NASA PATTERN

RELEVANCE GUIDE

VOL. II: CONCEPTS

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PATTERN RELEVANCE TREE

- NATIONAL OBJECTIVES IN SPACE
- PURPOSE OF ENDEAVOR
- TARGET OF ENDEAVOR
- FIELDS OF INTEREST
- CONCEPTS
- SYSTEMS
- SUBSYSTEMS
- FUNCTIONAL ELEMENTS
- SUBSYSTEM ALTERNATE CONFIGURATIONS
- TECHNOLOGY DEFICIENCY

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NASA PATTERN

RELEVANCE GUIDE

VOLUME II

CONCEPTS

Prepared by R. Laurence Day

Approved by William C. Sproull

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This document has been prepared as a part of NASA Contract NAS 8-20207 and is intended to contain summary information to be used in assigning relevance to elements on the PATTERN relevance tree, levels five through ten. The elements of these levels of the tree are provided in the body of this document.

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RELEVANCE GUIDE

VOLUME II: CONCEPTS

Section 1

INTRODUCTION

Volume II of the Relevance Guide presents forty-six space mission concepts developed in skeletal form to indicate clearly and explicitly the elements of the concept. A concept description is included for each, composed of a brief statement of mission objectives, a general description of the concept, including some operational considerations, a list of systems comprising the concept, references, and a trajectory description. Certain systems (designated by an asterisk on the concept description) are described in detail, with a brief description of the system and a decomposition of the system to its subsystem, subsystem requirements, functional elements, alternative configurations, and corresponding technological deficiencies.

Completeness of the system descriptions and decomposition has been sacrificed in this presentation to provide a comprehensive concept overview in the time and space available. Considerable effort has been expended to produce a clear exposition of the nature of the concept, but an expert in any field will recognize the limited scope of the presentation of a particular subsystem, element, or configuration. For this we apologize, but not too strongly, as we feel the present structure provides a basic description of the concept which can be augmented by further work by experts in the various fields represented.

This volume represents the combined effort of a large number of contributors within Honeywell, primarily from the Military and Space Sciences Department, Washington, D. C., the Systems and Research Division, Minneapolis, Minnesota, and Aero-Florida Division, St. Petersburg, Florida. It is impossible to acknowledge here all of the contributions, but the major contributors to this present work were:

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W. C. Sproull	M&SSD

Section 2

CONCEPT SCOPE

Volume II of the Relevance Guide describes the concepts comprising the "how" portion of the PATTERN tree as contrasted to Volume I which provides the "why" portion. "How" and "why" here refer to the objectives of the US Space Program. Each concept is configured to accomplish a set of stated objectives and is composed of a number of major systems deemed necessary to accomplish those objectives.

One primary groundrule used in configuring the concepts was to utilize Apollo technology wherever possible and to assume the Apollo state-of-the-art as the technology base for estimating deficiencies. This latter assumption caused some difficulty in determining technological deficiencies (TD's) since it was necessary to extrapolate TD's from a future technology base rather than today's. Also, the manned interplanetary missions were configured using Saturn V as the earth launch booster, necessitating earth orbital assembly of a large number of modules in some cases. If the Apollo technology base were not specified, a larger earth orbital booster would have been specified for many of these as a more desirable solution to the launch of these missions.

Tree Description

The NASA/PATTERN tree contains ten levels, the first four of which are described in Volume I and the remaining six in Volume II. The tree is a morphological decomposition of a set of potential goals and concepts of the US Space Program specifically designed to permit the assignment of relevance numbers to all elements of the complex (branches of the tree). These relevance numbers are assigned using PATTERN methodology by qualified experts in appropriate fields.

The relationship between the concepts described in Volume II and the Fields of Interest developed in Volume I is presented explicitly in Figure II-1. The development of the first three levels of the tree is indicated across the top of the figure, i.e., 1. the Purpose of Endeavor, 2. the Target of Endeavor, and 3. the Fields of Interest. Arrayed against the Fields of Interest are all of the concepts, grouped as described below. Each X in this array indicates potential contribution by that concept in satisfying the goals of the particular field of interest.

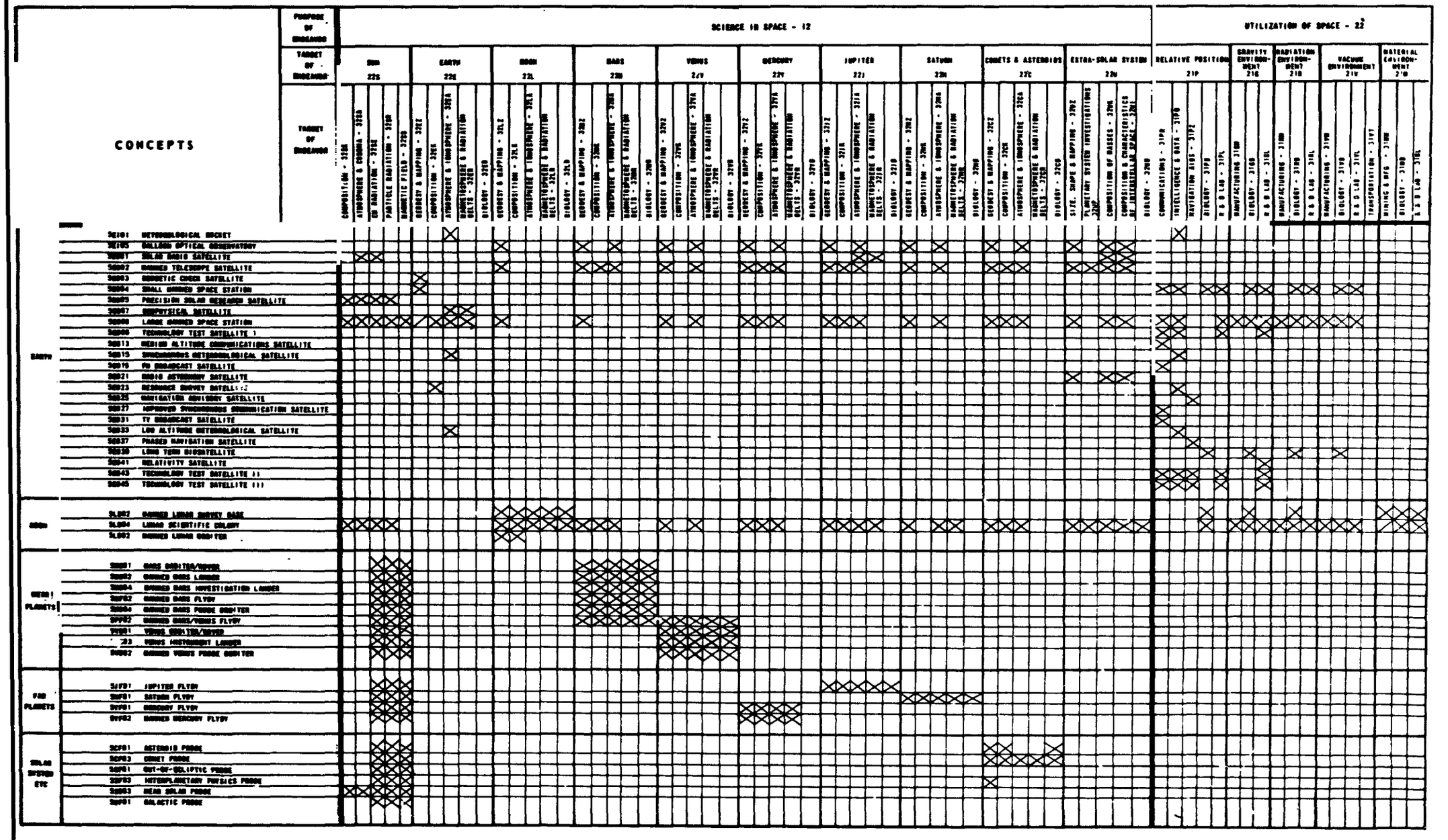

FIGURE II-1. CONCEPT RELATIONSHIP

This information was utilized in developing one set of ballots for relevance voting, namely the Level 3 to 5 vote which established the overall relevance of the various concepts in the NASA/PATTERN ranking.

Concept Grouping

The concepts are organized into groups determined by the primary target of interest or area of the solar system being investigated. Twenty-four concepts are directed at earth investigation or utilization of the space near the earth from earth orbit. These range in scope from an advanced meteorological sounding rocket to a large manned space station.

Three concepts relate to investigation of and utilization of the moon for scientific purposes. These are all manned concepts, building on Apollo technology, and range from precision orbital observation and mapping of the lunar surface to the establishment of a lunar scientific colony for long term investigation of the moon, the solar system, and other astronomical observation.

A group of nine concepts, both manned and unmanned, and ranging from flyby to fairly long term landing missions, are directed at the two nearest planets to the earth, Mars and Venus.

Four concepts are directed at certain planets farther from earth, Mercury inward and Jupiter and Saturn outward relative to the Sun.

In addition, six concepts are postulated as more general in nature, directed at the solar system in general, the space out of the ecliptic plane, comets, asteroids, etc.

Concept Timing

The concept descriptions, timing, and subsequent system decompositions have been based upon a detailed, but not exhaustive examination of the available sources. These included the popular press, technical periodicals, appropriate technical papers, study reports by various contractors, NASA reports, and private communications.

The concepts span the next twenty years of the US Space Program. An approximate operational date or period has been established for each concept, to provide a basis for determination of technological requirements and capabilities of the various subsystems.

The time phasing of the concepts selected for NASA/PATTERN is presented in Figure II-2. This figure displays graphically the scope (in time) of this study, namely through 1985. The solid line indicates a probable operational date or period while a dotted line indicates extended operation or uncertainty in the operational date.

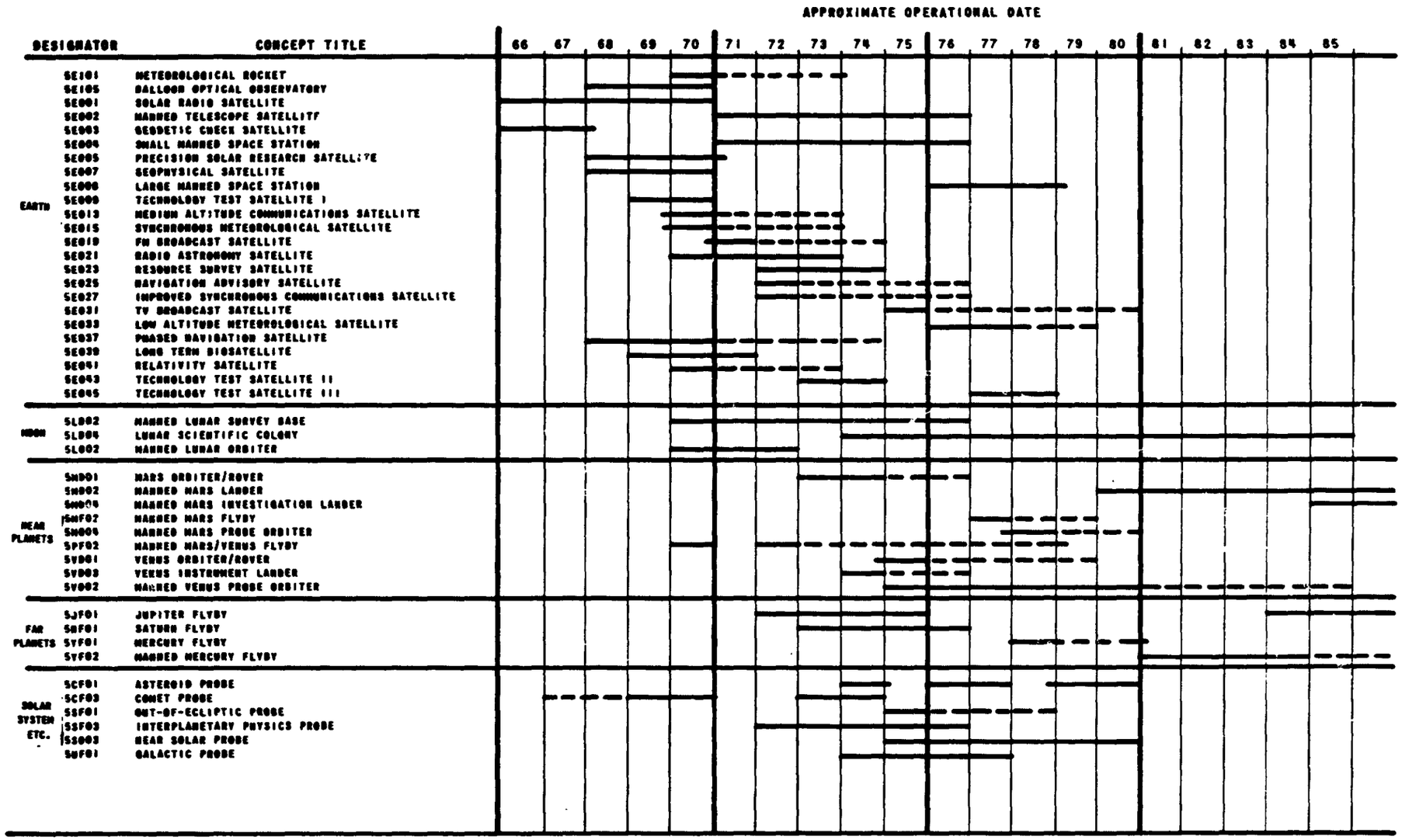

FIGURE II-2. TIME PHASING OF THE CONCEPTS

Section 3

CONCEPT CONSTRUCTION AND IDENTIFICATION

The concepts developed in this volume represent a comprehensive cross-section of the missions anticipated for the US Space Program. The concepts were developed level by level to indicate as clearly as possible within the limited scope of the study, the nature of the mission, requirements of each system and subsystem and the capabilities of hardware to perform as required. The concepts are primarily hardware rather than operationally oriented, due to the desire to spotlight existing technological deficiencies in each element.

Identification

To describe the concept construction adequately, perhaps it is best to consider first the naming and identification of various elements of the structure. The NASA/PATTERN analysis is assisted by the use of a high speed digital computer, and hence the tree, decision nodes, ballots and balloted relevance are designated to facilitate operation with the computer. Each element or node of the tree is assigned a designator or coded name, and in addition certain elements are identified by keywords, which also have associated coded names. Only the concept element designators will be discussed in this section — the keywords are identified in the procedures manual for operating the computer program.

Each element of the concept decomposition is assigned a designator which contains up to ten alphanumeric digits that unambiguously locate the element both as to level of the tree and to specific identity.

The first element in the code is a symbol designating the level of the tree at which the element is located.

The second and third elements are alphabetic letters making up a mnemonic code for the target and the type of mission.

The fourth and fifth elements are decimal numbers identifying specific concepts within a given category. The odd numbers are assigned to unmanned missions and the even numbers to manned missions.

The sixth element is an alphabetic symbol identifying the system under consideration.

The seventh element is another alphabetic symbol indicating the subsystem.

Elements eight, nine and ten are decimal digits designating the functional element, configuration, and technology deficiency respectively.

These are illustrated in Figure II-3.

Level	Element
5	Concept
6	System
7	Subsystem
8	Functional Element
9	Configuration
10	Technology Deficiency

Tree

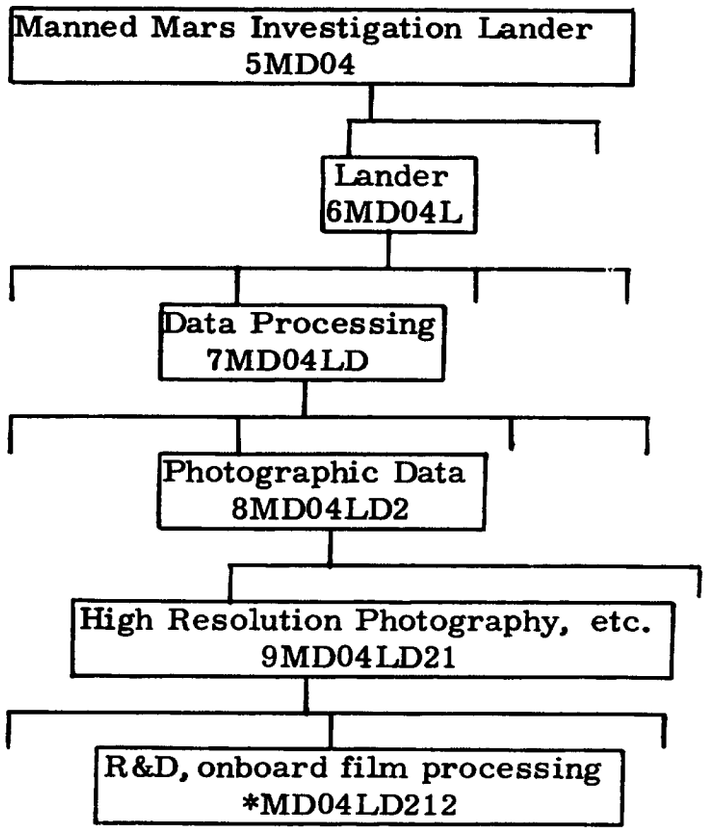

FIGURE II-3. NASA/PATTERN Tree Levels 5 through 10

The complete concept mnemonic code is listed in Table II-1 for reference as desired. An example of the naming of a technology deficiency is presented below with each element identified for clarity:

*M D 04 L D 2 1 2

*	Tenth level of the tree (Technology Deficiency)
M	Mars
D	Descent
04	Manned, identified 04
	Manned Mars Investigation Lander Concept
L	Lander System
D	Data Processing Subsystem
2	Functional Element, Photographic Data
1	Configuration Description
2	Technology Deficiency #2, R&D for onboard film processing

Each concept is developed in a brief concept description and one or more system descriptions.

The concept description consists of the name and designator of the concept (level designator is omitted), a brief summary of the mission objectives, and a general description of the concept including timing, operational considerations, gross size and weight, etc. A list of systems comprising the concept is included, as well as the more pertinent references utilized in developing the concept. The systems to be developed further on system description sheets are marked by an asterisk (*) on the concept description sheet.

The system description sheet is headed by the system designator and the names of the concept and system to be described. A brief paragraph describes the general requirements for the system including physical characteristics, operational problems, size, weight, and other pertinent information.

A list of subsystems and their associated requirements is next postulated. While the space limitation precludes extensive development of the requirements, the primary or critical requirements for each subsystem have been described.

TABLE II-1. CONCEPT MNEMONIC CODE

Level	5	Concept	Level	8	Functional Element
	6	System		9	Configuration
	7	Subsystem		*	Technology Deficiency

Concept 5 a b 01

a's				b's	
C	Asteroids and Comets	S	Sun	D	Descent (landing)
E	Earth	T	Theory	F	Flyby
J	Jupiter	U	Universe	I	Impact
L	Lunar	V	Venus	O	Orbit
M	Mars	X	General (multiple)		
N	Saturn	Y	Mercury		
P	Planet (unspecified)				

System 6 LD06 x

x's	
B	Launch Booster
E	Maintenance Shelter
F	Portable Power Unit
G	Ground Support Facility
J	Upper Stage Booster
K	Cargo
M	Earth Re-entry Module
P	Probe
Q	Fuel Regeneration Unit
R	Rover
S	Spacecraft
T	Transportation
U, V, W, X, Y, Z	Miscellaneous

Subsystem: 7 LD06 A y

y's	
A	Auxiliary Power
D	Data Processing
E	Escape/Recovery
G	Guidance/Navigation
H	Life Support
I	Task Instrumentation
M	Checkout/Maintenance
N	Detection/Discrimination/Tracking
P	Propulsion
R	Communication
S	Vehicle Stability/Control
T	Simulation/Training
V	Vehicle
Y	Display

The functional element level may or may not be used in breaking down the subsystem. Its use depends on the complexity of the subsystem and the need for multiple elements to describe the subsystem.

