSIS OF IMPACT MOTION OF INFLATED SPHERE LANDING VEHICLE. NASA Technical Note D-314, Apr 60, 45p.

Analysis of technique based on use of inflated sphere to absorb shock for achieving soft landing of instrument packages on surface of moon, planets, or other bodies in space; requirements and capabilities of system and curves describing motion are obtained from analysis.

789. Rinehart, J.S.

Stresses associated with lunar landings.

BRITISH INTERPLANETARY SOCIETY. JOURNAL v. 17, n. 12, p. 431-436, 1960.

Qualitative and quantitative study of the probable stresses which would be developed during lunar impact landings. For landings against rocks in the velocity range from a few hundred feet per sec. to a few thousand feet per sec., the stress is proportional to the first power of the impact velocity, with its magnitude depending upon the paticular rock struck and increasing approximately linearly with shear strength and with specific acoustic resistance, but ranging roughly from 6,000 lb./in^2 at 100 ft./sec. to 2,000,000

789. (Cont'd)

lb./-in^2 at 6,000 ft./sec. In landings against loose soils, the stress, much lower than for rock impacts, is substantially independent of velocity at low velocities, but begins to depend strongly on the square of the velocity as the velocity is increased. The excursions of a 10,000-lb. vehicle into rock and soil surfaces are compared.

790. Stehling, K.R.

Lunar landing problems.

AIRCR. ENGRG. v. 32, n. 382, p. 368.

Brief considerations of problems.

791. Tross, C.

Lunar landing sites selection. ARS

JOURNAL v. 31, p. 1153-1155, 1961.

Brief discussion of the selection of lunar landing sites. It is concluded that normal trajectories will serve for early probes such as Ranger and Surveyer. For later missions requiring a return voyage, landing site requirements should be probably re-examined in order to locate one site suitable for both landing and take-off and which simultaneously would minimize trajectory sensitivity.

792. von Tiesenhausen, G.

Saturn ground support and operations.

ASTRONAUTICS v. 5, n. 12, p. 30-33, 78,

80, 82, 1960.

Logistical support of launching of lunar mission Saturn space vehicles from Atlantic Missile Range (AMR) will present major transportation problems; transportation of booster, second and third stages, eventually fourth stage, and payload; part of booster final assembly jig is used to make up transporter assembly; docking operations; launch site and launcher design; liquid-oxygen storage and transfer system; launch site and booster recovery operations.

793. Weber, R.J., Pauson, W.M. and Burley, R.R.

LUNAR TRAJECTORIES. U.S. National

Aeronautics and Space Administration.

Rept. no. TN D-866, Aug 61, 67p.

Compilation of coasting paths between the earth and the moon, accounting for three-dimensional factors but neglecting multibody effects. Flight times, velocity increments, and launch azimuths are given for various positions of the moon and various injection points in the northern hemisphere. The distance covered during powered flight is found to have an important effect on the mission energy requirements. The effect of flight-path angle at burnout is studied, and it is found that nonhorizontal burnout is often advantageous. The effect of launching from an earth orbit, rather than directly from the surface, is discussed. Because precession may cause an unfavorable orientation of the orbital plane; departure from a permanent space station is usually undesirable. The velocity increment necessary to accomplish lunar landings or take-offs is computed as a function of the thrust-weight ratio and of the desired landing location.

794. Weber, R.J. and Pauson, W.M.

SOME THRUST AND TRAJECTORY CONSIDERATIONS

FOR LUNAR LANDINGS. NASA Technical Note no.

D-134, Nov 59, 27p.

Proposed method for accomplishing soft landings on moon is first to establish circumlunar orbit and then to transfer to lowest acceptable altitude by minimum-energy elliptical path; characteristic velocity increment for typical landing (starting from orbit) is 6880 fps; effects of trajectory errors and thrust level.

795. Wilkins, H.P.

Where to land on the moon. BRITISH

INTERPLANETARY SOCIETY. JOURNAL v. 13, n.

2, p. 65-67, 1954.

Charting of possible landing sites.