Each functional element is next broken down to one or more alternative configurations that may be desired, and these are further broken down to anticipated technology deficiencies for the elements of the configuration. Specific elements of the configuration are underlined indicating that they are identified by keywords. Each TD is identified by a coded keyword as well as the element designator code.

For each technology deficiency a block is provided for estimating the status and timing associated with the TD. The timing numbers in the lower boxes indicate a rough estimate of the number of years to remedy the TD, phased as described below.

Box

1 Available - State-of-the-art off-the-shelf hardware available for operational use, including production time.

2 Product Design - Technical problems solved, feasibility demonstrated, development completed, and equipment ready for production design.

3 Advanced Development - Includes all development efforts which have moved into the state of experimental fabrication for testing in realistic operating environment to determine equipment capability to solve a particular operating problem.

Box

4 Exploratory Development (Applied Research) - Includes all development efforts aimed at establishing technically feasible techniques for solving specific operating problems. Bench test and laboratory evaluation of breadboard/circuit-board hardware to determine the technical feasibility of a particular design approach is inherent in this type of effort.

5 Fundamental Research - Includes all effort directed toward increased knowledge of natural phenomena and environment and efforts directed toward the solution of problems in the physical, behavioral, and social sciences.

Timing numbers are placed in each of the lower boxes to represent the years required to move to the next most advanced technology status. An "X" is placed in the upper box that represents the status of each technology deficiency level item in meeting its subsystem requirements.

Example

			X	
1	2	4	3	

- Technology for this subsystem is currently in Exploratory Development status.
- Three years before technology reaches Advanced Development Status.
- Four years required to move from initial Advanced Development status to Product Design status.

- Two years required to move from initial Product Design status to Available.

- One year from Available to initial Operational status (This period includes adaptation, qualification, and checkout).

- Ten years required from present status to operational status.

Subsystem Requirement Level

The same definitions for status and timing described above hold true at the subsystem level. Here, however, the following rules apply:

The status and timing designators indicate the status and timing of the subsystem as paced by the earliest acceptable configuration. This means that where an alternate exists for far out technology deficiencies the shorter development alternate is used to indicate status and timing of the subsystem. The subsystem and timing block have the same designation and numbers as the farthest out technology deficiency in the earliest acceptable configuration.

Branch Termination

For each system being described, all subsystems will be identified and requirements written. However, subsequent levels, i.e., functional elements, or configurations will terminate if they are deemed to be state-of-the-art (SOA). This is done because the primary function of the tree is to develop the technology deficiencies for each element and state-of-the-art elements should not have TD's associated with them.

If a node contains any element which continues to the next level of the tree, all elements at that node will be described, even though they are terminated as SOA. This is to permit comparison of all the elements of the node.

The rules for termination are illustrated in Figure II-4.

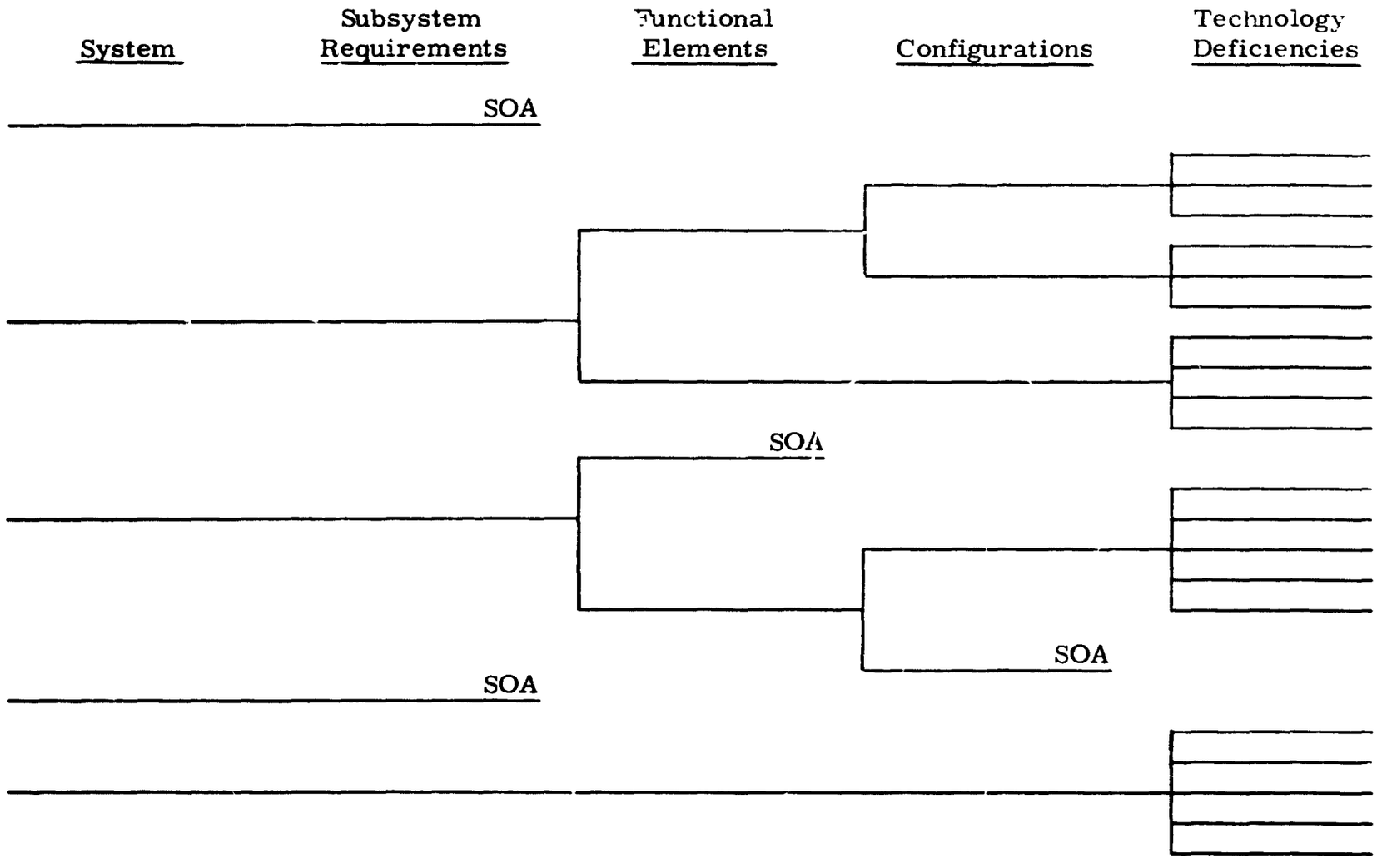

FIGURE II-4. Branch Termination Representation

CONCEPT DESCRIPTION

CONCEPT METEOROLOGICAL ROCKET

DESIGNATOR EI01

MISSION OBJECTIVES Provide an inexpensive atmospheric vertical sounding rocket which extends present capability to altitudes over 70 km and which provides inexpensive routine measurements in populated areas.

GENERAL DESCRIPTION An unmanned mission in which the system must satisfy requirements of range support, research and network, and measurement of all significant meteorological parameters. A 20 lb. payload boosted to 90 km is most desirable. Mission date lies in the 1968-70 and subsequent period.

LIST OF SYSTEMS

B *Booster
G *Ground Support Facility
S *Spacecraft

REFERENCES

1. OSSA Small Meteorological Rocket
2. Chemiluminescent Measurements of Upper Atmosphere Winds, AIAA paper 65-508, 26 July 1965.

*Detailed description follows.

SYSTEM DESCRIPTION

Inexpensive rocket motor or motors with self-destruct or consumable casings for use in populated areas. Should carry approximately 20 lb to 100 km. Initially the developmental program may utilize boosters such as Arcas. Booster should cost less than $2000.

DESIGNATOR EI01 B

CONCEPT METEOROLOGICAL R[illegible]

SYSTEM Booster

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
BP Propulsion (S: x; T: 1 2 2 3)	ΔV 1500 m/sec Payload - 20 lbs. 3σ dispersion < 10 km		BP11 Solid chemical rocket BP12 Storable liquid rocket	BP111 Low cost (S: x; T: 1 2 2) BP112 Self-consuming (S: x; T: 1 2 2 3) BP121 Low cost (S: x; T: 1 2 2) BP122 Self-destruction (S: x; T: 1 2 2 1)
BS Stab/Cont	Spin stabilized	SOA		
BV Vehicle	Structure is motor case. Interface ring with payload.	SOA		

SYSTEM DESCRIPTION

Mobile system for field use would consist of data acquisition equipment and transponding or skintracking radar, raw data storage, data processing and display, re-transmission of reduced data to homebase, homing beacon for auto-homing instrument recovery system.

Portable, easily assembled launcher to provide sufficient guiding and additional thrust so that rocket leaves launcher at high enough velocity to avoid wind canting. Useable from unprepared launch sites and shipboard.

DESIGNATOR EI01 G
CONCEPT METEOROLOGICAL ROCKET
SYSTEM Ground Support Facility

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
GD Data/Proc.	Automatic data reduction RATES Input data rate - 300 bits/sec STORAGE Recoverable ("Permanent")	SOA		
GM Check/Maint.	Prelaunch checkout Performance monitor, report	SOA		
GN D/D/T	Range: 5 m Angle: 0.005°		GN11 3 Tracking Stations with audio and radar trackers	GN111 Low Cost GN112 Portability GN113 Angle Accuracy
GR Comm.	Homing beacon Range: 100 km min.	SOA		

SYSTEM DESCRIPTION

Instruments for ascent probing and/or descent sounding of all significant meteorological parameters with inexpensive nonrecoverable sensors if possible. Payload will include telemetry power supply sequence programmer, controllable parachute with self-destruct capability, transponder, or steerable auto-homing parachute. Change of payload weight and size should not upset aerodynamic stability.

DESIGNATOR EI01S — EI01S
CONCEPT METEOROLOGICAL ROCKET
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S, T)	Cont. Power: 5 watts, 2 hours	SOA		
SI Task/Instr. (x; 1 1 2)	Obtain altitude profile of: Wind velocity Temperature Air density Pressure Humidity		SI11 Dropped chaff Staged grenades with multiple ground directional microphone Temperature sensitive oscillator Speed of sound detector Aneroid pressure sensor Humidistat	SI111 Cost of grenades (x; 1 1 2) SI112 Size & weight of grenades (x; 1 1 2) SI113 Size of met. sensors (x; 1 2 3) SI114 Response time of met. sensors (x; 1 2 3)
SM Check/Maint.	Prelaunch checkout	SOA		
SR Comm. (x; 1 1 1)	Trans. data rate - 300 bits/sec Range - 100 km		SR11 Direct modulation VHF/UHF transmitter	SR111 Low cost (x; 1 1 1) SR112 Standby reliability (x; 1 1 1)
SS Stab./Cont. (x; 1 1 1)	Pointing accuracy: ±10°	SS1 Homing sensor	SS11 Radio direction finder	SS111 Low cost (x; 1 2 1) SS112 Size (x; 1 2 1) SS113 Standby reliability (x; 1 2 1)
		SS2 Parachute capstan	SS21 Electro-mechanical drive	SS211 Low cost (x; 1 1 1) SS212 Weight (x; 1 1 1) SS213 Size (x; 1 1 1)
SV Vehicle	Subsystem integration Instrumentation Communications Atmospheric entry Thermal environment	SOA		

CONCEPT DESCRIPTION

CONCEPT BALLOON OPTICAL OBSERVATORY

DESIGNATOR EI05

MISSION OBJECTIVES Study using a balloon-borne observatory of the gas dynamics of the stars and nebulae, stellar evolution, planetary phenomena such as seasonal variations, and lunar observation from an area nearly free of the earth's atmosphere. Large balloon-borne telescopes and advanced light amplification techniques are employed, with emphasis placed on long duration flights made on a routine basis.

GENERAL DESCRIPTION An unmanned mission in which a telescope of 48-inch aperture or greater, employing advanced light amplification techniques is balloon-carried to 80,000 feet for measurements in the visible UV and IR spectrums. Special emphasis is placed on balloon design to achieve flights of up to 10 days duration. The anticipated telescope/gondola weight is 10,000 lbs. A stability control system similar to Stratoscope II is necessary. This concept is highly competitive on the bases of scientific capability and of cost with satellite astronomical systems. Mission initiation date lies in the 1968-70 period.

LIST OF SYSTEMS

G Ground Support Facility (Stratoscope II)
S *Telescope Gondola/Balloon

REFERENCES

1. Electronic Design, 16 Aug 1965, p. 12

*Detailed description follows.

SYSTEM DESCRIPTION

An unmanned balloon system similar to Stargazer II but using a larger balloon and a telescope of larger aperture (48 or more) and employing advanced light amplification techniques to reduce time necessary to hold the target. This is especially important for stellar research.

DESIGNATOR EI05 S

CONCEPT BALLOON OPTICAL OBSERVATORY

SYSTEM Telescope Gondola Balloon

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
A Aux. Power	Peak power: 1500 watts, 10% duty cycle Continuous power: 300 watts Mission duration: 10 days Note: Guidance and Navigation by ground tracking with transponder aboard gondola.	SOA		H_2-O_2 fuel cells plus AgZn battery SOA	
Task Instr.	Optical, UV, and IR telescopic viewing equipment. Onboard television of star field for tracking and image viewing. Stabilization of telescope with respect to star field: Attitude: 10^{-2} arc sec. Rate: 10^{-3} arc sec/sec. during sighting		SI11	48" telescope with image intensifier and image disector star tracker. Low light level television. Ring shaped inertial mass with electro-mechanical servo telescope torquer.	SI111 R&D required, image intensifier SI112 R&D required, star tracker
Comm.	Transmit data and slow scan TV to ground Receive operational commands from ground Max. Distance - 300 n.m., operating time - 10 hours.			SHF Transmitter for TV data 1450 mc, bandwidth 150 mc HF Transmitter for telemetry 70 channels, ≈ 2 mc, bandwidth of 300 KC with commutation SOA	
Stab./Control	Attitude accuracy (gondola): 0.1 degree continual Attitude rate (gondola): 0.01 deg/sec during sighting Altitude maintenance control system TV used for coarse attitude and control through ground command.		SS11	Electromechanical motor drive against inertial mass for coarse attitude control DC torquer and reed hinges for fine mirror positioning in star tracker loop. Barometric altimeter and tanked H_2 for altitude control	SS111 Cost SS112 Performance
Vehicle	Balloon adequate to lift gondola (10,000 lbs) to 80,000 ft. altitude and hold for 10 days. Gondola similar to Stratoscope II	SOA			

CONCEPT DESCRIPTION

CONCEPT SOLAR RADIO SATELLITE

DESIGNATOR EO01

MISSION OBJECTIVES Observation by earth satellite of both sporadic solar noise bursts below 10 mc's and noise bursts from Jupiter, as well as measurement of the spatial and frequency distribution of cosmic radio noise. This satellite precedes the Radio Astronomy Satellite (EO21).

GENERAL DESCRIPTION An unmanned mission in 6000 km circular earth orbit inclined 50°. The spacecraft weighs about 260 lbs., including 100 lbs. of equipment and antenna. Power is estimated at 40 watts. The mission date lies in the 1966-70 period, as data will be useful in conjunction with manned space flight operations. A life of at least three years is desirable.

LIST OF SYSTEMS

B Booster (Thor/Delta)
G Ground Support Facility (STADAN)
S *Spacecraft

REFERENCES

1. OSSA Radio Astronomy Explorer

*Detailed description follows.

SYSTEM DESCRIPTION

A 260-lb. spacecraft with a pair of diametrically opposed V-antennas approximately 700 ft. long and capable of providing 30° x 30° average beam width at low frequencies and 10° x 10° beam width at high frequencies required for observations required by the concept. Spacecraft lifetime--three years.

DESIGNATOR EO01 -
CONCEPT SOLAR RADIO SATELLITE
SYSTEM Spacecraft

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

SA Aux. Power

Continuous power: 40 watts

SD Data Proc.

Process signals from onboard radio noise sensors and format for transmission to earth-based tracking stations.

Stored data required for later transmission:

Input data rate	10^4 bits/sec
Output comm. rate	10^6 bits/sec
Temporary storage	10^8 bits

SI Task Instr.

Sensing of sporadic radio bursts (below 10 mc) from Sun and Jupiter

High Frequency Bandwidth: 10° x 10°
Low Frequency Bandwidth: 30° x 30°

R Comm.

Data and command link to satellite, to 6000 km orbit.

Communication data rate 10^6 bits/sec

S Stab./Control

Earth referenced stabilization - attitude accuracy ±5°

V Vehicle

Note: Vehicle is a standard SOA structure. Antenna is covered as a communications Technology Deficiency.

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

SA11 Silicon solar cells plus NiCad batteries

- SA111 Abrasion, solar cells
- SA112 Specific power, solar cells
- SA113 Specific cost, solar cells
- SA114 Reliability, NiCad

SD11 Small digital processor, variable speed tape recorder

- SD111 Reliability, tape recorder
- SD112 Weight, tape recorder
- SD113 R&D req'd., tape recorder

SI11 Pair of diametrically opposed 700-ft. V-antennas, reeled metal tape boom.

- SI111 Antenna deployment--unreeling of 700 ft booms.

SR11 UHF Transceiver--solid state Digital data transmission in burst mode operation at 400 mc. Antenna gain nominal (+6 db). Antenna will point at earth during transmission period. FM-tone control system operating at 136 mc (mindirectional antenna on vehicle).

- SR111 Transmitter efficiency
- SR112 Reliability, UHF

SS11 Gravity gradient stabilization

- SS111 Damping, gravity gradient

CONCEPT DESCRIPTION

CONCEPT MANNED TELESCOPE SATELLITE

DESIGNATOR EO02

MISSION OBJECTIVES An earth orbiting satellite for high resolution astronomy of the planets, stars, nebulae, galaxies, and detailed lunar mapping, including both high resolution spectroscopy over the entire spectrum and high resolution photography from ultraviolet to infrared. This should lead to a more detailed description of the composition and structure of the universe and of the origin and nature of the stars. The Manned Telescope is the logical evolution issue of the current Orbiting Astronomical Observatory (OAO) mission. It follows such missions as the Precision Solar Research Satellite (EO05). A goal is a five-year life.

GENERAL DESCRIPTION An auxiliary vehicle for use in conjunction with the Small Manned Space Station (EO04). It will utilize the ability of man to operate and service telescopes in space to provide an order of magnitude greater resolving capability than those presently in use or in development in the unmanned program. The spacecraft circular 30° inclined orbits at 475 km and is physically separate from the space station because of the stabilization and pointing control tolerances required for fine pointing of the telescope. Rendezvous operations are necessary because of separate launchings to establish the telescope satellite. Servicing (film replacement, etc.) will be accomplished by an astronaut from the Small Manned Space Station using a maneuvering unit. Aiming will be accomplished with a TV link; fine pointing will be automatic. The mission date lies in the 1970-1976 period. Better than 1/10 arc second resolution is desired.

LIST OF SYSTEMS

B Launch Booster (Saturn I-B)
S *Spacecraft
G Ground Support Facility

*Detailed description follows

REFERENCES

SYSTEM DESCRIPTION

The Manned Telescope Satellite would carry a primary stellar optical telescope. The size of the cylinder would be about 10 feet by 30 feet. Additional components and experiments might extend the size to 15 feet by 40 feet.

Wide and narrow band spectrophotometric measures of all wave lengths of electromagnetic radiation shorter than millimetric. Very high resolution images of astronomical objects in visible and UV light. High resolution spectrum scans in numerous parallel channels. It is not anticipated that man would be aboard the Manned Telescope Satellite during observations since his presence is likely to be incompatible with highly accurate telescope observations. However, he would perform repair and maintenance and change scientific experiments as required (on the order of several months interval).

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (1 2 3 5)	Peak Power 1000 watts, 10% duty cycle continuous power 500 watts	SA11 Isotope thermoelectric	SA111 Specific energy; SA112 Shielding; SA113 Radiation damage, semiconductor; SA114 Temperature limited efficiency; SA115 Isotope resources; SA116 Waste heat rejection	SA111: 1 2 3 x; SA112: 1 2 3 x; SA113: 1 2 3 10 x; SA114: 1 2 3 10 x; SA115: 1 2 3 12 x; SA116: 1 2 4 x
SD Data Proc. (1 2 3)	Input data rate: 10^3 bits/sec. Output communication rate: 10^3 bits/sec. Recoverable storage: photographic plates command information, status, pointing, attitude, etc.; video transmitted directly; see Comm.	SD1 Data storage, permanent	SD11 Photographic film	SD111 Radiation damage, film; SD112 R&D required, onboard processing SD111: 1 2 3 x; SD112: 1 2 3 2 x
SI Tech. Instr. (1 2 3 5)	Telescope; spectrometers; photographic recording; TV monitor	SI11 Stellar telescope	SI111 Weight, mirror; SI112 Fabrication precision	SI111: 1 2 3 6 x; SI112: 1 2 2 x
SM Check/Maint.	Prelaunch checkout; performance monitor, report; Switching of redundant units; malfunction diagnosis; Orbital assembly checkout	SOA		
SP Propulsion	Δ V 150 m/sec. for orbit control Payload 20,000 lbs.	SOA		
SR Comm.	Transmission data rate - 10^7 bits/sec. video Range - 5500 km maximum	SOA		
SS Veh. Stab/Cont. (1 2 5)	Pointing accuracy { ± 1 degree, 100 hours - periods over 5 years ± .01 arc sec., 1 hour } Body rate 3 x 10^{-4} degrees/sec. } star tracking	SS1 Actuator servos: Rotation sensors SOA; Attitude actuators SOA SS2 Inertial reference SS3 Electronics	SS11 Electromechanical drive; SS21 Hollow sphere	SS111 Dynamic range; SS112 Vibration; SS113 Threshold - rate sensors; SS114 Accuracy - pointing; SS115 Reliability; SS211 Weight SS111: 1 2 3 x; SS112: 1 2 3 x; SS113: 1 2 3 6 x; SS114: 1 2 3 x; SS115: 1 2 3 x; SS211: 1 2 5 x

SYSTEM DESCRIPTION

DESIGNATOR EO02 S
CONCEPT MANNED TELESCOPE SATELLITE
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES	ST
ST Sim/Train.	Prelaunch skill requisition and inflight skill retention for vehicle operation and scientific work	SOA				
SV Vehicle	Subsystem integration for field of view, communications, no vibration, thermal environment, EVA portals, orbital checkout and maintenance, re-supply.				SV:11 Thermal body flexure	x 1 2 3 5
SE Display	Subsystem Status	SOA				

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CONCEPT DESCRIPTION

CONCEPT GEODETIC CHECK SATELLITE

DESIGNATOR EO03

MISSION OBJECTIVES Performance of geometric geodesy by earth satellite on a global basis to provide data which, with surface baseline and gravity data available from other sources, determines the positions of fiducial control points on the earth to an accuracy of 10 meters in an earth center-of-mass coordinate system. The program will last approximately five years.

GENERAL DESCRIPTION An unmanned mission similar to PAGEOS in a 4250 km circular orbit inclined 90°. The payload weighs about 250 lbs. with a passive Echo I-type spacecraft. The mission date lies in the 1966-67 period.

LIST OF SYSTEMS

B Booster (TAT/Agena D)
G *Ground Support Facility
S *Spacecraft

REFERENCES

1. OSSA Geodetic Explorer

*Detailed description follows.

SYSTEM DESCRIPTION

Observing stations needed are:

Smithsonian Astrophysical Observatory Optical Network
NASA MOTS
Mobile cameras operated by the Department of Defense and the Coast and Geodetic Survey, who will photograph it against a star background.

DESIGNATOR EO03S

CONCEPT GEODETIC CHECK SATELLITE

SYSTEM Ground Support Facility

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
GD Data Process.	Storage - recoverable ("permanent") SOA			
GN D/D/T	Angle accuracy .001 arc sec. for star tracking Temporal coverage 5 parts in 10" per day for synchronization	GN1 Radar trackers	GN11 AN FPS-16	GN111 Accuracy, angle readout GN112 Accuracy, refraction correction
		GN2 Cameras	GN21 Theodolite-star tracker	GN211 Accuracy, tracking GN212 Accuracy, angle readout GN213 Response, shutter
		GN3 Timers	GN31 Atomic clock SOA	

S
T

1 2 3 x
1 2 3 x
1 2 4 x
1 2 4 x

SYSTEM DESCRIPTION

An Echo I type 100 ft. diameter expandable balloon is the spacecraft. No electronics are included. Constructed of 84 tailored panels of 0.5 thousandths Mylar, the outer surface coated with vapor-deposited aluminum. Precise control of optical and physical properties is required. Sphere will weigh 130 lbs. and is packed in cannister from which it is ejected into space. 30 lbs. of benzoic acid and anthraquinone subliming chemicals are used for inflation.

DESIGNATOR EO03 S
CONCEPT GEODETIC CHECK SATELLITE
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
ST				ST
SV Vehicle		SOA		

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CONCEPT DESCRIPTION

CONCEPT SMALL MANNED SPACE STATION

DESIGNATOR EO04

MISSION OBJECTIVES Study aboard a space station of man's capability, endurance, and usefulness in space prior to commitment to long duration interplanetary missions or to large permanent space stations. The station measures and tests many factors including: man's performance of functional and scientific tasks; the degrading effects of weightlessness, confinement, radiation, extra-vehicular exposure; and man's usefulness in constructing large objects in space, checking and repairing equipment, and maintaining the station. This mission precedes manned interplanetary flights, the Large Manned Space Station (EO08) and the Manned Telescope Satellite (EO02).

GENERAL DESCRIPTION A manned mission lasting 1 to 5 years, resupplied four times a year in a 475 km circular orbit, inclined 30°. The crew is 6 to 9 men including both astronauts and scientists, with a duty cycle of 3 to 6 months. The space station weighs about 30,000 lbs. and provides shirtsleeve environment. It is launched unmanned with the crew sent up on the first shuttle. A centrifuge is available for crew conditioning and 0 to 0.4 g experiments. Resupply is accomplished by modified Apollo equipment. Mission date is in the 1970-76 period.

LIST OF SYSTEMS

B Station Booster (Saturn I-B)
G Ground Support Facility
S *Space Station
X Logistics Booster (Saturn I-B)
Y *Logistics Vehicle

*Detailed description follows.

REFERENCES

1. AW&ST, 16 Nov 1964, 20 Dec 1964.
2. Space/Aeronautics, June 1964
3. "Report on the Optimization of the Manned Orbital Research Laboratory (MORL) System Concept," Douglas Report SM-48151

SYSTEM DESCRIPTION

A 3-9 man non recoverable space station with sufficient life support for four months. Station weight about 30,000 lbs. Size and shape shall correspond to launch vehicle required. Station shall be kept in prescribed orbit by ΔV changes approximately every four days. The station shall contain crew living quarters plus a separate laboratory for work on experiments.

DESIGNATOR EO04 S — EO04S —

CONCEPT SMALL MANNED SPACE STATION

SYSTEM Space Station (Page 1 of 3)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power	Continuous Power: 6.7 kw, 1 - 5 years		SA11 Solar Dynamic	SA111 High temperature materials
				SA112 Waste heat rejection
				SA113 Wearout
			SA12 Photovoltaic solar cells and NiCad batteries	SA121 Abrasion, solar cells
				SA122 Specific area, solar cells
				SA123 Radiation damage, semi-conductor
				SA124 Reliability, NiCad
				SA125 Specific cost, solar cells
			SA13 Isotope thermoelectric	SA131 Waste heat rejection
				SA132 Shielding
				SA133 Isotope resources
				SA134 Temperature limited efficiency
				SA135 Specific energy
SD Data Proc.	Input data rate 10^7 bits/sec Output communication rate 10^7 bits/sec Output display rate 10^3 bits/sec Recoverable tape storage, film 10^9 bits Temporary random access storage 10^6 bits		SD11 Digital computer, tape recorder, video encoder, film	SD111 Memory density, digital computer
				SD112 Memory density, tape recorder
				SD113 Reliability, tape recorder
				SD114 Reliability, digital computer
				SD115 Data compression
SG Guid/Nav.	Velocity accuracy ± 0.3 m/sec Station keeping angle ± 3 degrees Rendezvous and docking: Relative position 0.3 m Relative velocity 0.3 m/sec Acquisition cond. 200 km	SG1 Station keeping guid. & nav.	SG11 Inertial system working with manned space net and star tracker	SG111 Reliability, inertial system
		SG2 Rendezvous & docking guidance and navigation	SG21 Radar, rendezvous	SG211 Tracking accuracy, radar
				SG212 Reliability, radar
			SG22 Laser, rendezvous	SG221 Tracking accuracy, laser
				SG222 Reliability, laser
				SG223 R&D req'd., laser

SYSTEM DESCRIPTION

DESIGNATOR EO04 S
CONCEPT SMALL MANNED SPACE STATION
SYSTEM Space Station (Page 2 of 3)

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

SH Life Support

- Air: 1.8 lb. O_2/man/day
- Water: 6.16 lb. (drink), 9.84 lb (hygiene)/man/day
- Food: 3,000 cal/man/day
- T.P.H.: 75 ± 5° F, 46% RH, 3.5-14.7 PSIA
- Med: medical, dental care, physiological monitoring
- Radiation: inst. 100 rem, cumulative 350 rem 1 yr.

SI Task Instr.

Capable of carrying instruments in the following Instrument Groups:
- Manned Systems
- Planet Oriented
- TV Mapping
- Atmospheric Entry
- Surface Surveillance & Micro TV
- Radar Mapping
- Radar Propagation Experiment
- Gas Dynamic Behavior

SOA

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Functional Element	Configuration	Technology Deficiency	S	1	2	4
SH1 Air	SH11 Nitrogen/oxygen	SH111 Leak detection & alarm			x	
		SH112 CO_2 & CO monitor, alarm, removal			x	
		SH113 Contaminant detection			x	
		SH114 Odor & contaminant removal			x	
SH2 Water	SH21 Recycled water	SH211 Psychological implications				x
		SH212 Ion removal and pH control			x	
		SH213 Trace contaminants				x
SH3 Food	SH31 Stored food	SH311 Monotony - same food day after day			x	
		SH312 Waste disposal			x	
		SH313 Preservation & storage			x	
		SH314 Nutrient/bulk ratio			x	
		SH315 Preparation &/or reconstitution, crumbs, outgassing			x	
		SH316 Biological gas and odor production			x	
SH4 T.P.H.	SH41 Automatic TPH	SH411 Fast action repressurization				x
		SH412 Fire exting., non-toxic				x
		SH413 Comfort factors			x	
		SH414 Atmospheric circulation and cycling			x	
SH5 Medical/psycho	SH51 Medical/psycho	SH511 Zero-G physiology				x
		SH512 Morale				x
		SH513 Sanitation			x	
		SH514 Diagnosis and treatment, health			x	
		SH515 Surgical implant of biomedical sensors				x
		SH516 Reduction in natural immunities				x

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SM Check/Maint.	Prelaunch checkout Performance monitor, report Switching of redundant units Malfunction diagnosis Orbital assembly checkout		SM11 [illegible] monitor and [illegible] isolation	SM111 Monitoring & switching SM112 Fault isolation SM113 Spares weight & interchangeability SM114 Zero-G work, tools SM115 Tech. Data Access
SP Propulsion	ΔV 300 m/sec for station keeping Payload, 30,000 lbs.	SOA		
SR Comm.	Trans. data rate - 10^7 bits/sec. Range - 5500 km	SOA		
SS Stab/Control	Attitude control ±5.0°, continuous Pointing accuracy ±0.1 sec (experiment platform only), 5 hrs. accumulated Body rate 5×10^{-4}°/sec (experiment platform only)	SS1 Attitude actuators SS2 Rotation sensors	SS11 Control moment gyro SS12 Hypergolic reaction jets SS21 Rate gyro	SS111 Reliability, gyro SS121 Reliability, HRJ SS211 Threshold, gyro
ST Sim/Train	Prelaunch skill acquisition and inflight skill retention for vehicle operation and scientific work	SOA		
SV Vehicle	External view for astronauts Shielding Thermal environment EVA portals Docking		SV11 Closed spacecraft structures Nonrecoverable spacestation with separate living quarters and experiment lab.	SV111 Docking shock SV112 Meteoric protection SV113 Material degradation SV114 Portal reaction thrust SV115 Optical window degradation
SY Display	Inflight displays of operation (mission & subsystem management) Subsystem Status (equipment state monitoring and maintenance) Task (scientific instrumentation and analysis.	SOA		

SYSTEM DESCRIPTION

An Apollo Command and Service Module type vehicle modified to four-man shuttle capability. Tankage and storage shall be provided for in the service module for resupply of life support, orbit keeping propellant, equipment and experiment components to the spacecraft. The Apollo Command Module is reusable after replacement of heat shield. The modified service module is expendable. The command module may remain docked at the Space Station for extended periods of time to serve as an escape and recovery vehicle for personnel.

DESIGNATOR EO04 Y
CONCEPT SMALL MANNED SPACE STATION
SYSTEM Logistic Vehicle

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
YA Aux. Power		SOA		
YE Escape/Recy.		SOA		
YG Guid. /Nav.	Injection: Velocity ± 0.3 n; Pos. Accuracy ± 1.0 km; Angle ± .02 degree Approach: Position ± 5 km Rendezvous & Docking: Rel. Pos. (range accuracy) 0.3% (or m); Rel. Vel. (rate accuracy) 0.3 m/sec; Acquisition Cond. 100 km	YG1 Rendezvous & Docking (guidance)	YG11 Radar, rendezvous YG12 Laser, rendezvous	YG111 Tracking accuracy, radar (1 2 3 x) YG121 Tracking accuracy, laser (1 2 4 x) YG122 Reliability, laser (1 2 4 x) YG123 R&D req'd., laser (1 2 4 3 x)
YH Life Support	SOA			
YM Check/Maint.	SOA			
YP Propulsion	Δ V ft/sec Maneuver weight: 36,000 lbs. Rendezvous Propulsion Required	SOA		
YR Comm.		SOA		
YS Stab/Control		SOA		
YV Vehicle	Astronaut and supply transfer. Initial personnel transfer, emergency return of personnel from space station.	YV1 Cryogenic fuel transfer (food and other resupplied--SOA)	YV11 Apollo CSM type	YV111 Cryogenic freezing (1 2 3 x) YV112 Complete expansion, cryogenic (1 2 3 x)

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CONCEPT DESCRIPTION

CONCEPT PRECISION SOLAR RESEARCH SATELLITE

DESIGNATOR EO05

MISSION OBJECTIVES Acquisition by earth satellite of precise solar data in such areas as solar photospheric turbulence, detailed active features of the chromosphere, and low corona characteristics of the limb of the sun concentrating interest on the visible light, x-ray and ultraviolet, gamma and x-ray regions.

GENERAL DESCRIPTION An unmanned AOSO-type experiment launched into a maximum sunlight orbit with telescopic equipment for precision (1/10 arc sec. resolution) scan of the solar surface. Two spacecraft will provide continuous surveillance of the sun.

LIST OF SYSTEMS

B Booster (TAT/Agena B)
G Ground Support Facility (OSO-SOA)
S *Spacecraft

REFERENCES

1. OSSA - AOSO
2. NASA NRC 1079
3. Space/Aeronautics, Jan 1965
4. AW&ST, Mar 1963, p. 48

*Detailed description follows.

SYSTEM DESCRIPTION

A 1,450 lb. spacecraft placed in 550 km retrograde 83° orbit (maximum sunlight orbit) with high resolution instrumentation for observation of the sun. Spacecraft is approximately 140 inches long by 55 inches in diameter. Lifetime of the spacecraft - 2 years.

DESIGNATOR EO05 S

CONCEPT PRECISION SOLAR RESEARCH SATELLITE

SYSTEM Spacecraft (Page 1 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S, T)	Continuous Power 560 watts for two years		SA1[illegible] [illegible] battery, [illegible] with 43,000 N P [illegible] amp hour [illegible]	SA111 Specific cost, solar cells SA112 Reliability, NiCad SA113 Abrasion solar cells
SD Data Proc.	Onboard processing and storage for readout twice per orbit. Rates: Input data rate 3×10^3 bits/sec Output comm. rate 5×10^5 bits/sec Storage: Recoverable 5×10^7 bits		SD11 [illegible] processor for experiment programming of sequencing and commutation of data to the recorder. Onboard high speed readout variable speed tape recorder	SD111 Reliability, tape recorder SD112 Reliability, data processor SD113 R&D req'd, tape recorder
	Note Guidance & Navigation by ground based tracking. No onboard requirement after injection. Beacon on spacecraft - 137 mc.			
SI Task Instr.	Equipment for detailed scan of the sun in IR, UV, Gamma ray, X-ray and visible spectra. Use coarse and fine scanning with offset pointing modes.		Equipment includes separate telescopes for scanning in IR UV Optical Gamma ray (scintillator type) X-ray (scintillator type) SOA	
SR Comm.	Data communication to ground monitor station Range: 1200 km Comm. Data rate: 5×10^5 bits/sec Command communication link - 70 functions		Data Link UHF transceiver (solid state) - 400 mc 11 watt multi-channel Spacecraft Status Link UHF Transmitter (solid state) 136 mc - 10 watts Command Link UHF Receiver/decoder 148 mc - 70 function multi-channel Low Gain Antenna (SOA)	

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES	S T
SS Sub. /Control	Attitude accuracy - 5 arc sec - sun oriented Jitter rate limited to 0.5 arc sec/sec. Provision required for ±5 degrees freedom in two axes about solar center for offset pointing. Required to have two Attitude Scan modes as follows: Coarse raster: 40 arc min x 40 arc min 120 lines - 20 arc sec spacing - 25 min time per frame Fine raster: 5 arc min x 5 arc min 60 lines - 5 arc sec spacing - 5 min time per frame Rasters can be selected from 10 deg x 10 deg square centered on solar disc.	SS1 Rotation sensors	SS11 Rotating slab sun tracker with digital pickoffs. Canopus identifier star tracker. Opportunity star tracker for night side stabilization. Strapdown rate gyros and rate integrating gyros Coarse sun finder.	SS111 R&D required, sun tracker	1 2 2 x
				SS112 R&D required, raster motion.	1 2 1 x
				SS113 Reliability, gyros	1 2 3 x
		SS2 Actuators	SS21 Reaction wheels Magnetic torquer (earth's field) Cold gas jets (Nitrogen)	SS211 Wear out, reaction wheels	1 2 2 1 x
				SS212 Vibration noise, reaction wheels	1 2 2 1 x
SV Vehicle	Spacecraft as required with vibration and temperature flexure suppression.		SV11 Cylinder spacecraft with 8 radial solar paddles.	SV111 Vibration suppression	1 2 2 1 x

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CONCEPT DESCRIPTION

CONCEPT GEOPHYSICAL SATELLITE

DESIGNATOR EO07

MISSION OBJECTIVES High resolution measurement by earth satellite of the earth's environment. This continues and expands on present OGO studies to encompass the 1968-1970 time period of maximum solar activity.