796. Apollo: giant equipment, problems.

MISSILES AND ROCKETS v. 9, n. 12, p. 18-19, 68, 1961.

Manned space-flight effort introduces entirely new parameters in transportation, assembly and checkout.

797. The Apollo project

THE AEROPLANE & ASTRONAUTICS v. 100, p. 746, 747, 1961.

Discussion of the Apollo program for an earth-orbiting space laboratory, a circumlunar spacecraft, and a lunar landing vehicle. Particular attention is given to the lunar landing vehicle and to the booster which will be used.

798. Barnes, T.G., Finkelman, E.M. and Barazotti, A.L.

Radiation shielding of a lunar spacecraft.

ASTRONAUTICAL SCIENCES REVIEW v. 3, p. 11-18, 1961.

Review of current knowledge of the particle radiation which exists above the earth's atmosphere and which can be both biologically hazardous and damaging to sensitive spacecraft equipment. Implications for unmanned and manned cislunar flight are discussed from the point of view of the spacecraft designer. Consideration is given to galactic cosmic rays, solar protons, and both protons and electrons trapped in the earth's magnetic field. The main source of radiation damage, it is believed, is solar protons. Approaches to protecting equipment from this damage are noted, and shielding requirements for men are discussed. A possible corridor of flight paths which avoids the region of maximum radiation intensity is considered, and solar flare encounter probability is studied.

799. Boeing Airplane Co., Seattle, Wash. S

STRUCTURAL INVESTIGATIONS EARTH-MOON TRANSPORTATION VEHICLES (U).

799. (Cont'd)

Document no. D7-2568. Final rept.,

30 Sep 59, 230p. (Contract AF 18(600)1824).

ASTIA AD-314 968L. SECRET REPORT

Notice: All requests require approval of Air Force Ballistic Missile Div., P. O. Box 262, Inglewood, Calif. Attn: WDSOT.
DESCRIPTORS: Instrumentation; Structures*; Spaceships; Space flight; Theory; Design.

800. Campbell, J.W.

Rocket flight to moon. LONDON, EDINBURGH

AND DUBLIN PHILOSOPHICAL MAG. AND J. OF

SCIENCE v. 31, n. 204, p. 24-34, 1941.

Consideration of two possible systems: The observer may fly in rocket, or fly in capsule from which are fired controlling rockets.

801. The case for manned lunar flight. MISSILES

AND ROCKETS v. 5, n. 36, p. 24-25, 1959.

NASA officials, speaking for themselves, argue that man can accomplish more than instruments and outline plans for flight direct to moon.

802. Clark, E.

USSR moon robot shot tests foreseen.

AVIATION WEEK AND SPACE TECHNOLOGY v. 72,

n. 3, p. 28-29, 1960.

Test firings of "more powerful" Soviet space rockets into the central Pacific Ocean this year are believed to be aimed at proving a vehicle that would put robot tank "laboratories" on the moon and launch the first Russian into space.

803. Cole, D.M. and Muir, D.E.

Around the moon in 80 hours. 30p.

In AMER. ASTRONAUTICAL SOC. PROC. N.Y.

p. 27-1-25, 1958. (Papers presented before

Western Regional Meeting 18-19 Aug 58,

Palo Alto).

Conceptual design of a manned circumlunar vehicle for the early 1960's is presented showing how early availability and low cost can be achieved by making maximum use of ICBM hardware and facilities. Results of orbit, space medicine, and reentry studies critical to the circumlunar flight are included.

804. Cooper, R.S.

Nuclear powered lunar rockets. AMERICAN

NUCLEAR SOCIETY, TRANSACTIONS OF THE v. 4,

n. 1, p. 163-164, 1961.

The usefulness of nuclear rocket propulsion for a manned lunar expedition is evaluated.

805. Delsemme, A.H.

Will we reach the Moon by 1970? CIEL ET

TERRE v. 68, p. 137-144, 1952. (In French)

General discussion of the problems.

806. Earth to moon in 80 hours? MISSILES AND

ROCKETS v. 4, n. 9, p. 13, 1958.