GENERAL DESCRIPTION An unmanned mission placing small satellites in low polar orbit or highly eccentric orbits inclined about 30° to equatorial. Eccentric orbit missions will be launched over the Atlantic Missile Range and polar orbit missions over the Pacific Missile Range. Various high resolution measurements of the space environment, magnetosphere, ionosphere, gravity field, albedo heat balance, and others are to be performed. A 1000 to 1500 pound spacecraft is anticipated. The mission date lies in the 1968-1970 period.

LIST OF SYSTEMS

B Booster (Atlas/Agena or TAT/Agena)
G Ground Support Facility (OGO)
S *Spacecraft

*Detailed description follows.

REFERENCES

1. OSSA OGO's
2. AW&ST, 15 Mar 1965, pp 121-123
3. Space/Aeronautics, Jan 1965, pp 64-66

SYSTEM DESCRIPTION

[illegible] 200 lb spacecraft launched into highly elliptic [illegible] orbits (280 KM perigee 150,000 KM [illegible] polar orbits. Instrumentation will be provided for [illegible] physical studies. Low [illegible] measure phenomena of the polar regions such as auroras [illegible] investigate phenomena of the ionosphere and upper atmosphere. Nominal spacecraft lifetime 1 year.

DESIGNATOR [illegible] EO07S -2S

CONCEPT GEOPHYSICAL [illegible]

SYSTEM [illegible]

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S: X; T: 1 1 3)	Continuous power 250 watts	SA11 Solar cells and NiCad battery		SA111 Specific cost, solar cells (S: X; T: 2 3); SA112 Reliability, NiCad (X; 1 1 2 3); SA113 Abrasion, solar cells (X; 1 1 3 3)
SD Data Proc. (X; 1 2 3)	Processing of data from experiments with encoding and recording for transmission to ground stations. Input data rate 10^3 bits/sec. Output communication rate 10^3 bits/sec in bursts Storage up to 10^8 bits for elliptic orbits	SD11 Digital processor plus variable speed tape recorder		SD111 Reliability, tape recorder (X; 1 2 4); SD112 Reliability, data processor (X; 1 2 3); SD113 Radiation [illegible] of memory (X; 1 2 2 3); SD114 R&D req'd, tape recorder (X; 1 2 4)
SI Task Instr.	Capable of carrying instruments in the following instrument groups Planet Oriented	SOA		
SR Comm.	Spacecraft to ground data link Ground to spacecraft command OGO	SOA		
SS Stab/Control (X; 1 2 2)	Attitude accuracy to local vertical ± 1.0 degree Attitude rate ± 0.3 deg/sec Experiment package alignment to orbit plane ± 5.0 degrees Solar cell alignment to sun ± 5.0 degrees	SS11	Strapdown rate gyros, cold gas reaction jets and electromechanical servos for solar panels	SS111 Bearings, solar panels (X; 1 2 2); SS112 Reliability, rate gyros (X; 1 2 3)
SV Vehicle	Similar to OGO	SOA		

CONCEPT DESCRIPTION

CONCEPT LARGE MANNED SPACE STATION

DESIGNATOR EO08

MISSION OBJECTIVES Development aboard a space station of man's capability for long duration missions in space, and further investigation of the earth, solar system and universe through the performance of functionally designed experiments. This mission actually utilizes the systems and human capabilities first tested on the Small Manned Space Station (EO04).

GENERAL DESCRIPTION A permanent manned mission, maintained in orbit by orbit-keeping propulsion and resupplied four times per year in a 475-550 km circular orbit inclined 30°. The crew includes 24 - 36 men--astronauts, scientists, technicians and medical personnel. The space station weighs about 250,000 lbs. and provides a shirtsleeves environment. It is launched unmanned with the crew sent up via personnel shuttle vehicles. The mission is a large national effort employing systems designed specifically for sustained, efficient utility and maintenance such as reuseable logistics systems. Resupply is accomplished by reuseable maneuverable logistics vehicles. The mission date lies in the 1975-78 period. Mission duration up to five years.

LIST OF SYSTEMS

B	Booster (Saturn V)
G	Ground Support Facility (Manned Space Net)
S	*Space Station
V	Expendable Logistics Booster (Saturn I-B)
W	*Manned Reuseable Logistics Vehicle
X	*Extra-Vehicular Activity Unit
Y	*Manned Reuseable Booster
Z	*Expendable Logistics Vehicle

* Detailed description follows.

REFERENCES

1. "Study of a Rotating Manned Orbital Space Station," Final oral presentation, Lockheed LR17516, 4 Feb. 1964.
2. "A Multipurpose Manned Orbital Space Station," C. W. Mathews & E. H. Olling, AIAA & Aero Space Medical Assn. Conference, May 1963.
3. AW&ST, 16 November 1964.
4. AW&ST, 21 December 1964.
5. "Hypersonic Airbreathing Propulsion," Avery & Dugger, Astronautics and Aeronautics, June 1965.
6. "Assessing Reuseable Space Vehicles," H. H. Koelle, Astronautics and Aeronautics, June 1964.

SYSTEM DESCRIPTION

A large Y-shaped rotating 150,000 lb. space station with 100,000 lbs of expendable supplies. The space station shall contain both shirtsleeve living and work facilities for the 24-36 man crew. Total volume of space station [illegible] 7,000 [illegible]. The space station shall contain about 10,000 lbs of replaceable [illegible] equipment including a large telescope for astronomical measurements. The station shall be folded during launch and extended in orbit. A radiation protection "storm cellar" shall be provided during solar flare activity. The space station shall be kept permanently in orbit with all subsystems being both repairable and replaceable as required.

DESIGNATOR CONCEPT SYSTEM

[illegible] EO08S -30

LARGE [illegible] STATION

Space Station
(Page 1 of [illegible])

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

SA Aux. Power (1 2 4)

Continuous power 28 KW.
Permanent power required - subsystem equipment must be replaceable as required.

SD Data Proc. (1 2 4)

RATES
- Input data rate: 10^8 bits/sec including video
- Output comm. rate: 10^8 bits/sec including video
- Output display rate: 10^4 bits/sec

STORAGE
- Recoverable tape, film 10^{12} bits
- Temporary random access $> 10^6$ bits

SG Guid. /Nav. (1 2 4)

Velocity accuracy: ±0.3 m/sec
Position accuracy: ±3.0 km

Rendezvous & Docking
- Relative position 0.3 m
- Relative velocity 0.3/sec
- Acquisition cond. 200 km

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Functional element	Configuration	Technology deficiency	S	1	2	3	4	5	10
SA11 Solar cell with NiCad battery plus fuel cells	SA111	Specific power, solar cells				x			
	SA112	Specific cost, solar cells				x			
	SA113	Service life, fuel cells				x			
	SA114	Specific power, fuel cells				x			
	SA115	Specific power, battery				x			
SA12 Nuclear reactor thermoelectric	SA121	R&D required, nuclear reactor					x		
	SA122	Reliability, nuclear reactor					x		
	SA123	Waste heat rejection					x		
	SA124	Specific power, nuclear reactor					x		
	SA125	Shielding				x			
SA13 Solar dynamic	SA131	High temperature materials					x		
	SA132	Waste heat rejection				x			
	SA133	Wearout					x		
SD11 Multi-processor, tape recorder, digital computer, video encoder, film	SD111	Memory density, tape recorder				x			
	SD112	Reliability, tape recorder				x			
	SD113	Reliability, digital computer				x			
	SD114	Data compression					x		
	SD115	Maintainability, dig. computer				x			
SG1 Orbit keeping; SG11 Inertial system horizon scanner and star tracker working with Manned Space Net	SG111	Reliability, inertial system				x			
	SG112	Reliability, star tracker				x			
SG2 Rendezvous & docking; SG21 Radar, rendezvous	SG211	Tracking accuracy, radar				x			
	SG212	Reliability, radar				x			
SG22 Laser, rendezvous	SG221	Tracking accuracy, laser				x			
	SG222	Reliability, laser				x			
	SG223	R&D req'd., laser					x		

SYSTEM DESCRIPTION

DESIGNATOR EO08 S
CONCEPT LARGE MANNED SPACE STATION
SYSTEM Space Station (Page 2 of 3)

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

Life Support

AIR: 1.8 lb. O_2/man/day
WATER: 6.16 lb. (drink), 9.84 lb (hygiene)/man/day
FOOD: 3,000 cal/man/day
TPH: 75±5°F, 46% RH, 3.5-14.7 PSIA
MED: medical, dental care, physiological monitoring
RADIATION: inst. 100 rem, cumulative 350 rem 1 yr.

Task Instr.

Gimballed telescope to provide 10 ft. resolution on earth surface.

Capable of Carrying Instruments in the Following Groups:
- Manned Systems
- Planet Oriented
- TV Mapping
- Atmospheric Entry
- Surface Surveillance & Micro TV
- Radar Mapping
- Radio Propagation Experiment
- Gas Dynamic Behavior

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

SH1	Air	SH11	Nitrogen/oxygen	SH111	Leak detection & alarm
				SH112	CO_2 & CO monitor, alarm, removal
				SH113	Contaminant detection
				SH114	Odor & contaminant removal
SH2	Water	SH21	Recycled water	SH211	Psychological implications
				SH212	Ion removal and pH control
				SH213	Trace contaminants
SH3	Food	SH31	Stored food	SH311	Monotony - same food day after day
				SH312	Waste disposal
				SH313	Preservation & storage
				SH314	Nutrient/bulk ratio
				SH315	Preparation &/or reconstitution, crumbs, outgassing
				SH316	Biological gas and odor production
SH4	T. P. H.	SH41	Automatic TPH	SH411	Fast action repressurization
				SH412	Fire exting., non-toxic
				SH413	Comfort factors
				SH414	Atmospheric circulation and cycling
SH5	Medical/psycho	SH51	Medical/psycho	SH511	Coriolis effect
				SH512	Morale
				SH513	Sanitation
				SH514	Diagnosis and treatment, health
				SH515	Surgical implant of bio-medical sensors
				SH516	Reduction in natural immunities
		SI11	140 mm gimballed refractive telescope	SI111	Telescope gimballing
				SI112	Thermal effect on large lenses
				SI113	Pointing accuracy
				SI114	Vibration suppression

SYSTEM DESCRIPTION

DESIGNATOR FO EO08S -82
CONCEPT LARGE MANNED SPACE STATION
SYSTEM Space Station (Page 2 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SM Check/Maint (x: 3)	Prelaunch checkout Performance monitor, report Switching of redundant units Malfunction diagnosis Orbital assembly checkout	SM11	Automatic failure monitor and fault isolation	SM111 Monitoring & switching (S/T: 3) SM112 Fault isolation (x: 3) SM113 Spares weight & interchangeability (x: 3) SM114 Zero-g work, tools (x: 3) SM115 Tech. data access (x: 3)
SP Propulsion	ΔV 300 m/sec for station keeping Payload 250,000 lb. SOA			
SR Comm.	Trans. data rate 10^8 bits/sec including video Range: 5500 km SOA			
SS Stab./Control (x: 3)	Attitude control ±5.0° continuous Pointing accuracy ±0.1 sec (experiment platform only) 5 hrs. accumulated Body rate 5×10^{-4}°/sec (experiment platform only)	SS1 Attitude actuators SS2 Rotation sensors	SS11 Control moment gyro SS12 Hypergolic reaction jets SS21 Rate gyro	SS111 Reliability, gyro (x: 3) SS121 Reliability, reaction jets (x: 3) SS211 Threshold, gyro (x: 4, 5)
ST Sim/Train	Prelaunch skill acquisition and inflight skill retention for vehicle operation and scientific work. SOA			
SV Vehicle (x: 2)	In space unfolding of large Y-shaped space craft required.	SV11	Closed spacecraft structure with separate living quarters Large Y-shaped spacecraft	SV111 Handling large masses in space (x: 2) SV112 Structural integrity (x: 2) SV113 Leakage, atmosphere (x: 2) SV114 Portals, EVA (x: 2) SV115 Mechanical reliability, rotating structure (x: 2)
SY Display	Inflight displays of operation (mission & subsystem management) Subsystem status (equipment status monitoring and maintenance) Task (scientific instrumentation and analysis) SOA			

SYSTEM DESCRIPTION

A maneuvering reuseable shuttle vehicle launched from the Manned Reuseable Booster (6EO08Y) at approximately M=20 at 180,000 ft. The vehicle is the second stage of the reuseable vehicle concept where the second stage separates and flys into orbit for the purpose of resupplying the space station before returning for a normal earth landing. The vehicle has rendezvous capability for logistic supply of the space station. Configurations shall consist of a 6 to 9-man personnel transport or a version with 10,000 lb. of cargo. Vehicle shall be reuseable with change of ablative materials. Total loaded weight of the vehicle shall be 50,000 lbs. The vehicle shall be storable in earth orbit for up to 30 days.

DESIGNATOR EO08 W

CONCEPT LARGE MANNED SPACE STATION

SYSTEM Manned Reuseable Logistics Vehicle (Page 1 of 2)

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS / FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

WA Aux. Power (S, T)

- Continuous power. 2 KW for up to 24 hours (storage time in orbit - 30 days) — SOA

WE Escape/Recy.

- Safe return of astronauts. — SOA

WG Guid./Nav. (S, 1, 2, 3)

Injection Guidance:
- Velocity accuracy ±0.5 m/sec
- Position accuracy ±3.0 km
- Attitude accuracy ±.02°
- Altitude accuracy ±1500 m

Rendezvous guidance and acquisition:
- Range - 185 km on a 1m^2 target
- Field of view - 30° x 30°
- Resolution - 1 mr
- Range rate accuracy - 15 fps
- Range accuracy - 100 ft
- Angle rate accuracy - 0.5 mr/sec

Short range docking:
- Range - ~ 18 km
- Range accuracy - ± 10%
- Range rate accuracy - .05 m/sec
- Angle rate accuracy - 0.1 mr/sec
- Visual docking capability

Approach - Velocity Accuracy:
- Position - runway approach
- Angle - ±1.0 deg.

- WG1 Injection
  - WG11 Inertial system plus ground-based updating.
    - WG111 Reliability, inertial system (1, 2, 4)
    - WG112 Restart and alignment in orbit (1, 2, 4)
- WG2 Rendezvous & docking
  - WG21 Radar, rendezvous
    - WG211 Tracking accuracy, radar (1, 2, 3)
    - WG212 Reliability, radar (1, 2, 3)
  - WG22 Laser, rendezvous
    - WG221 Tracking, laser (1, 2, 4)
    - WG222 Reliability, laser (1, 2, 4)
    - WG223 R&D req'd., laser (1, 2, 4, 3)
- WG3 Approach
  - WG31 ILS type ground cooperative terminal guidance
    - WG311 Velocity accuracy, ILS (1, 1, 1)
    - WG312 Acquisition & vectoring, ILS (1, 1, 1)
    - WG313 Automatic beam coupling, ILS (1, 1, 1)

WH Life Support

- Support for up to 10 men for 24 hours. — SOA

WM Check/Maint. (S, 1, 2, 3)

- Onboard checkout required
  - WM11 Automatic checkout
    - WM111 Fault isolation
    - WM112 Reliability
    - WM113 Technical data access

WP Propulsion (S, 1, 2, 3)

- Injection ΔV 1600 m/sec (50,000 lb. vehicle)
- In space ΔV 160 m/sec
- Propulsion in atmosphere for terminal maneuvers (SOA)
  - WP11 Cryogenic liquid rocket plus small airbreathing turbojet.
    - WP111 Cryogenic storage

WR Comm.

- Vehicle to space station
- Vehicle to ground - voice communications — SOA

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES	S T
WS Stab./Control (1 2 x 3)	In Space Attitude control ±1.0 deg. Body rate < .01 deg/sec In Atmosphere Vehicle stability and control for pilotage and terminal guidance.	WS11	Hypergolic reaction jets with aerodynamic control. Full enveiope autopilot functions.	WS111 Reliability, HRJ (1 2 x 3) WS112 Higher order control techniques (1 2 3 x 3)	
WV Vehicle (1 2 x 5)	Reuseable aerodynamic vehicle required L/D supersonic 1.1 L/D subsonic 2.8	WV11	Maneuvering re-entry body	WV111 Control moment generator (1 2 x 5) WV112 Weight, ablative (1 2 x 5) WV113 R&D required, radiative re-entry (1 2 x 5)	
WY Display	Flight and terminal guidance displays	SOA			

SYSTEM DESCRIPTION

This is a non-pressurized one-man space tug used for major assembly jobs in earth orbit. The operator will wear a conventional EVA space suit. It should be useable for 10 hours, rechargeable from spacecraft. Must have adequate propulsion for self and equipment. Must be able to control attitude in orbit. Must be capable of performing any necessary work in assembling the various systems. Communications for voice to 500 miles.

DESIGNATOR EO08 X
CONCEPT Large Manned Space Station
SYSTEM Extra-Vehicular Activity Unit

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
XA Aux. Power	Continuous power 200 W, 10 hours	SOA		
XE Escape/Recy	To vacate unit in emergency and rely on EVA suit until rescue.	SOA		
XH Life Support	Tanks for oxygen, water, food, waste.	SOA		
XP Propulsion	Total ΔV 2.0 m/sec, 250,000 lb. payload, to maneuver units for docking. Acceleration impulse limited to 0.5 m/sec ΔV. Throttleable.		XP11 Cryogenic liquid rockets XP12 Hypergolic storable liquid rockets	XP111 Specific impulse XP112 Cryogenic storage XP113 Restart reliability XP114 Throttleability XP121 Specific impulse XP122 Restart reliability XP123 Throttleability
XR Comm.	4 channel voice 200 km 10 hrs. 1 channel voice 2000 km 10 min. 1 channel biomed, digital data link 200 km 10 hrs.	XR1 Voice, local — SOA XR2 Voice, long range, biomed data link	XR21 VHF/UHF Transceiver	XR211 Antenna directivity XR212 Power XR213 Coding
XS Stab./Control	0.25°/sec 3-axis angular rate sensor, display only, manual control of attitude jets.	SOA		
XT Sim/Train	Prelaunch skill acquisition for vehicle maneuvering and docking operation and docking crew coordination.		XT11 Assembly training	XT111 Realism of zero-g work XT112 Crew mix
XV Vehicle	Unpressurized open one-man vehicle with propulsion and life support package to support one worker in space suit. Grapplers and shock absorbers for maneuvering and docking operations.		XV11 Open, one-man space vehicle	XV111 Docking shock XV112 Grappling of large masses
XY Display	Display of attitude rate, propulsion and life support supply status, biomedical monitor display.	SOA		

SYSTEM DESCRIPTION

DESIGNATOR EO08Y EO08Y
CONCEPT LARGE MANNED SPACE STATION
SYSTEM Manned Reuseable R[illegible]

The vehicle is the first stage of a two-stage reuseable booster which takes off from a jet runway, accelerates to Mach 4 with turbojets and M = 20 with scramjets and releases the Manned Reuseable Logistics Vehicle 6(EO08)W weighing 50,000 lbs.