It was concluded by D. M. Cole and D. E. Muir of The Martin Company's Denver Division, in a paper presented at the American Astronautical Society meeting held recently in Palo Alto, Calif., that a manned vehicle will make the trip around the moon in 80 hours possibly as early as 1963.

807. Ehricke, K.A.

Manned orbital and lunar space vehicles.

Benson, O.O. and Strughold, H., eds. In

PHYSICS AND MEDICINE OF THE ATMOSPHERE

AND SPACE. N.Y., Wiley, p. 294-338, 1960.

808. Equipping man for a flight to the moon.

ENGINEERING v. 188, p. 634-635, 1960.

809. Farnsworth, R.L.

Rocket to moon. AM. HELICOPTER v. 2, n. 4,

p. 19, 41, 1946.

Presentation of technical and other problems involved in going to the moon.

810. Fielder, G.

Conditions on the Moon with which the first

landing crew will contend. SPACEFLIGHT v. 1,

p. 216-219, 1958.

811. Flight to Moon. ASTRONAUTICS v. 3, n. 4,

p. 32-4, 1958.

Pictorial description of Donald FARRELL's week-long simulated space voyage at USAF School of Aviation Medicine.

812. Gardner, T.

We're going to the moon...does the public

know why. AIR FORCE AND SPACE DIGEST

v. 44, n. 8, p. 55, 1961.

The urgency and implications of President Kennedy's call for a national commitment to manned lunar exploration are not fully understood by Americans,

812. (Cont'd)

warns Trevor Gardner, who has earned wide recognition as a prophet and pioneer of the space age. Mr. Gardner puts the question...

813. Gardner analyzes U.S. lunar race plan.

AVIATION WEEK AND SPACE TECHNOLOGY v. 75,

n. 1, p. 52-53, 55-56, 1961.

This analysis of the factors involved in a national effort to land men on the moon before Soviet Russia was presented recently by Trevor Gardner before a joint meeting of the Institute of Aerospace Sciences and the American Rocket Society in Los Angeles. Aviation Week published the complete speech because of the industry's interest in this important new program.

814. Garrigan, T.E.

Lunar flight control display. ASTRONAUTICS

v. 6, n. 6, p. 42, 56-59, 1961.

The possible nature and arrangement of a space engineer's instruments and displays is demonstrated by a full-scale mockup recently designed and constructed at Sperry Gyroscope to illustrate the possible relationship between man and his instruments in future space vehicles.

815. Gatland, K.W., Kunesch, A.M. and Dixon, A.E.

Fabrication of orbital vehicle. BRIT.

INTERPLANETARY SOC - J v. 12, n. 6,

p. 274-85, 1953.

Space vehicle using liquid chemical propellant considered as means of obtaining manned reconnaissance of Moon; methods of assembling vehicle in close satellite orbit from prefabricated parts carried out to base orbit by 500-ton freighter rockets; light jig recommended to facilitate assembly operations in space.

816. Heaton, D.H.

U.S. LUNAR TRAVEL PROGRAM. SAE--Paper S276

for meeting 8 Dec 60 (Metropolitan Sec) 15p.

NASA lunar program has long-range objective of manned landings on lunar surface and establishment of lunar base for scientific observation; three phases of

816. (Cont'd)

program, earth satellite, lunar, and planetary; unmanned lunar program and spacecraft types under development Able 5 and Ranger; Surveyor, designed for lunar soft-landing mission using Centaur launch vehicle, will deposit instruments capable of making direct measurements of chemical and physical properties of lunar crystal material.

817. Himpan, J. and Reichel, R.

Can we fly to moon. AM. J. PHYSICS v. 17,

n. 5, p. 251-63, 1949.

Calculations and designs for 50-ton moon rocket on basis of most advanced information available; conclusion that, with chemical propellants, very low ratio of payload to total weight would require rocket of impractical size and expense to carry one man to moon; discussion of possibilities of nuclear fuel and critical problems of heat dissipation.

818. Hurst, J.H. and Voss, R.G.

MANNED EARTH-LUNAR TRANSPORTATION SYSTEMS.

National Aeronautics and Space Administration.