The booster shall have the following characteristics prior to launch of second stage
Airbreathing jet boost takeoff to M = 4.0 h=100,000 ft.
Scramjet to M = 20 h=180,000 ft.
The first stage booster shall then return to a conventional jet runway using turbojet power.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS		TECHNOLOGY DEFICIENCIES		ST
YA Aux. Power	Continuous power 2 KW, 6 hours			Mechanical generator and fuel cells	SOA			
YE Escape/Recy. (1 2 3 x)	Safe return of pilot for all conditions of flight			YE11 Single man ejectable pod - rocket separated		YE111	R&D required, escape pod	1 2 3 x
YG Guid/Nav.	Take off to second stage release: Velocity accuracy ± 0.3 m/sec. Position accuracy ± 2.0 km Altitude accuracy 1000 M Terminal guidance: Guidance to runway landing Flight path terminal accuracy ± 0.5 deg.	SOA		Doppler aided inertial system plus terminal cooperative ILS approach equipment	SOA			
YH Life Support	Life support for one man for 6 hours	SOA						
YM Check/Maint. (1 2 3 x)	Automatic onboard checkout and inflight status information required			YM11 Automatic failure monitor and fault isolation		YM111	Fault isolation	1 2 3 x
YP Propulsion (1 2 10 1 x)	Propulsion required to achieve performance described above Takeoff weight = 550,000 lbs. Minimum landing weight = 231,000 lbs.		YP1 Initial and terminal propulsion YP1 High speed propulsion	Six P&W J58 or equivalent turbojet engines. Thrust = 200,000 lbs. YP11 H_2 scramjet	SOA	YP111	R&D required, H_2 scramjet	1 2 10 1 x
YR Comm.	Booster to second stage and booster to ground communications	SOA						
YS Stab/Control (1 2 3 x)	Standard aircraft handling qualities throughout flight profile			YS11 Adaptive flight control system		YS111	Higher order adaptive techniques	1 2 3 3 x
YV Vehicle (1 2 14 x)	Vehicle Weight Breakdown Structure 180,000 lbs. Turbojets 36,000 lbs. Scramjets 15,000 lbs. Payload 50,000 lbs. H_2 fuel 200,000 lbs. RP-10 fuel 69,000 lbs. Takeoff weight 550,000 lbs. Vehicle Characteristics: Supersonic L/D = 2.0 Subsonic L/D = 4.0			YV11 Variable geometry wing with boundary layer cooling		YV111 YV112 YV113 YV114 YV115	Hypersonic release of second stage High temp. structures R&D required boundary layer cooling R&D required, variable geometry wing High strength/light weight structures	1 3 4 1 x 1 3 4 1 x 1 3 4 1 x 1 3 4 1 x 1 3 4 1 x
YY Display	Flight and terminal guidance displays	SOA						

SYSTEM DESCRIPTION

DESIGNATOR EO08 Z
CONCEPT LARGE MANNED SPACE STATION
SYSTEM Expendable Logistics Vehicle

An unmanned expendable cargo spacecraft with rendezvous capability with the space station. The vehicle will be launched into earth orbit by a Saturn I-B booster, then rendezvous with the station. After transfer of the payload, the vehicle will be deorbited and destroyed on re-entry to remove any hazard. Total vehicle weight shall be 30,000 lbs. with approximately 23,000 lbs. cargo capability. Size and shape shall be consistent with booster requirements.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
ZA Aux. Power	Continuous power: 500-1000 watts for up to 24 hours.	SOA	AgZn battery	
ZG Guid. /Nav.	Provide orbital injection of Logistics Vehicle to: Position ±5 miles Vehicle: ±5 ft/sec Provide onboard cooperative rendezvous system controlled by Space Station.	ZG11	Onboard strapdown inertial system working with ground control for orbit injection. Commanded rendezvous guidance consisting of strapdown inertial, radar or laser reflector.	ZG111 R&D req'd. inertial system ZG112 Low cost, inertial system
ZP Propulsion	Propulsion required to effect rendezvous: ΔV 300 m/sec Vehicle weight 30,000 lbs.		Cryogenic liquid rocket propulsion. SOA Hypergolic reaction jets. SOA	
ZS Stab. /Control	Attitude accuracy ±1.0 deg.			
ZV Vehicle	Rendezvous, docking and cargo transfer required.	ZV11	Logistics vehicle structure	ZV111 Cryogenic transfer ZV112 Cargo transfer techniques ZV113 Cryogenic storage

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CONCEPT DESCRIPTION

CONCEPT TECHNOLOGY TEST SATELLITE 1

DESIGNATOR EO09

MISSION OBJECTIVES First in a series of satellites developed to test advanced technologies in communications, meteorology, navigation, etc. To be investigated are: pointing of large antennas (30 ft. aperture), pilot beam pointing of high gain phased arrays (40 - 50 db), pointing of meteorological TV and IR sensors to ±1°, testing of communication link. This mission provides technical data needed for later communications and meteorological satellite programs.

GENERAL DESCRIPTION Similar to ATS4. An unmanned mission in which equipment to perform the above investigation is placed in synchronous equatorial orbit. Spacecraft weight approximately 800 lbs. To launch 800 lb. spacecraft into an approximately synchronous near equatorial orbit will require a booster combination such as Atlas B/Agena D/200,000 lb. sec. Apogee kick motor, all of which are available or under development. Concept is to launch into a highly elliptic transfer orbit with 33,800 km apogee and then circularize and change orbit inclination to near zero, simultaneously. Attitude control to guidance command - allowable error $\leq$ .01° equivalent. Useful life at least 2 years. Two launches--in 1969 and 1970.

LIST OF SYSTEMS		REFERENCES	
B	Booster (Atlas/Agena D/ATS Kick)	1.	OSSA ATS-4
G	Ground Support Facility (ATS Facility)		
S	*Spacecraft		

*Detailed description follows.

SYSTEM DESCRIPTION

Spacecraft to carry a 30 ft. operative antenna and high gain phased array antennae. Antenna stabilization and meteorological TV and IR sensing devices to ± 1°. Components for working with small or mobile ground station to be included. 200 watts power will be required.

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

SA Aux. Power (S: x; T: 1 2 3)

Continuous power 200 watts, 3 years. Desired life of solar cells (if used) is 50% of initial output after 3 years.

SD Data Proc. (x; 1 2 3)

Input data rate: 10^3 to 10^5 bits/sec digital
Output communication rate: 10^7 bits/sec. video
Temporary storage: 10^5 bits (program)

SG Guid/Nav (x; 1 2 4)

Injection into synchronous equatorial orbit
Velocity: ± 1.0 m/sec.
Position accuracy: ± 2 km
Angle: ± 0.25 degree
Station keeping velocity ± 0.1 m/sec (station keeping requirement not essential)

SI Task Instr. (x; 1 2 5)

Measure:
Stabilization Accuracy
Antenna Pointing Accuracy
Pilot Beam Accuracy
Meteorological Data
TV & IR Performance
Communications Equipment Performance
Radiation Spectrum Analysis

SP Propulsion (x; 1 2 2)

For station keeping (not essential):
Δ V 150 m/sec.
Payload 800 lb.

SR Comm. (x; 1 2 2 2)

Transmission data rate 10^3 to 10^5 bits/sec. digital; 10^7 bits/sec. video
Range 40,000 km
30 ft. antenna, pilot beam pointing of high gain (40-50 db) phased array antenna.

SS Stab/Control (x; 1 2 5)

Attitude control } ± 1° for antennae
Pointing accuracy } ± 5° for solar cells
Body rate .001°/sec.

SV Vehicle

SOA

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Functional element	Configuration	Technology deficiency	S	T
	SA11 Solar cells and NiCad batteries	SA111 Reliability, solar cells	x	1 2 3
		SA112 Abrasion, solar cells	x	1 2 2 5
		SA113 Reliability, NiCad battery	x	1 2 3
		SA114 Radiation damage, semi-conductors	x	1 2 3
		SA115 Specific power, solar cells	x	1 2 3
	SD11 Small digital processor plus video encoder	SD111 Reliability, digital processor	x	1 2 4
		SD112 Noise, video encoder	x	1 2 3 2
		SD113 Reliability, video encoder	x	1 2 3
	SG11 Radio command with onboard strapdown inertial system, planet tracker	SG111 Reliability, inertial system	x	1 2 4
		SG112 R&D required, inertial system	x	1 2 4
		SG113 R&D required, planet tracker	x	1 2 5
	SI11 High resolution TV and IR, radiometer and miscellaneous performance measuring equipment plus undefined experiment packages	SI111 R&D required, high resolution TV	x	1 2 5
		SI112 R&D required, high resolution IR	x	1 2 5
	SP11 Storable hypergolic liquid rocket	SP111 Impulse accuracy	x	1 2 2
	SR11 30-ft. parabolic antenna (operating below 1000 mc) and phased array antenna for "C" to "X" bands	SR111 Parabolic antenna size, deployment of 30-ft. antenna in space	x	1 2 3
		SR112 Antenna gain, phased array	x	1 2 2 3
	SS11 Gravity gradient plus hypergolic reaction jets and rate gyros	SS111 Threshold, rate gyros	x	1 2 4 5
		SS112 Attitude accuracy, gravity gradient	x	1 2 4 1
		SS113 Settling time, gravity gradient	x	1 2 4 1
		SS114 Reliability, reaction jet system	x	1 2 5
		SS115 Reliability, rate gyros	x	1 2 2

CONCEPT DESCRIPTION

CONCEPT MEDIUM ALTITUDE COMMUNICATIONS SATELLITE

DESIGNATOR EO13

MISSION OBJECTIVES Worldwide, low-cost commercial communications service using earth satellites with emphasis on high quality performance over long ranges. The system consists of satellites at medium altitudes and provides continuous service in densely populated latitudes with sporadic service in low density regions. Terminal equipment of medium complexity and cost is required.

GENERAL DESCRIPTION An unmanned mission in which a series of active relay satellites are placed in controlled 11,000 km orbits. Each satellite is equipped with a medium power transmitter/receiver serving about 1000 multiplex channels as well as a broadly directional antenna covering the disc of the earth. The satellites weigh 260 lbs. gross each and have a useful life over five years. Multiple injection of 5 to 8 satellites per launch booster is required for economy. Capability for performance monitoring and replacement of 12 - 18 orbiting satellites is required. Mission date lies in the 1970 period.

LIST OF SYSTEMS

B Booster (Atlas/Agena)
G *Ground Support Facility
S *Spacecraft

REFERENCES

1. H. Rosen, TRW/STL, Signal Magazine, May 1965, p. 90.

*Detailed description follows.

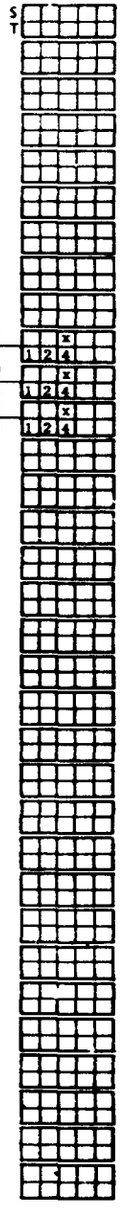
SYSTEM DESCRIPTION

Prelaunch checkout and maintenance.

Tracking and orbit establishment by existing networks.

System of ground-based communications terminals for two-way non-storage relay via the satellites.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
GD Data Proc.	Data processing equipment will be required at all terminals for encoding, decoding, addressing, sequencing, etc., the multiplexed messages (up to 1000 simultaneously). Individual messages must be prepared in the proper format and merged for transmission. Data rates will be on the order of 10^6 bits/sec for the processor.	SOA		
GR Comm.	Satellite tracking with two-way communication required. High gain antenna with low noise receiver. RF band width: approaching 10 mc Operating frequency: 1-6 gc Modulation: FM analog		GR11 UHF/SHF Transceiver	GR111 Signal to noise ratio GR112 Doppler compensation GR113 Antenna directivity



SYSTEM DESCRIPTION

The spacecraft will be carried into an elliptical orbit with apogee at 11,000 km altitude, and individual spacecraft propulsion units used to circularize the orbit at that altitude. This will permit a single launch vehicle to inject 5 to 8 satellites in the appropriate orbit.

DESIGNATOR EO13S

CONCEPT MEDIUM ALTITUDE COMMUNICATIONS SATELLITE

SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (1 2 3 x 3)	Continuous power 300 watts, 5 years		SA11 Isotope decay/thermoelectric 300 watt SA12 Photovoltaic silicon solar cell plus AgCd battery	SA111 Specific energy (S 1 2 x 3) SA112 Waste heat rejection (1 2 x 4) SA113 Isotope resources (1 2 3 x 2) SA121 Specific power density, solar cells (1 2 x 3) SA122 Specific cost, solar cells (1 2 x 3) SA123 Specific cost, AgCd battery (1 2 x 3)
SP Propulsion	A small rocket motor capable of providing 50 to 75 m/sec ΔV for circularizing the spacecraft orbit is required. Spacecraft weight is about 200 lb. exclusive of propulsion. The propulsion unit may be released or ejected from the spacecraft after use.	SOA		
SR Comm. (1 2 3 x)	Channel capacity: 1000 multiplex 3KC bandwidth RF bandwidth: approaching 10 mc Antenna gain: 3-6 db Operating frequency: 1-10 gc Power output: 75 watts maximum Receiver noise: 6 db Modulation: FM analog		SR11 UHF/SHF Transceiver	SR111 Transmitter efficiency (1 2 x 3) SR112 Antenna gain (1 2 x 3) SR113 Multiple access (1 2 3 x 3)
SS Stab./Control (1 2 3 x 1)	Attitude control: 2° local vertical continuous		SS11 Gravity gradient plus damper	SS111 Attitude accuracy (1 2 4 x 1) SS112 Damping (1 2 4 x 1)
SV Vehicle	200 lb., 5 year life, low cost spacecraft	SOA		

Note: Data Processing integrated with communication subsystem G and N

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CONCEPT DESCRIPTION

CONCEPT SYNCHRONOUS METEOROLOGICAL SATELLITE

DESIGNATOR EO15

MISSION OBJECTIVES Operational weather advisory service using earth satellites as well as research through continuous observations and measurements of short-lived meteorological phenomena from fixed points over the equator and through pattern recognition and tracking of severe storms.

GENERAL DESCRIPTION An unmanned mission in which at least three synchronous equatorial satellites with stabilized high-resolution cameras, IR, UV, spectrometers, and RF sferics detectors are used to obtain global coverage at populous latitudes. Multichannel telemetry of data and actual pictures are to be transmitted to earth. The satellites gross 1000 lbs. each and have a useful life greater than two years. This mission is an operational version of a technology to be evaluated in ATS 4 (EO09). The mission date lies in the 1970 period.

LIST OF SYSTEMS

B Booster (Atlas/Agena/7K)
G *Ground Support Facility
S *Spacecraft

REFERENCES

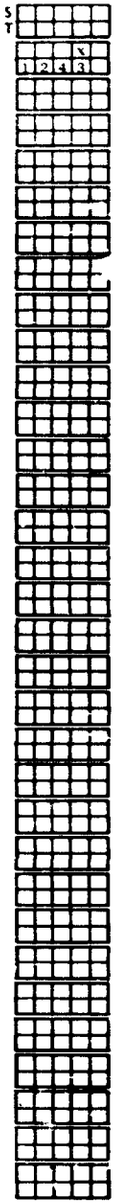
1. OSSA Concept, Same name

*Detailed description follows.

SYSTEM DESCRIPTION

A ground complex consisting of a programmed high gain antenna (transmit and receive), a narrow bandwidth up-command [illegible] and a wide bandwidth low noise receiver amplifier, tape recorder, control data processor, [illegible] age display.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
GD Data Proc. (1 2 4 3 X)	Digital (numerical) to pictorial display. Thunderstorm and tornado identification and tracking by pattern recognition--real time processing.		GD11 Central digital computer	GD111 Pattern recognition



SYSTEM DESCRIPTION

A 1,000 lb. spacecraft in synchronous equatorial orbit.
Spacecraft lifetime two years.

DESIGNATOR EO15S
CONCEPT SYNCHRONOUS METEOROLOGICAL SATELLITE
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power	Continuous power 750 watts		SA11 Nuclear fission reactor, thermoelectric SA12 Solar cells plus NiCad battery oriented panels 1500 watts	SA111 Specific power, nuclear reactor SA112 R&D required, nuclear reactor SA113 Waste heat rejection SA114 Reliability, nuclear reactor SA121 Abrasion, solar cells SA122 Specific power, solar cells SA123 Specific cost, solar cells SA124 Bearings, solar cell array SA125 Solar cell deployment SA126 Reliability, NiCad
SD Data Proc.	Analog to digital conversion to communications format.		SD11 Small digital processor	SD111 Reliability, digital processor
SI Task Instr.	Advanced camera systems to achieve 0.1 mi. resolution from synchronous altitude. Camera freedom ± 20 degrees 2 axes. Camera pointing 0.01 deg. with respect to spacecraft		SI11 High resolution TV camera with high resolution optics - digital electronics. Advanced digital IR, UV and spectrometer systems. Sensors stabilization by gimballed platform.	SI111 R&D required, TV camera SI112 R&D required, IR sensor SI113 R&D required, UV sensor SI114 R&D required, spectrometer SI115 R&D required, digital electronics
SP Propulsion	ΔV 200 m/sec Payload ~ 1000 lb. for orbit keeping		SP11 Storable hypergolic liquid rockets	SP111 Impulse accuracy
SR Comm.	Transmission data rate 5×10^6 bits/sec. Continuous readout Multi-channel telemetry		SHF transmitter, VHF/UHF transceiver, 50 W digital transmission, bandwidth 25 mc ATS 1, 2 & 3 (SOA	
SS Stab/Control	Attitude control +0.1 degree of local vertical Body rate: .001 deg/sec. Yaw control ± 0.1 degree	SS1 Rotation sensing SS2 Attitude actuation	SS11 Rate gyros, horizon scanner, and star tracker SS21 Cold gas reaction jet SS22 Magnetic torquing plus single axis cold gas reaction jet	SS111 Star identification star tracker SS112 Accuracy, horizon scanner SS113 Threshold, rate gyros SS114 Reliability, rate gyros SS211 Specific impulse, reaction jets SS221 Accuracy, magnetic torquing SS222 Limited torquing rates SS223 Specific impulse, reaction jets
SV Vehicle	Cylinder 5 ft. diameter by 6 to 8 ft. long Provision for sensor stabilization Environmental control for sensors SOA			

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CONCEPT DESCRIPTION

CONCEPT FM BROADCAST SATELLITE

DESIGNATOR EO19

MISSION OBJECTIVES Creation via earth satellite of direct radio broadcast service through the re-broadcast of program material direct to low-cost FM radio receivers throughout the populous latitudes from one or more fixed points over the equator. This concept follows technology development programs such as Technology Test Satellites I (EO09) and II (EO43).

GENERAL DESCRIPTION An unmanned mission in synchronous equatorial orbit with orbit-keeping ability carrying a high-power FM transmitter and a highly directional antenna. The antenna can be stabilized ±2° to ±5° by gravity gradient with passive damping or by hybrid active/gravitational means. The satellite grosses 2000 lbs. and broadcasts program material received from specific earth terminals. Two to three KW of power are required to provide the desired clear channel FM operation. The mission date lies in the 1971 period.

LIST OF SYSTEMS

B Booster (Atlas/Centaur/7K)
G Ground Support Facility (High Gain FM Transmitter)
S *Spacecraft

REFERENCES

1. OSSA, FM Broadcast Satellite,
2. Space Aeronautics, Aug 1965, p. 55.

*Detailed description follows.

SYSTEM DESCRIPTION

A 2,000 lb. spacecraft placed in equatorial synchronous orbit for direct relayed FM broadcasting to selected areas of the earth. Expected life three years.

DESIGNATOR [illegible]
CONCEPT FM BROADCAST SATELLITE
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES		S T
SA Aux. Power (1 2 x 3)	Continuous power requirement 1,000 watts	SA11	Solar cell plus AgCd battery, 2-3KW array	SA111	Attrition, solar cells	1 1 2 5
				SA112	Specific power, solar cells	1 2 x 3
				SA113	Specific cost, solar cells	1 2 x 3
				SA114	Solar cell deployment	1 2 x 2
				SA115	Radiation damage, semiconductors	1 2 x 3
				SA116	Reliability, AgCd battery	1 2 x 3
SG Guid/Nav. (1 2 x 4)	Injection into synchronous equatorial orbit Velocity ± 1.0 m/sec. Position ± 2 km Angle ± 0.25 degrees Station-keeping velocity ± 0.1 m/sec.	SG11	Radio command with onboard strap-down inertial system	SG111	R&D required, inertial system	1 2 x 4
SP Propulsion (1 2 x 2)	Δ V 150 m/sec. Payload 2,000 lbs.	SP11	Storable hypergolic liquid rocket	SP111	Specific impulse	1 2 x 2
				SP112	Reliability, liquid rocket	1 2 x 2
SR Comm. (1 2 x 3)	FM bandwidth 75 KC Frequency change capability Operate with state-of-the-art commercial FM receivers with -110 dbm sensitivity Beam width 16.5 degrees	SR11	VHF FM transceiver antenna gain 20 db, antenna diameter 45 ft., 250 watt transmitter	SR111	Antenna deployment	1 3 x 4
				SR112	Transmitter life	1 2 x 3
				SR113	Transmitter efficiency	1 2 x 3
SS Stab/Control (1 2 x 4)	Attitude control ± 5 degrees Initial stabilization on injection Yaw stabilization ± 5 degrees	SS11	Gravity gradient with damping, cold gas jets for stabilization during thrusting and for roll control	SS111	Damping, gravity gradient	1 2 4 x 1
SV Vehicle	Antenna and solar cell deployment in space	SV11	Cylinder spacecraft with 1,000 sq. ft. of solar cells plus 45 ft. dia. antenna (See Aux. Power & Communications) SOA			

CONCEPT DESCRIPTION

CONCEPT RADIO ASTRONOMY SATELLITE

DESIGNATOR EO21

MISSION OBJECTIVES Mapping by earth satellite of selected portions of the sky in the radio frequency portion of the spectrum, study of the gaseous structure of the galaxies at very long wave-length, and study of radio stars. This concept follows the Solar Radio Satellite (EO01).

GENERAL DESCRIPTION An unmanned mission in a 2000 km orbit similar to the Radio Astronomy Observatory. A two to five ton spacecraft/antenna pointable and stabilized is used. Spacecraft contains four antennas ranging from 5 to 15 feet in diameter. The mission date lies in the 1970-1973 period.

LIST OF SYSTEMS

B Booster (Atlas/Centaur or Saturn I-B)
G Ground Support Facility (STADAN)
S *Spacecraft

REFERENCES

1. OSSA, Radio Astronomy Observer

*Detailed description follows.

SYSTEM DESCRIPTION

A stabilized 2 - 5 ton spacecraft launched into 2,000 km orbit. The spacecraft has a 15-ft. fixed parabolic antenna and three 5-ft. steerable radio astronomy parabolic antennas plus a steerable communications antenna.

DESIGNATOR EO21S
CONCEPT RADIO ASTRONOMY SATELLITE
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S: x; T: 1 1 3)	Continuous power 100 - 200 watts	SA11	Solar cells plus NiCad Battery	SA111 Specific cost, solar cells (S: x; T: 1 2 3) SA112 Specific power, solar cells (x: 1 2 3) SA113 Reliability, NiCad (x: 1 1 2 3)
SD Data Proc. (x: 1 2 4)	The data processing requirements for this system have not yet been studied in any detail. It is anticipated that the data processor will serve as a means of collecting, temporarily storing, formatting, possibly compacting, and transmitting to the communications system the information derived from the RF sensors. This information must be annotated with attitude information andtime for further analysis and construction of RF energy distribution maps. Requirement for programmed antenna pointing.	SD11	Small digital processor plus variable speed tape recorder	SD111 Reliability, digital processor (x: 1 2 4) SD112 Reliability, tape recorder (x: 1 2 4) SD113 R&D required, tape recorder (x: 1 2 4)
SI Task Instr. (x: 1 1 2)	Requirement to track four simultaneous radio noise sources.	SI11	Low noise amplifiers Three steerable 5-ft. parabolic antennas plus a fixed 15-ft. parabolic antenna. Requirement for simultaneous operation of all antennas. 15 ft. antenna: 250-1000 mc band 5 ft. antenna: study of radio stars	SI111 Reliability, antenna steering (x: 1 1 2) SI112 Antenna deployment (x: 1 1 2)
SR Comm. (x: 1 1 2)	Data and command link - data to be transmitted includes antenna pointing position and magnitude of the received signals. The command signals will include antenna positioning data and instrument operating modes. Spacecraft communication system operates with STADAN ground based system.	SR11	UHF/VHF transceiver, steerable parabolic antenna, down link gain +12 db, 35° beam	SR111 Reliability, antenna steering (x: 1 1 2)
SS Stab/Control (x: 1 2 3)	Initial spacecraft attitude from command ± 0.5 degree. 5-ft. antenna pointing (multi-antennas) ± 0.1 degree with respect to spacecraft.	SS11	Gimballed horizon sensor and strapdown rate gyros. Strapdown attitude gyros. Cold gas reaction jets.	SS111 Reliability, rate gyros (x: 1 2 3) SS112 Reliability, attitude gyros (x: 1 2 3) SS113 Reliability, horizon sensors (x: 1 2 4) SS114 Specific impulse, cold gas jets (x: 1 2 3)

CONCEPT RESOURCE SURVEY SATELLITE

DESIGNATOR EO23

MISSION OBJECTIVES The survey by earth satellite of natural resources and the examination of changes in natural and ecological features on the earth's surface. This mission surveys such things as tillable land, oil and mineral deposits and monitors such things as cultivated vegetation, forests, land use, ocean currents, metropolitan growth, detection of air and water polution. It provides worldwide resource management information on food, etc., to aid in early distribution of resources in anticipation of shortages.

GENERAL DESCRIPTION An unmanned mission in a 375 km orbit, inclined 60°, equipped with a variety of instruments ranging from optical cameras, IR, UV and microwave radiometers to laser and microwave radars. Selection of instruments and data processing for various survey objectives is controlled in accordance with stored subroutines commanded periodically from earth. Multichannel telemetry to earth includes photo facsimile capability. Both macroscopic and selected high resolution coverage are included. The satellite weighs 2,000 lbs. Mission date is in the 1972-74 period.

LIST OF SYSTEMS

B Booster (Atlas/Agena)
G Ground Support Facility (STADAN)
S *Spacecraft

REFERENCES

1. "Manned Earth Orbital Program in Earth Sensing", Univ. of Michigan/IBM, 65-825-1472, Apr 1965.

*Detailed description follows.

SYSTEM DESCRIPTION

A 2,000 lb. spacecraft designed to carry a multiple of sensor payloads. Spacecraft is launched into 375 km 60° orbit. Spacecraft lifetime one year.

DESIGNATOR EO23S

CONCEPT RESOURCE SURVEY SATELLITE

SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S: x; T: 1 2 3)	Continuous power 750 watts	SA11	Solar cells plus NiCad battery 1500 watts	SA111 Specific cost, solar cells (S: x; T: 1 2 3) SA112 Specific power, solar cells (x; 1 2 3) SA113 Reliability, NiCad (x; 1 1 2 3)
SD Data Proc. (x; 1 2 4)	Onboard data processing to compare sensor data with that obtained from previous pass. Output communication rate 10^6 bits/sec. Recorder capability 10^{12} bits Data compaction by large scale onboard digital computer may be required.	SD11	Large capacity digital computer and tape recorder	SD111 R&D required, digital computers (x; 1 2 4) SD112 R&D required, pattern recognition techniques (x; 1 2 4 3) SD113 R&D required, recorder high speed readout (x; 1 2 4) SD114 Data compression (x; 1 2 4 5)
SI Task Instr. (x; 1 2 4)	Nine simultaneous photographs every 5 seconds. Resolution 200 ft. Camera platform rate (tracking) < 10^{-3} deg/sec.	SI11	Multi-lens camera - platform mounted IR, UV and microwave radiometers Possibly laser & microwave radars	SI111 R&D required camera platform (x; 1 2 3) SI112 R&D required, high resolution high fidelity color TV (x; 1 2 6)
SR Comm. (x; 1 2 3)	Transmission data rate 10^6 bits/sec (max.)	SR11	SHF solid state transmitter with 1000 mc total bandwidth (possibly multi-channel) VHF/UHF transceiver. Steerable antenna 5 deg. beam 30 db. Pilot beam steering Omni-directional receive antenna	SR111 Wide band modulation, SHF (x; 1 2 3) SR112 Antenna, steering (x; 1 2 3) SR113 Transmitter efficiency (x; 1 2 3) SR114 Communication efficiency (x; 1 1 2 3)
SS Stab/Control (x; 1 2 4)	Attitude accuracy ± 1.0 deg - 3 axes local vertical Body rate < 10^{-2} deg/sec. Camera pointing accuracy	SS11 SS12	Gravity gradient with magnetic torquing gyro compassing Hypergolic reaction jets with strapdown rate gyros and horizon scanner	SS111 Attitude accuracy gravity gradient (x; 1 2 4 1) SS112 Damping, gravity gradient (x; 1 2 4 1) SS121 Reliability, rate gyros (x; 1 2 3) SS122 Reliability, horizon scanner (x; 1 2 4) SS123 Reliability, reaction jets (x; 1 2 3) SS124 Minimum impulse reaction jets (x; 1 2 3)
SV Vehicle	Compatible with varying experiment requirements. Thermal control compatible with experiment resolution constraints.	SOA		

CONCEPT DESCRIPTION

CONCEPT NAVIGATION ADVISORY SATELLITE

DESIGNATOR EO25

MISSION OBJECTIVES Global all-weather navigation and traffic control capabilities using earth satellites for airborne, seaborne, orbital and suborbital vehicles. The satellites also include the communication channels required for this purpose.

GENERAL DESCRIPTION An unmanned mission, synchronous equatorial, providing position fixes to interrogating vehicles. Both user vehicles and ground control stations are equipped with radio links to the satellite including pulse transponders for distance measurement. The satellites use RF interferometers and pulse ranging to obtain raw data on user vehicle positions. This data is relayed to ground control stations, translated to position fixes by computers there, and relayed back via the satellite to the users. The satellite, similar to CN-2, grosses 900 lbs. equipped with 150-foot boom antennas. The mission date lies in the 1972 period.

LIST OF SYSTEMS

B Booster (Atlas/Centaur)
G *Ground Support Facility
S *Spacecraft

REFERENCES

1. OSSA, CN-1, CN-2
2. "Navigation Satellite System", Westinghouse, Def. & Space Center, 30 Jan 1964
3. Space Aeronautics, Jan 1965, p. 60.

*Detailed description follows.

SYSTEM DESCRIPTION

Orbital tracking and control by existing networks.

System of surface-based navigation and traffic control stations at surveyed sites relative to which the positions of user vehicles will be determined. Data processing and communications equipment at each site will correlate distance and angle data received from the satellite pertaining to users and the control station, respectively. Computed longitude and latitude and a coded user address will be relayed back to each user via the satellite on a time-sharing basis.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
GD Data Proc.	The data processing system will compute the position of the user (aircraft, ship, etc.) based upon range and angle measurements from one or more satellite and knowledge of the ephemerides of the satellites. This position will then be relayed to the user via the satellite. High speed processing and memory access, programming flexibility to accept and properly compute desired information. Processing frequency may be as high as one per three seconds on the average.	GD11 Commercial type digital computer	GD111 Navigation software	
GM D/D/T	High accuracy radar ranging from ground station	Three gound stations SECOR	SOA	

SYSTEM DESCRIPTION

The satellite is a 900-pound structure consisting of a cylinder with a long vertical rod for gravity gradient stabilization and four orthogonal 150-ft. booms holding antennas for radio interferometer measurements, distance measurement, and communications. Spacecraft lifetime three years.

DESIGNATOR EO25S
CONCEPT NAVIGATION ADVISORY SATELLITE
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES	S T
SA Aux. Power (1 2 3 x)	Peak Power: 1,000 watts Continuous Power: 500 watts - 3 years		SA11 Silicon solar cells plus NiCad battery (1000 watts)	SA111 Abrasion, solar cells SA112 Specific power, solar cells SA113 Specific cost, solar cells SA114 Radiation damage, semi-conductors SA115 Reliability, NiCad battery	1 1 2 5 x 1 2 3 x 1 2 3 x 1 2 3 x 1 1 2 3 x
SD Data Proc.	Data processing required to handle interrogations by a large number of users. Processor will handle multiple access, antenna beaming and address sequencing of interrogating stations. Requirements - 20 interrogations per minute (about 10^3 bits/sec.) Storage for 20 simultaneous interrogations	SOA	Small special purpose digital computer Random access memory SOA		
SG Guid/Nav.	Injection into synchronous equatorial orbit Velocity: ± 1.0 m/sec. Position: ± 2 km Angle: ± 0.25 degrees Station-keeping velocity ± 0.1 m/sec.		Radio ground command with onboard strapdown inertial SOA		
SP Propulsion (1 2 2 x)	Δ V 150 m/sec. Spacecraft weight 900 lbs.		SP11 Storable hypergolic liquid rocket	SP111 Specific impulse SP112 Reliability	1 2 2 x 1 2 2 x
SR Comm. (1 2 2 2 x)	Multiple access Transmit/Receive data rate 10^3 bits/sec. Range 10,000 km Transponder required		SR11 VHF/UHF 10-watt transceiver (4) 150 ft. pole antennas - interferometer receiver - phased array antenna - transmitter transponder	SR111 Transmitter efficiency SR112 Multiple access SR113 R&D required, phased array SR114 R&D required, interferometer techniques	1 2 3 x 1 2 3 3 x 1 2 2 3 x 1 2 2 3 x
SS Stab/Control (1 2 4 1 x)	Attitude accuracy ± 1.0 degrees		SS11 Gravity gradient plus damper	SS111 Attitude accuracy, gravity gradient SS112 Damping, gravity gradient	1 2 4 1 x 1 2 4 1 x

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CONCEPT DESCRIPTION

CONCEPT IMPROVED SYNCHRONOUS COMMUNICATIONS SATELLITE

DESIGNATOR EO27

MISSION OBJECTIVES Worldwide commercial communications service using earth satellites with multiple access to 1200 voice channels (or equivalent) provided by each satellite and additional channels and backup redundancy afforded by overlapping coverage. The satellite system is spaced in synchronous equatorial orbit. This concept follows gravity gradient experiments such as Technology Test Satellite (EO09).

GENERAL DESCRIPTION An unmanned mission similar in general configuration to SYNCOM with gravity gradient stabilization. The satellite grosses 1500 lbs.and has a useful life over five years. The mission date lies in the 1972 period.

LIST OF SYSTEMS

B Booster (Atlas/Agena)
G Ground Support Facility (Early Bird Type)
S *Spacecraft

REFERENCES

1. OSSA Concept
2. Space Aeronautics, Jan 1965.

*Detailed description follows.

SYSTEM DESCRIPTION

A 1500 lb. spacecraft drawing on ATS experiment technology.
Satellite is placed in equatorial synchronous orbit.

DESIGNATOR EO27S
CONCEPT IMPROVED SYNCHRONOUS COMMUNICATIONS SATELLITE
SYSTEM Spacecraft

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

SA Aux. Power

Peak power: 1000 watts
Continuous power: 500 watts, 5 years.

Note: No onboard data processing--see communications.

SG Guid. /Nav.

Injection into synchronous equatorial orbit
Velocity 1.0 m/sec
Position accuracy 2 km
Angle 0.25°
Station keeping velocity: 0.1 m/sec

SP Propulsion

For station keeping: 150 m/sec

Payload: 1500 lbs.

SR Comm.

Channel capacity: 1200 3K voice channels with multiple access
Operating frequency: 1-10 gc
Power output: 100 watts
Modulation:
Beam width: 16.5° for 1/2 power point

SS Stab. /Cont.

Attitude control: 2 day of local vertical
Despin after injection
Null body rates to 0.02 deg/sec

SV Vehicle

1500 lb, 5 year life - 8 to 9 ft. antenna

SOA

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

SA11 Solar cells plus AgCd battery
- SA111 Abrasion, solar cells
- SA112 Specific power, solar cells
- SA113 Specific cost, solar cells
- SA114 Specific cost, AgCd battery
- SA115 Radiation damage, semi-conductors
- SA116 Reliability, AgCd battery

SA12 Isotope/thermoelectric
- SA121 Specific energy isotope
- SA122 Waste heat rejection
- SA123 Isotope resources

SG11 Radio command with onboard strap-down inertial system
- SG111 R&D required, inertial system

SP11 Electric propulsion system
- SP111 R&D required, electric propulsion
- SP112 Operating life, electric propulsion
- SP113 Inflight test, electric propulsion

SR11 UHF/SHF Transceiver
- SR111 Transmitter efficiency
- SR112 Antenna gain
- SR113 Multiple access

SS11 Gravity gradient with dampers plus cold gas reaction jet initial stabilization
- SS111 Attitude accuracy, gravity gradient
- SS112 Damping, gravity gradient

CONCEPT DESCRIPTION

CONCEPT TV BROADCAST SATELLITE

DESIGNATOR EO31

MISSION OBJECTIVES Direct TV broadcast service using earth satellites through rebroadcast of program material direct to low-cost television receivers in populous areas from one or more fixed points over the equator. Service to areas the size of Western Europe or India is anticipated as state-of-the-art in 1975.

GENERAL DESCRIPTION An unmanned mission in synchronous equatorial orbit with orbit-keeping ability carrying a high power television transmitter and an antenna of medium directivity. The antenna can be stabilized by servoed horizon control or other onboard sensors to maintain the intended coverage. The satellite broadcasts program material received from specific earth terminals and grosses at launch 20,000 lbs. (including 10,000 lbs. shroud). Size is a 20-foot diameter and a 60-foot height assuming nuclear reactor power (SNAP 8) plus an additional 10 feet in height for other payload and separation structures. The satellite has a useful life of two years. The mission date lies in the 1975 period.