Geo. C. Marshall Space Flight Center, Huntsville,

Ala. NASA MTP-M-S&M-F-60-4, 28 Nov 60, 17p.

Not available for abstracting.

819. Ley, W.

The shape of ships to come. INTERAVIA v. 5,

n. 10, p. 496-499, 1950.

General plan form of a space ship; suggested propulsive mechanisms; differences between equipment on the ship for a lunar run and for a trip to Mars or Venus; crew oxygen requirements.

820. Lockheed Missiles and Space Division.

PROPOSAL FOR STUDY OF THE FLIGHT CONTROL REQUIREMENTS OF A MANNED LUNAR VEHICLE.

Rept. no. LMSD 49941, 4 Sep 59.

The purpose of the proposed study is to develop concepts, to carry out analyses, and to present a preliminary design of a flight control system for a manned lunar vehicle. The following will be done: Determine the basic vehicle system requirements for manned lunar flight; determine the basic flight control requirements for an unmanned vehicle capable of lunar landing and return to earth; determine the role of a human being for a similar (manned) mission; determine specific problem areas for further detailed analysis.

821. Lunar journey. LANCET, LONDON v. 1, n. 7134, p. 1117-1118, 1960.

This article briefly reviews the physiological problems of orbital and space flight.

822. Man moon landing in 1971 circumlunar trip two years earlier. WESTERN AVIATION MISSILES AND SPACE v. 41, n. 6, p. 4-5, 1961.

The schedule for the lunar exploration program through 1971 is reviewed.

823. Mears, C.M. and Peterson, R.L.

Landing on the moon - safely...softly. SAE JOURNAL p. 92-96, 1961.

The safe landing of a space vehicle on the moon will be the primary task of a lunar soft-landing system. To accomplish this, the system must precisely control the approach energy of the spacecraft, relative to the lunar surface, so that the velocity existing at contact will not cause damage to the instrument payload, the vehicle, or the crew. Such systems, for providing reliable and efficient landing on the moon, are currently under investigation in conjuction with the NASA program for manned lunar expeditions projected for the early 1970 period.

824. Miles, M.

Space trip set, experts told by von Braun.

ASTRONAUTICAL SCIENCES REVIEW v. 1, n. 3,

p. 4-5, 1959.

Man's first ballistic flight into space is already scheduled and he can orbit the moon within six years and land on the lunar surface in ten years, the Army's top space scientist said.

825. Myron, C.E., Nomiyama, F. and Wadleigh, R. S

SPACE TRANSPORT AND RE-ENTRY TESTS (U).

Boeing Airplane Co., Seattle, Wash. Document

no. D2-2979. Final rept. 30 Sep 59, 120p.

(Contract AF 18(600)1824). ASTIA AD-314 965L.

SECRET REPORT

Notice: All requests require approval of Air Force Ballistic Missile Div., P. O. Box 262, Inglewood, Calif. Attn: WDSOT.

826. NASA adds to weight of Apollo lunar spacecraft.

MISSILES AND ROCKETS v. 9, n. 4, p. 13, 1961.

NASA disclosed three important facts about the Apollo Man-to-the-Moon Program last week at a secret NASA-Industry Technical conference: (1) The Apollo spacecraft despite its ballistic shape will have to weigh about 20,000 to 25,000 pounds rather than 15,000 to 20,000 previously anticipated; (2) There appear to be no insurmountable technical obstacles to landing a manned spacecraft on the moon and returning it to earth; (3) NASA still does not have a firm Apollo program in mind nor has any decision apparently been made as to the precise way that NASA will manage the multibillion-dollar drive for the moon.

827. NASA launches studies for moon ship.

MISSILES AND ROCKETS v. 7, n. 14, p. 13,

1960.

Von Braun group to invest several million dollars for industry studies; three main approaches to moon are outlined, (1) the brute force chemical approach, using a Nova-type vehicle of 12 million lbs. takeoff thrust; (2) orbital refueling and rendezvous, by which seven Saturn launches could orbit tanks of fuel to support a three-man mission to the moon and return after a two-week stay; (3) nuclear upper stages, lifted by the basic 1.5- million-lb.-thrust Saturn booster.