LIST OF SYSTEMS

B Booster (Saturn I-B/Centaur)
G Ground Support Facility (High Gain TV Transmitter)
S *Spacecraft

REFERENCES

1. OSSA, TV Broadcast Satellite

*Detailed description follows.

SYSTEM DESCRIPTION

A 10,000 lb. spacecraft in equatorial synchronous orbit for direct TV broadcast to commercial home receivers. Approximately 10,000 lbs. of shielding shroud will be required for protection of ground personnel during launch. The shroud can be ejected after launch.

DESIGNATOR EO31S
CONCEPT TV BROADCAST SATELLITE
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (1 2 2 5)	Continuous power 10-35 KW for two years	SA11	Nuclear fission reactor, dynamic SNAP-8 type	SA111 R&D required nuclear reactors (1 2 2 6); SA112 High temperature materials (1 1 1 5); SA113 Shielding (1 1 2); SA114 Waste heat rejection (1 2 4); SA115 Wearout (1 2 2 6)
SG Guid/Nav. (1 2 4)	Injection into synchronous equatorial orbit Velocity ± 1.0 m/sec. Position accuracy ± 2 KM Angle ± 0.25 degrees Station-keeping velocity ± 0.1 m/sec.	SG11	Radio command with onboard strapdown inertial	SG111 R&D required, inertial system (1 2 4)
SP Propulsion (2 2 2 3)	Δ V 150 m/sec. Payload 9,600 lbs.	SP11	Electric propulsion system	SP111 R&D required, electric propulsion (2 2 2 3); SP112 Operating life, electric propulsion (2 2 2 3); SP113 Inflight test, electric propulsion (2 2 2 3)
SR Comm. (1 2 3)	TV bandwidth 4 mc (one channel) Frequency change capability Operate with existing "rabbit ear" commercial TV sets (operating freq 100 mc) Beam width 16.5 degrees	SR11	VHF TV transceiver 1.0 KW minimum antenna gain 20 db antenna diameter 45 ft.	SR111 Transmitter life (1 2 3); SR112 Transmitter efficiency (1 2 3)
SS Stab/Control (2 2 2 3)	Attitude control ± 1 degree Initial stabilization on injection	SS11	Electric propulsion system with horizon scanner and star tracker	SS111 Planet sensor accuracy (1 2 4); SS112 Reliability, planet sensor (1 2 3); SS113 R&D required, electric propulsion (2 2 2 3)
SV Vehicle	Antenna erected in space		Cylinder spacecraft with 45 ft. antenna SOA	

CONCEPT DESCRIPTION

CONCEPT LOW ALTITUDE METEOROLOGICAL SATELLITE

DESIGNATOR EO33

MISSION OBJECTIVES Establishment of an operational weather advisory service. The satellites observe cloud formation, pressure, temperature, wind and water vapor at various altitudes over the entire globe. In addition, they will serve as relay stations for the collection of weather data from remote sites.

GENERAL DESCRIPTION An unmanned mission of the advanced NIMBUS type in 1400 km circular orbit carrying camera systems, IR, UV and spectrometers as well as microwave sensors. The satellites readout data in digital form for telemetry to earth in response to interrogation. Each grosses about 1500 lbs. Their useful life is around two years. The mission date lies in the 1976 period.

LIST OF SYSTEMS

B Booster (Thor/Agena)
G Ground Support Facility (Alaskan CDA)
S *Spacecraft

REFERENCES

1. OSSA, Nimbus Follow-on
2. Space Aeronautics, Jan 1965, p. 55.

*Detailed description follows.

SYSTEM DESCRIPTION

A 1500 lb. Nimbus type spacecraft in 1400 km polar orbit.

Spacecraft life - two years.

DESIGNATOR EO33S

CONCEPT LOW ALTITUDE METEOROLOGICAL SATELLITE

SYSTEM Spacecraft (Page 1 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (1 2 3)	Continuous power: 500 watts		SA11 Nuclear fission reactor, thermoelectric generator (SNAP 10A) 500 watts (650 lbs.)	SA111 Specific power (S 1 2 3); SA112 R&D required, thermoelectric conv. (1 2 3 10); SA113 Waste heat rejection (1 2 4); SA114 Reliability, nuclear reactor (1 2 3)
			SA12 Solar cells plus Nicad battery, oriented panels, 1000 watts.	SA121 Abrasion, solar cells (1 1 2 5); SA122 Specific power, solar cells (1 2 3); SA123 Specific cost, solar cells (1 2 3); SA124 Bearings, solar cell array (1 2 3); SA125 Solar cell deployment (1 2 2); SA126 Reliability, NiCad (1 1 2 3)
SD Data Proc. (1 2 4)	Input data rate: 10^3 to 10^5 bits/sec digital Output comm. rate: 10^7 bits/sec video Temporary storage: 10^5 bits Tape storage: 10^9 bits		SD11 Small digital data processor plus video encoder & tape recorder	SD111 Reliability, digital data processor (1 2 4); SD112 Memory density, tape recorder (1 2 4); SD113 Data compression (1 2 4 5); SD114 R&D required, high speed tape recorder (1 2 4); SD115 Reliability, tape recorder (1 2 4)
SI Task Instr. (S T 1 2 2)	TV, IR, Scanning spectrometer		SI11 Advanced vidicon cameras system Automatic picture taking system High resolution IR radiometer UV scanner Interferometer Microwave sensors	SI111 R&D required, interferometer (S T 1 2 2); SI112 R&D required, microwave sensors. (1 2 2)
SR Comm. (1 2 2 3)	Transmission data rates: 10^7 bits/sec (100 seconds max.) Readout on command.		SR11 VHF/UHF transceiver SHF transmitter High gain phased array antenna - +30db Bandwidth - 30 mc Digital transmission	SR111 Communications efficiency, SHF (1 1 2 3); SR112 Antenna gain, phased array (1 2 2 3); SR113 Antenna pointing, phased array (1 2 2 3); SR114 Transmitter efficiency, SHF (1 2 3); SR115 Transmitter reliability, SHF (1 2 3)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SS Stab/Control	Attitude control: ±0.1 degrees Body rate: .001 degree Yaw control: ±1.0 degree	SS1 Rotation sensing	SS11 Rate gyros, horizon sensors, and star tracker	SS111 Reliability, star tracker SS112 Accuracy, horizon scanner SS113 Threshold, rate gyros SS114 Reliability, rate gyros SS115 Reliability, horizon scanner
		SS2 Attitude Actuation	SS21 Hypergolic reaction jets plus gravity gradient with cold gas jet damper	SS211 Reliability, reaction jets SS212 Specific impulse, cold gas jet SS213 Attitude accuracy, gravity gradient
			SS22 Hypergolic reaction jets plus gravity gradient with magnetic damping.	SS221 Reliability, reaction jets SS222 Earth field compensation, magnetic damper SS223 Attitude accuracy, gravity gradient
			SS23 Hypergolic reaction jets plus gravity gradient with lossy spring damping	SS231 Reliability, reaction jets SS232 Attitude accuracy, gravity gradient SS233 Attitude interference, lossy spring
SV Vehicle	Nimbus type with large solar cell array (See Aux. Power)	SOA		

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CONCEPT DESCRIPTION

CONCEPT PHASED NAVIGATION SATELLITE

DESIGNATOR EO37

MISSION OBJECTIVES Creation of a method of low-cost surface navigation, without the need for computers, by using a doppler receiver and a book of tables. Accuracy is around ± 5.5 km.

GENERAL DESCRIPTION An unmanned mission with three satellites in 750 km orbits, one satellite at 0° inclination and two others at 90° inclination, phased 90° apart, transmitting time and instantaneous satellite longitude and latitude as well as a CW doppler tracking signal. The satellites weigh 1500 lbs., each and have a useful life of three years. Residual drift is published as time corrections in NOTOMs, broadcast by each satellite in simple code, and periodically compensated by orbit-keeping adjustments. The mission date lies in the 1968-1970 period.

LIST OF SYSTEMS

B Booster (Thor/Agena)
G *Ground Support Facility
S *Spacecraft

REFERENCES

1. 1964 PATTERN D0631.

*Detailed description follows.

SYSTEM DESCRIPTION

Ground equipment necessary to launch precisely on time and to determine actual orbit and compute corrective thrusts and station-keeping thrusts. All computations of navigational position of the satellite, corrective information to issue to users, and updating data to reset spacecraft data processing system with proper ephemerides and time values.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
	NOTE: No advances in state-of-the-art are anticipated in order to provide the necessary launch, tracking, communications, and control functions for this concept. Generation of ephemeris data required NOTOMS			
GR Comm.	Determine satellite position, transmit orbit upgrade data to satellite, command correcting maneuvers.		Several stations will be required to accurately determine the satellite position. The master station will use a medium power transmitter to upgrade the data and command the vehicle SOA	

S
T

SYSTEM DESCRIPTION

1500 lb. satellite with continuous FM transmission of time and latitude and longitude, periodically resettable from earth. Area rather than directional radio radiation.

DESIGNATOR EO37 S
CONCEPT PHASED NAVIGATION SATELLITE
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S/T 1 2 3 x)	Estimated continuous power 150-250 watts	SOA	SA11 Solar cells plus NiCad battery ~ 500 watt	SA111 Abrasion, solar cells (S/T 1 1 2 5 x); SA112 Reliability, NiCad (1 1 2 3 x); SA113 Specific cost, solar cells (1 2 3 x); SA114 Specific area, solar cells (1 1 2 5 x); SA115 Specific power, solar cells (1 2 3 x)
SD Data Proc.	Onboard storage of data transmitted from ground station		SD11 Onboard continual readout recorder	SOA
SG Guid/Nav. (1 2 4 x)	Orbit correction as required		SG11 Radio command with strapdown inertial	SG111 Reliability, inertial system (1 2 4 x); SG112 R&D required, inertial system (1 2 4 x)
SR Comm. (2 2 5 x)	2-channel communication Transmit - (1) recorded orbital data (2) ultra stable frequency reference (2 parts in 10^9/day) Receives - (1) update information for recorder (2) commands for orbit changes		SR11 Airborne oscillator (clock) 25 watt transmitters VHF/UHF dual transceiver	SR111 Oscillator stability (2 2 4 x)
SS Stab/Control (1 2 4 1 x)	Attitude accuracy ± 3.0 degrees		SS11 Gravity gradient plus dampers	SS111 Attitude accuracy, gravity gradient (1 2 4 1 x); SS112 Damping, gravity gradient (1 2 4 1 x)
SV Vehicle		SOA		

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CONCEPT DESCRIPTION

CONCEPT LONG TERM BIOSATELLITE

DESIGNATOR EO39

MISSION OBJECTIVES Performance aboard an earth satellite of space biology experiments involving highly instrumented primates in low earth orbits. Secondary objectives include development of life support systems and techniques for long-duration manned space flight. This mission precedes any long duration manned flights.

GENERAL DESCRIPTION An unmanned mission in a 475 km circular or polar highly elliptical orbit conducting space biology experiments for periods of 90 - 180 days. Spacecraft design accommodates up to 2500 lbs. payload. Recovery of a 500-lb. module is provided for. The mission date lies in the 1969-1971 period.

LIST OF SYSTEMS **REFERENCES**

B Booster (TAT/Agena/7K)
G Ground Support Facility (STADAN)
S *Spacecraft

*Detailed description follows.

SYSTEM DESCRIPTION

A 2,500 lb. spacecraft in 465 km circular near-equat orbit, or polar highly elliptical orbit. Return 500 lbs. to earth for recovery is required. Orbi lifetime is 90 - 180 days.

DESIGNATOR EO39S
CONCEPT LONG TERM BIOSATELLITE
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (1 2 x 4)	Continuous power 250 watts Peak power 1000 watts		SA11 H_2O_2 fuel cell ≈ 600 lbs. for 90 - day mission. SA12 Solar cell plus NiCad battery - 500 watts	SA111 Specific power fuel cells (S 1 2 x 4) SA112 High load efficiency (1 2 x 4) SA113 Service life, fuel cells (1 2 x 4) SA121 Specific cost, solar cell (1 2 x 3)
SD Data Proc. (1 2 x 4)	Programming of experimental events. Commutate telemetered data Code telemetered data Recoverable data storage: 10^9 bits		SD11 Small digital computer, plus tape recorder. Reprogrammable from ground command.	SD111 Reliability, tape recorder (1 2 x 4) SD112 Memory density, tape recorder (1 2 x 4) SD113 Reliability, digital computer (1 2 x 4)
SE Escape/Recy.	Safe return of 500-lb. primate payload.	SOA		
SH Life Support (1 2 x 4)	Life support to provide for 90 to 180 days. Earth atmosphere Thermo control Water Food Waste management Meteoroid and radiation shielding Shock/vibration protection		SH11 Automatic: Nitrogen/oxygen system Fuel cell water, if used, tanked water, if not. Stored food. TPH system	SH111 Contaminant removal, N/O (1 2 x 4) SH112 Pressure control, TPH (1 2 x 4) SH113 Waste disposal (1 1 x 3)
SI Task Instr.	Similar to NASA Biosatellite. 90 - 180 day duration, larger subjects.	SOA		
SR Comm.	State-of-art telemetry. Transmission rate 10^6 bits/sec	SOA	UHF Transceiver - 5 mc bandwidth. SOA	
SS Stab/Control	Attitude rate control: 0.1° Deorbit attitude control and spin up.	SOA	Hypergolic reaction jets with rate gyros, horizon sensors, orbital gyro compassing. SOA	
SV Vehicle	2500 lb. vehicle with 500 lb. re-entry body.	SOA		

CONCEPT DESCRIPTION

CONCEPT RELATIVITY SATELLITE

DESIGNATOR EO41

MISSION OBJECTIVES Verification, using an earth satellite, of one implication of relativity — that a clock in a gravitational field different from that of the earth will run at a different rate because of the gravity dependence of time (dilatation). This checks the "twin paradox" postulate, measures the velocity of light in free space, and investigates whether space is truly isometric by measuring the velocity of light in various vehicle velocities.

GENERAL DESCRIPTION An unmanned mission in a 15,000 km orbit carrying an atomic clock with precision better than 1 second per thousand years. The clock frequency is 9.193 gigacycles. In this orbit, the clock should show a time difference of about one second in 60 years. A one-year experiment seeks a 1/60 second difference in indicated time lapse between the satellite clock and its earth-based twin. The vehicle will re-enter to a recovery area after one year to permit comparison of space clock with earth-based twin. During the year in orbit clock frequency and present accumulated time would be telemetered and compared with that of the ground-based clock. Comparison after recovery would verify indicated results. The mission date lies in the 1970 period.

LIST OF SYSTEMS

B Launch Booster (Atlas/Agena)
G Ground Support Facility
S *Spacecraft

*Detailed description follows.

REFERENCES

1. Electronic Design, July 22, 1959, "U. S. Will Orbit Maser Clock in New Check on Relativity," (contract to Hughes Aircraft Co.)
2. Machine Design, July 23, 1959, "Atomic Clock in Orbit Will Check Relativity Theory"
3. AIAA Paper 65-492, "A Small SOA Maneuverable Re-entry Body," R. T. Clapp, July 1965.

SYSTEM DESCRIPTION

A cylindrical structure about 3 ft. diameter by 6 ft. long weighing about 550 lbs A separable re-entry capsule contains the scientific payload. The vehicle would be launched into a 15,000 km circular orbit by an Atlas/Agena from AMR. It would remain in orbit for one year. 9,000 hours overall reliability of about 0.8 will be required.

DESIGNATOR EO41S
CONCEPT RELATIVITY SATELLITE
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S: x; T: 1 2 3)	Clock power continuous 50W at 26V d-c. Transmitter power continuous 20W Miscellaneous power: 100 W, intermittent. Total 170 W		SA11 80 lbs. of body mounted N/P silicon solar cells. 85 lbs. of NiCad storage batteries. 5 lbs. power conditioning electronics.	SA111 Specific cost, solar cells (S: x; T: 1 2 3)
SD Data Proc. (x; 1 1 2)	Clock countdown and accumulation of frequency from cesium beam tube resonator to produce coding representing percent, indicated, onboard time. Error must be less than 1 part in 10^{11}. Count must be immune to power interruptions. Input rate 9.193 gigacycles. Output rate 200 bits/sec.		SD11 Countdown electronics, miniaturized and space rated	SD111 R&D required, countdown electronics (x; 1 1 2) SD112 Temperature control (x; 1 1 2) SD113 Reliability, countdown electronics (x; 1 1 2)
SE Escape/Recy. (x; 1 1 2)	Clock must be kept in operation during and after recovery for at least ten hours by NiCad batteries. Re-entry is by ablative heat shielded maneuverable lifting body.		SE11 Start/Prime type vehicle (carrying experiment package). Parachute recovery (of entire re-entry vehicle).	SE111 R&D required, parachute recovery (x; 1 1 2)
SG Guid/Nav. (x; 1 2 4)	G&N for re-entry. Vehicle must align and retrofire upon ground command, then re-enter. Radar tracking and command guidance begins at about 50 km altitude. Maximum down range error +110 n.m., -85 n.m. Cross range +24, -23 n.m. Ground guidance to within 5 mile circle.		SG11 Horizon scanner and strapdown inertial system under control of command receiver and onboard digital computer. Subsystem weighs about 40 lbs. Ground radar guidance after re-entry by tracking onboard transponder	SG111 Shutdown reliability, inertial system (x; 1 2 4)
SI Task Instr. (x; 1 2 2)	Long beam cesium 133 resonator tube must operate continuously during entire mission to produce a 9+ gigacycle stable frequency counted down for clock drive. Clock is synchronized with earth-based mate prior to lift-off, and compared after recovery. Present, accumulated onboard UT-2 time is transmitted each second. Temperature controlled to ± 2° C.		SI11 Space rated version of HP5060A cesium 133 beam frequency standard with HP515BR clock circuitry (modified for space use) and associated auxiliary equipment. Thermal isolation of sensitive packages with thermoelectric controlled junction heating and cooling versus non-illuminated vehicle skin.	SI111 R&D required for space rated frequency standard (x; 1 2 2) SI112 R&D required for thermoelectric control loop (x; 1 2 2)
SP Propulsion	Deboost re-entry body upon command (Δ V 300 m/sec. ± 1.5°)	SOA		
SR Comm.	Transmit 200 bits/sec continuous; range: 25,000 km	SOA		
SS Stabil/Control (x; 1 2 4)	± 5.0° local vertical and orbit plane during orbit with Agena. Align ± 1.5° for retrofire using horizon sensors and strapdown INS for gyrocompassing to orbit plane.		SS11 Cold gas jets, horizon sensor, strapdown rate gyros, attitude from strapdown INS. Spoiler tab for re-entry roll control	SS111 Reliability, rate gyros (x; 1 2 3) SS112 Reliability, horizon sensor (x; 1 2 4)
SV Vehicle (x; 1 2 5)	Start/prime type LRV small, maneuverable re-entry body mated with Agena		SV11 Maneuverable re-entry body	SV111 R&D required for vehicle (x; 1 2 5)

CONCEPT DESCRIPTION

CONCEPT TECHNOLOGY TEST SATELLITE 2

DESIGNATOR EO43

MISSION OBJECTIVES A set of satellites developed to test advanced technologies in communications, meteorology, navigation, etc. To be investigated: (1) techniques for signal acquisition between orbiting spacecraft and medium data rate transmission between earth satellites and planetary lander probes, (2) high resolution pointing of optical and IR sensors (± .2°), (3) demonstration and use of ionic or electric thrusters for precision attitude and period control and environmental measurements.