828. National Aeronautics and Space Admin.

PROCEEDINGS OF FIRST NATIONAL CONFERENCE

ON THE PEACEFUL USES OF SPACE, TULSA,

OKLAHOMA, MAY 26-27, 1961. 184p.

ASTIA AD-262 055.

Available from Government Printing Office for $1.25. Copies not supplied by ASTIA. DESCRIPTORS: Space flight, Satellite vehicles, Manned, Communications, Astrophysics, Solar systems, Moon, Plasma physics, Space probes, Facsimile transmission, Meteorology.

829. Newell, R.G.

Parking on the moon. INDUSTRIAL AND ENGINEERING

CHEMISTRY v. 53, n. 10, p. 26A, 1961.

Nova booster with 9-million pound thrust could put three men on the moon.

830. Nuclear stage key to moon trips. MISSILES

AND ROCKETS v. 9, n. 10, p. 13, 1961.

A nuclear third stage would give Nova and Saturn boosters the capability of direct flights to the moon--perhaps by NASA's 1967 target date for moon landings.

831. Orbital work can aid moon landing.

MISSILES AND ROCKETS v. 8, n. 22, p. 24,

1961.

Rendezvous and orbital operations can help speed the U.S. manned landing on the moon.

832. O'Rourke, N.W.

LUNAR EXPLORATION SYSTEMS. SAE,

International Congress & Exposition of

Automotive Engineers, 1961, Detroit, Mich.,

9-13 Jan 61. Preprint 302D, 10p.

Discussion of the method of approach and the factors involved in program planning and in the design of a vehicle and systems to be used in manned lunar exploration. The effects of various vehicle and system design decisions and programming decisions are considered in relation to gross take-off weight, cost, effectiveness, safety, and reliability.

833. Partel, G.

Il razzo lunare. RIVISTA AERONAUTICA

p. 819-830, 1958.

Discussion of the basic problems of flight to the Moon, including the design and propulsion of a vehicle, as well as presentation of pertinent data.

834. Peske, A. and Swanlund, G.

Control considerations for a lunar soft

landing. AEROSPACE ENGINEERING v. 20, n. 2,

p. 26, 27, 72-74, 1961.

Discussion of vehicle control during powered lunar descent. Man's capabilities, minimum fuel landing trajectories, the amount of visual information required, and configuration of control equations are some of the major factors considered. The considered mission and the associated trajectory are described. It is assumed that the vehicle is used in conjunction with a permanent base. The

834. (Cont'd)

vehicle - roughly the size of the Nova - is landed at a particular landing site at the base under either manual or automatic control. It is found that fuel expenditure is a major factor in determining the controller. Not only must there be a specific controller configuration corresponding to each landing condition, but also the control variables must be measured very accurately. The consideration of fuel expenditure requires the manual control mode to have the same specific and accurate control variables as the automatic system. Thus, there seems to be little justification in having man in the control loop except in an emergency. Using a man to acquire and track the landing site is a function that better utilizes his capabilities and can obviate the carrying of special automatic equipment in many landing situations. Additional work is anticipated on a theoretical investigation of the optimum controller for a lunar descent. The control configuration for the presented study was obtained by a cut-and-try method using fuel expenditures as the criterion. Investigation of the landing situations is required to define the approach trajectory more closely.

835. Queijo, M.J. and Riley, D.R.

A FIXED-BASE-SIMULATOR STUDY OF THE ABILITY OF A PILOT TO ESTABLISH CLOSE ORBITS AROUND THE MOON. National Aeronautics and Space Administration, Washington, D. C. Rept. no. TN D-917, June 61.

A study was made on a six-degree-of-freedom fixed-base simulator of the ability of a human pilot to modify hyperbolic ballistic trajectories of a space vehicle approaching the Moon so as to establish a circular orbit 50 mi above the lunar surface. The pilot was given control of thrust along the vehicle's longitudinal axis and torques about all three body axes. The results showed that by using a hodograph presentation of rate of descent and circumferential velocity, an altimeter, and vehicle attitude and rate meters, the pilots could consistently establish final altitude and velocity combinations that result in orbits lying within an altitude range of 10 to 90 mi above the lunar surface with a fuel consumption from 1 to 3% of the initial vehicle mass more than that required by the two-impulse Hohmann maneuver.

836. Rising, B.

How Soviets may land man on Moon. AVIATION

WEEK v. 70, n. 19, p. 54-55, 57, 61, 1959.

An assessment of the requirements for a Moon-expedition, with detailed weight-analysis.

837. Rosen, M.W. and Schwenk, F.C.

Nova--a manned lunar rocket. ASTRONAUTICS

v. 4, p. 20-23, 96, 97, 1959.

Discussion of the preliminary design of a two-man 8,000-lb space capsule for prospective use in a direct flight to the moon, landing, and returning to Earth.

838. Rosen, M.W. and Schwenk, F.C.

A ROCKET FOR MANNED LUNAR EXPLORATION.

International Astronautical Congress, 10th.

1959, 14p. Also In AIRCRAFT ENGINEERING v. 31,

n. 370, p. 375, 1959 and IRE TRANSACTIONS ON

SPACE ELECTRONICS AND TELEMETRY v. SET-5,

p. 155-62, 1959.

After comparing direct flight and orbital rendezvous techniques for achieving a manned lunar landing, authors describe the five-stage Nova rocket and its use for direct flight to the Moon. The vehicle would weigh 6,700,000 lb. at take-off and stand about 220 ft. high. The 48-ft, diameter first stage would be powered by six 1,500,000-lb. thrust LOX/kerosene engines; a single engine of this type but modified for high-altitude operation would propel the second stage. The third stage would consist of four 150,000-lb. thrust LOX/liquid hydrogen engines. These first three stages suffice to send a 102,000-lb. payload on its way towards the moon; braking and landing is carried out by firing the fourth stage which has four variable-thrust engines utilizing high-energy propellents. Retractable landing legs are provided, and the payload placed on the Moon would have a mass of 36,000 lb. The crew of two or three men would spend twelve days on the Moon, then use the fifth-stage engine to launch the capsule and return to Earth. The outer surface of the capsule would be covered with ablative material for removal of heat generated

838. (Cont'd)

during atmospheric re-entry. For the outward journey, initial, mid-course and terminal guidance would be by inertial, Earth-based radio, and radar-optical methods respectively, but lunar-based radio beacons could be used to assist landing.

839. Ross, H.E.

Orbital bases. BRIT. INTERPLANETARY SOC-

J v. 8, n. 1, p. 1-19, 1949.

Reduction in overall energy requirements occur if, instead of postulating journey direct to surface of moon and back again, voyage is split up into easy stages and ships refueled in space; rocket drive in one form or another will probably be used; scheme for reaching moon described; manned "spacestation" described; food, air and water requirements of spacestation; illustrations.

840. Schechter, H.B.

Some weight considerations for manned lunar

missions. ARS JOURNAL v. 30, n. 2, p. 195-97,

1960.

The total weight requirements for three possible types of manned, round trip, soft landing lunar missions are investigated, all starting out from a space station circling Earth at an altitude of about 350 miles. The first and second missions follow direct hit flight trajectories and employ chemical and nuclear powerplants, respectively. Thrust magnitudes needed are determined by imposing an initial landing deceleration load factor of 3 Earth g. The third missions makes use of a nuclear powerplant as a sort of "ferry boat" to reach a circular orbit around the moon, whereas for the landing and ascent portions at the moon, the final payload is propelled by chemical rockets. After rendezvous with and attachment to the orbiting ferry boat, the payload is returned to the Earth space station.

841. Shepherd, L.R.

A critical review of "Can we fly to the Moon?

BRITISH INTERPLANETARY SOCIETY. JOURNAL v. 8,

n. 5, p. 197-199, 1949.

J. Himpan and R. Reichel (AMERICAN JOURNAL OF PHYSICS v. 17, p. 251-263, May 1949) have reviewed the possibility of firing instrument-carrying rockets on

841. (Cont'd)

to the Moon and of building manned rockets capable of making return flights to the Satellite. They conclude that the first project would be possible, but that the cost of developing such rockets would be excessive. As to the manned lunar rocket, they conclude here, as a result of somewhat superficial arguments, that such a vehicle is impossible.....

842. Shoemaker, A.F.

Space viewports: Challenge to glassmakers.

MISSILES & ROCKETS v. 8, p. 40, 41, 1961.

Discussion of the requirements and construction techniques for space viewports. Three projects are considered: B-70, Dyna-Soar, and the Mercury capsule. In the latter vehicle, the composition of the glass, arrangement of the four panels, testing program, and the coatings used on the panels are described.

843. Slye, R.E.

VELOCITY REQUIREMENTS FOR ABORT FROM THE BOOST TRAJECTORY OF A MANNED LUNAR MISSION. U.S. National Aeronautics and Space Administration.

Rept. no. TN D-1038, July 61, 41p.

An investigation is made of the abort velocity requirements associated with failure of a propulsion system for a manned lunar mission. Two abort problems are considered. The first is the abort at less than satellite speed which results in decelerations in the following entry. The second is the abort at greater than satellite speed with immediate return to earth.

844. Stehling, K.R.

Getting to the moon. SPACE/AERONAUTICS v. 35, n. 1, p. 51-53, 1961.

Discussion of the problems of propulsion, control, and crew environmental systems, which have to be met in landing a vehicle on the moon. Rendezvous techniques and attitude control techniques, including auxiliary engines for course corrections, are considered; and requirements for an environmental system insuring the survival of the crew are noted.

845. Still, E.W.

HIGH ALTITUDE CHAMBERS AND PRESSURE SUITS AND THEIR PART IN MANNED FLIGHT TO THE MOON. British Interplanetary Society. Lecture, Westminster, 28 Apr 60. Paper. 40p. Also In JOURNAL OF THE BRITISH INTERPLANETARY SOCIETY v. 17, n. 8, p. 239-74, 1960.

Study of environmental system engineering to sustain man during all phases of a journey to the Moon and back. A review of current and projected man-bearing vehicles is made; information from these projects is then used to estimate parameters such as size of cabin, number of crew, duration of flight, and possible heat loads for all stages of such a journey. The environmental requirements necessary to sustain life, together with a statement of assumptions in respect to the flight phases concerned, are given. A detailed description is made of the environmental engineering systems for a small Earth-to-orbit vehicle, a large space station, and a lunar suit. In addition, mention is made of some possible emergencies and their countermeasures. The conclusion is reached that a manned trip to the Moon presents no insuperable extension of existing knowledge, but if voyages are projected to Mars or other planets, this will require considerable development of closed-circuit ecology.

846. Three men on the moon.

MACHINE DESIGN v. 33, n. 21, p. 24-6, 1961.

A brief description of the Project Apollo with objectives and general plans concerning booster development and spacecraft design.

847. Violette, F., Boiteau, H. and Bernard, S.

STUDY OF THE POSSIBILITIES OF SURVIVAL DURING THE COURSE OF A CIRCUM-LUNAR VOYAGE. International Congress of Rockets and Satellites, 2nd. Paris, 1959. Paper VIII-3. (In French)

848. Wong, T.J. and Slye, R.E.

THE EFFECT OF LIFT ON ENTRY CORRIDOR DEPTH AND GUIDANCE REQUIREMENTS FOR THE RETURN LUNAR FLIGHT. National Aeronautics and Space Administration, Washington, D. C. Rept. no. TR R-80, 1961, 17p.

Corridors for manned vehicles are defined consistent with requi avoiding radiation exposure and for limiting values of peak dec Use of lift increases the depth of the entry corridor. Midcour requirements appear to be critical only for the flight-path ang the energy of the transfer orbit increases the required guidanc the flight-path angle. Corrective thrust applied essentially p local horizontal produces the maximum change in perigee altitu increment of velocity. Energy required to effect a given chang altitude varies inversely with range measured from the center o

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