Depends upon results of Technology Test Satellite 1 (EO09) and in turn provides information needed for later communications and meteorological programs.

GENERAL DESCRIPTION Similar to ATS-5. An unmanned mission in which equipment to perform the above investigation is placed in synchronous equatorial orbit. Spacecraft weight, 1000-1400 lbs. Useful life two years. Two launches, about 1973 and 1974.

LIST OF SYSTEMS

B Booster (Thor/40K/7K)
G Ground Support Facility (STADAN/ATS)
S *Spacecraft

REFERENCES

1. OSSA, ATS-5

*Detailed description follows.

SYSTEM DESCRIPTION

A vehicle for technology development of spacecraft to spacecraft data or message techniques evaluated in earth orbit. Techniques will include simulation of medium data rate transmission between unmanned planetary landing experiments and earth satellite. Pointing of high resolution optical and/or IR sensors will be required. Three axis active control to ± 0.2° will be required. Orbit (period) control capability will be included. Environmental measurement experiments such as magnetic field and solar output would be carried. Spacecraft weight: 1,000 to 1,400 lb.

DESIGNATOR EO4[illegible] -76-

CONCEPT TECHNOLOGY TEST SATELLITE 2

SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S: 1 2 3; T: x)	Peak power: 1,000 W, 10% duty cycle Continuous power: 500 W, 2 years		SA11 Solar cells plus nickel cadmium battery and power conditioning (high voltage)	SA111 Reliability, solar cells (S: 1 2 3; T: x) SA112 Reliability, N.Cad battery (1 1 2 3; x) SA113 Abrasion solar cells (1 1 2 5; x) SA114 Specific power, solar cells (1 2 3; x) SA115 Radiation damage, semi-conductors (1 2 3; x)
SD Data Proc. (1 2 4; x)	Input data rate: 10^4 to 10^6 bits/sec. Output communication rate: 10^8 bits/sec. video Temporary data storage: 10^5 bits (program)		SD11 Small digital data processor with core memory plus video encoder	SD111 Reliability, digital processor (1 2 4; x) SD112 Noise, video encoder (1 2 5 2; x) SD113 Reliability, video encoder (1 2 3; x)
SG Guid/Nav. (1 2 4; x)	Injection into synchronous equatorial orbit Velocity: ± 1.0 m/sec Position accuracy: ± 2 km Angle: ± 0.25 degree Station keeping velocity ± 0.1 m/sec.		SG11 Radio command with onboard strapdown inertial system.	SG111 Reliability, inertial system (1 2 4; x) SG112 R&D required, inertial system (1 2 4; x)
SI Task Instr. (1 2 5; x)	Task instrumentation as required by mission		SI11 High resolution optics, TV, IR sensors; environmental measurements plus undefined experiment packages	SI111 R&D required, high resolution TV (1 2 6; x) SI112 R&D required, high resolution IR (1 2 6; x)
SP Propulsion (2 2 2 3; x)	Δ V 150 m/sec. Payload - 1,000 to 1,400 lb.		SP11 Hypergolic storable liquid rocket plus electrical propulsion system	SP111 R&D required, electric propulsion (2 2 2 3; x) SP112 Operating life, electric propulsion (2 2 2 3; x) SP113 Inflight test, electric propulsion (2 2 2 3; x) SP114 Reliability, liquid rocket (1 2 2; x)
SR Comm.	Transmission data rate: 10^3 to 10^5 bits/sec digital; 10^7 bits/sec video Temporal requirements: 40,000 km SOA			
SS Stab/Control (1 2 4; x)	Attitude control: ± 0.2° Pointing accuracy: ± 5° (solar cells) Body rate: .001 deg/sec.		SS11 Hypergolic reaction jets, electric propulsion actuator system plus rate gyros and horizon sensors (same rocket as station keeping propulsion)	SS111 Threshold rate gyros (1 2 4 5; x)
SV Vehicle	SOA			

CONCEPT DESCRIPTION

CONCEPT TECHNOLOGY TEST SATELLITE 3

DESIGNATOR EO45

MISSION OBJECTIVES A set of satellites developed to test advanced technologies in communications, meteorology, navigation, etc. To be investigated: (1) pointing and acquisition techniques for laser beams, (2) extremely high accuracy pointing of optical and IR sensors (10^{-5} to 10^{-6} deg), (3) environmental capabilities. Utilizes results of earlier test satellites to further technology development.

GENERAL DESCRIPTION Similar to ATS 6. An unmanned mission in which equipment to perform the above investigation is placed in synchronous equatorial orbit. Spacecraft weight 1000 -1400 lbs. Useful life two years. Two launches, 1977 and 1978.

LIST OF SYSTEMS

B Booster (Thor/40K/7K)
G Ground Support Facility (STADAN & ATS)
S *Spacecraft

REFERENCES

1. OSSA, ATS-6

*Detailed description follows.

SYSTEM DESCRIPTION

DESIGNATOR CONCEPT SYSTEM

EO45S

TECHNOLOGY TEST SATELLITE

Spacecraft

Primary purpose is to conduct experiments with active control systems suitable for laser transmission from satellite to satellite or from satellite to manned interplanetary vehicles. Required attitude accuracies will be 10^{-5} to 10^{-5} degrees. Included will be extremely high accuracy pointing of optical and IR sensors (a few hundred yards on the ground). 500 to 1,000 watts power is anticipated. Orbit (position) control will be required. Equipment will be included for demonstrating pointing and acquisition techniques for the very narrow beams associated with lasers and the optical sensors. Extremely high accuracy IR & TV sensors for meteorological and other applications would also be included.

In addition, environmental measurement experiments such as magnetic field and solar output would be carried. Two launches about 1977 and 1978.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S: x; T: 1 2 3)	Peak Power: 1,000 W, 10% duty cycle Continuous Power: 500 W, 2 years		SA11 Solar cells (sun seeking paddles) plus NiCad batteries	SA111 Reliability, solar cells (S: x; T: 1 2 3) SA112 Reliability, NiCad batteries (x; 1 1 2 3) SA113 Abrasion, solar cells (x; 1 1 2 5) SA114 Specific power, solar cells (x; 1 2 3) SA115 Radiation damage, semiconductors (x; 1 2 3)
SD Data Process. (x; 1 2 4)	Input data rate 10^4 to 10^6 bits/sec. Output communication rate 10^8 bits/sec. Temporary data storage 10^5 bits		SD11 Small digital data processor with digital memory plus video encoder	SD111 Reliability, digital processor (x; 1 2 4) SD112 Noise, video encoder (x; 1 2 3 2) SD113 Reliability, video encoder (x; 1 2 3)
SG Guid/Nav. (x; 1 2 4)	Guidance injection into equatorial synchronous orbit Velocity: ± 1.0 m/sec. Position Accuracy: ± 2 km Angle: ± 0.25 degree Station keeping velocity ± 0.1 m/sec.		SG11 Radio command with strapdown inertial system	SG111 Reliability, inertial system (x; 1 2 4) SG112 R&D required, inertial system (x; 1 2 4)
SI Task Instr. (x; 1 2 5)	As required for mission: Damage on parts and components. Pointing and acquisition of laser and optical equipment. Extremely high accuracy in optical and IR sensor pointing (few yards on ground) Continuing environment testing.		SI11 Very high resolution TV, high resolution IR imager, and environmental measurement equipment plus undefined experiment packages	SI111 R&D required, high resolution TV (x; 1 2 6) SI112 R&D required, high resolution IR (x; 1 2 6) SI113 Pointing accuracy, TV (x; 1 2 4)
SP Propulsion (x; 2 2 2 3)	Station keeping propulsion Δ V - 150 m/sec. Payload 1,000 - 1,400 lbs.		SP11 Electric propulsion system	SP111 R&D required, electric propulsion (x; 2 2 2 3) SP112 Operating life, electric propulsion (x; 2 2 2 3) SP113 Inflight test, electric propulsion (x; 2 2 2 3)
SR Comm. (x; 1 2 4 5)	Transmission data rate - 10^8 bits/sec. Ground communications and tracking with STADAN and ATS complexes. (Experiment equipment)		SR11 Laser transceiver plus instrumentation data link from 1970 STADAN state-of-the-art	SR111 Laser tracking (x; 1 2 4) SR112 Laser acquisition (x; 1 2 4 3) SR113 R&D required, laser (x; 1 2 4 3)
SS Stab/Control (x; 1 2 3)	Attitude control ± 10^{-5} to 10^{-6} for 2-year lifetime		SS11 Electric propulsion actuators plus ±.002 arc sec star trackers (two required). The star tracker would be an image dissector (counter torque to provide for sun seeking auxiliary power paddles)	SS111 R&D required, star trackers (x; 1 2 3) SS112 Knowledge of star positions (x; 1 1 1 5)
SV Vehicle		SOA		

CONCEPT DESCRIPTION

CONCEPT MANNED LUNAR SURVEY BASE

DESIGNATOR LD02

MISSION OBJECTIVES Exploration and mapping from a manned base of points of special interest on the lunar surface and subsurface, testing of man's usefulness as a lunar explorer, and determination of the usefulness of locations for sustained lunar exploration and colonization. This mission precedes the establishment of the Lunar Scientific Colony (LD04).

GENERAL DESCRIPTION A manned mission supporting three men for approximately ninety days on the lunar surface. The temporary base consisting of two modules is located in an area of major local interest landed unmanned by a lunar logistics vehicle. The modules, consisting of a crew shelter and a manned rover, are capable of reactivation and reoccupation for later intermittent use. Modified Apollo command and service modules are used to transfer personnel between Earth and lunar orbits. The command and re-entry module is capable of supporting three people for the two-way translunar flight plus re-entry to a water landing on earth. The service module provides life support and provisions for allowing sustained lunar orbit in support of the surface base operations. The Lunar Manned Lander will land three men in the vicinity of the shelter and return them to the orbiting command and re-entry module at the end of their lunar stay. The CSM will remain in a 35-114 km lunar orbit serving as a command and relay center, return vehicle to earth, and support vehicle to lunar exploration through high-resolution mapping and site location. The mission date lies in the 1970-1976 period.

LIST OF SYSTEMS

B Booster (Saturn V)
G Ground Support Facility (Saturn V)
L Lunar Manned Lander (Apollo SOA)
M Command and Re-Entry Module (Apollo SOA)
R *Rover
X *Lunar Shelter
Y *Lunar Logistics Vehicle
Z Orbital Service Module (Apollo SOA)

*Detailed description follows.

References

1. "Initial Concept of Lunar Exploration Systems for Apollo", Boeing Report, NASA CR-35, March, 1964.

SYSTEM DESCRIPTION

A two-man surface transportation vehicle which is landed on the moon with the Lunar Shelter 6(LD02)X, before the crew arrives. It is unpressurized, contains tankage for life support. Total range of 50 km. Weight 1500 lbs. gross, 400 lbs. empty.

DESIGNATOR LD02R
CONCEPT MANNED LUNAR SUPPLY BASE
SYSTEM Rover

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
RA Aux. Power (S: x; T: 1 2 4)	Peak Power 1 KW, 10 hours, for electric drive Continuous Power 200 watts, 24 hours, for life support & communications		RA11	Fuel cell plus AgZn battery	RA111 Reliability, shutdown fuel cell (S: x; T: 1 2 4) RA112 Service life, fuel cell (x; 1 2 4)
RG Guid. /Nav.	Visual pilotage plus RDF to base, northfinder gyro az. ref. to ±5°	SOA			
RH Life Support	Tankage for air, water, food, power necessary for TPH in EVA space suit. Environment maintenance in suit through umbilical from Rover for 24 hrs. for two men	SOA			
RI Task Instr. (x; 1 1 1 1)	Surface sampling Photography Seismology		RI11	Instrument package	RI111 Measurement techniques (x; 1 1 1 1) RI112 Accuracy (x; 1 1 1 1) RI113 Reliability, instr package (x; 1 1 1 1) RI114 Spaceborne package (x; 1 1 1 1)
RP Propulsion	Propel vehicle at 10 km/hr over hard surface for 24 hour mission.	SOA		Electric motor drive	
RR Comm. (x; 1 1 1 1)	Voice communication to base up to 100 km.		RR11	LF/MF Transceiver VHF/UHF Transceiver	RR111 Over-the-horizon radio propagation, LF/MF (x; 1 1 1 1)
RV Vehicle (x; 1 2 1 3)	Open 2-man vehicle with steerable running gear for rough terrain.		RV11	Open two-man vehicle	RV111 Steerable running gear (x; 1 2 1) RV112 Crevice avoidance (x; 1 2 1 4) RV113 Weight (x; 1 2 1) RV114 Uncertainty in lunar terrain (x; 1 1 1 3)

SYSTEM DESCRIPTION

This is a 28,000 lb. LESA-I type shelter module which is flown unmanned to the lunar surface by the Lunar Logistics Vehicle before the crew arrives. It contains living and working space for three men for 90 days.

DESIGNATOR LD02 X

CONCEPT MANNED LUNAR SURVEY BASE

SYSTEM Lunar Shelter (Page 1 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
XA Aux. Power	Peak power:	5 K watts		XA11 Fuel cell, solar cells, NiCad batteries	XA111 Specific power, fuel cell
	Continuous power:	3.75 K watts			XA112 Specific area, solar cell
					XA113 Service life, fuel cells
					XA114 Reliability, NiCad batteries
XD Data Proc.	Input data rate:	10^4 bits/sec. digital plus real time TV		XD11 Central digital computer, tape recorder, video encoder, film	XD111 Radiation alteration of memory
	Output communication rate:	10^4 bits/sec			XD112 Reliability, digital computer
	Output display rate:	10^4 bits/sec.			XD113 Maintainability, digital computer
	Recoverable storage:	magnetic tape and film			XD114 Reliability, tape recorder
	Temporary storage:	10^8 bits			
XH Life Support	Air:	1.8 lb. O_2/man/day	XH1 Air	XH11 Nitrogen/oxygen low pressure	XH111 Leak detection
	Water:	5.16 lb. (drink), 9.84 lb. (hygiene)/man/day			XH112 CO_2 & CO monitor, alarm, removal
	Food:	3,000 cal/man/day			XH113 Contaminant detection
	TPH:	75±5°F, 46% RH, 3.5 - 14.7 PSIA			XH114 Odor & contaminant removal
	Medical:	medical, dental care, physiological monitoring			XH115 Reclamation of breathing oxygen
	Radiation:	inst. 100 rem. cumulative 350 rem 1 year	XH2 Water	XH21 Recycled water	XH211 Psychological
					XH212 Trace contaminants
					XH213 Ion removal & pH control
					XH214 Bacteria destruction
			XH3 Food	XH31 Stored food	XH311 Preservation & storage
					XH312 Monotony
					XH313 Nutrient/bulk ratio
					XH314 Preparation and/or reconstitution
					XH315 Biological gas & odor production
			XH4 TPH	XH41 Automatic TPH	XH411 Fast acting repressurization
					XH412 Non-toxic fire extinguisher
					XH413 Reliability of controls
			XH5 Medical/psycho	XH51 Medical/psycho	XH511 Surface g physiology
					XH512 Diagnosis and treatment
					XH513 Morale
					XH514 Natural immunity loss
					XH515 Surgical implant of bio-medical sensors

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
XI Task Instr.	Capable of carrying instruments in the following instrument groups Manned Systems Planet Oriented TV Mapping Surface and Subsurface Manned Operations Surface Surveillance & Micro TV Radar Mapping Radio Propagation Experiment Gas Dynamic Behavior	XI11 Instrument package	XI111 Measurement techniques XI112 Accuracy XI113 Reliability, instr. package XI114 Spaceborne packaging	
XM Check/Maint.	Performance monitor, report Switching of redundant units Malfunction diagnosis	XM11 Automatic failure monitoring and fault isolation.	XM111 Monitoring & switching XM112 Reliability, checkout equip. XM113 Spares weight and interchangeability XM114 Fault isolation XM115 Technical data access	
XR Comm.	With Rover and Individuals: Voice communication VHF/UHF - 100 km For direct communication to earth: Digital data 10^4 bits/sec. plus real time TV and voice - 380,000 km	XR11 LF/MF Transceiver VHF/UHF Transceiver SHF Transceiver	XR111 Antenna directivity, SHF XR112 Antenna tracking, SHF XR113 Solar and cosmic noise, SHF XR114 Reliability, VHF/UHF XR115 Over the horizon radio prop., LF/MF	
XV Vehicle	Similar to LESA Base Model I with integral mounting for the Rover Contains lab equipment and life support for three men for 90 days on lunar surface. Soft landed by Logistics Vehicle — remains on lunar surface.	XV11 Living quarters	XV111 Portal air loss XV112 Meteoric protection XV113 Radiation protection	
XY Display	Ground displays of operation (mission & subsystem management) Subsystem status (equipment status monitoring and maintenance) Task (scientific instrumentation and analysis) SOA			

SYSTEM DESCRIPTION

A high energy liquid propellant rocket for transporting the Lunar Shelter and Rover to a soft landing on the lunar surface from Earth orbit. Contains own guidance for soft landing.

DESIGNATOR LD02 Y
CONCEPT MANNED LUNAR SURVEY BASE
SYSTEM Lunar Logistics Vehicle

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
YA Aux. Power		SOA		
YG Guid/Nav.	M/C: Velocity accuracy ± 1 m/sec. Angle accuracy ± 3° Deboost: Velocity accuracy ± 0.1 m/sec. Angle accuracy ± 0.25° Landing: Velocity accuracy: ± 0.5 m/sec. Altitude: ± 2 m or 5%. Surface Position: ± 500 m. from selected spot	YG11	Inertial system with star tracker attitude reference, radar altimeter and altitude rate. Real time approach TV for final approach correction from earth.	YG111 Inertial system shutdown reliability YG112 Radar altimeter reliability YG113 R&D, approach TV
YP Propulsion	ΔV 2.75 km/sec for payload for midcourse, deboost to lunar orbit, and soft landing	YP11	Cryogenic liquid rocket with start/restart, requiring 60K lb. injected in lunar transfer orbit	YP111 Specific impulse YP112 Cutoff precision YP113 Cryogenic storage YP114 Throttleability YP115 Restart reliability
YR Comm.	10^3 bits/sec. digital for system status plus real time TV	YR11	SHF Transceiver VHF/UHF Transceiver	YR111 Antenna directivity, SHF YR112 Reliability, communication equipment
YS Stab/Control		SOA		
YV Vehicle		SOA		

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CONCEPT DESCRIPTION

CONCEPT MANNED LUNAR SCIENTIFIC COLONY

DESIGNATOR LD04 (Page 1 of 2)

MISSION OBJECTIVES Establishment of a semi-permanent or permanent lunar base to explore the lunar surface and subsurface structure, to operate in the lunar environment, and to promote further exploration of the planets, solar system, and universe. Radio-astronomy and optical astronomy observatories will be established to utilize the stable lunar base and lack of atmosphere to extend man's knowledge of the universe. Particular investigations will be involved with the following fields: (1) Geological and geophysical surveys, (2) Astrophysical observatory, (3) Geophysical observatory, (4) Fuel synthesis pilot plant, and (5) Lunar environmental research.

GENERAL DESCRIPTION A manned mission, built up in modular fashion, to an ultimate 18-man crew, rotated at six-month intervals. The colony is constructed of six-man shelter modules, maintenance shelters, nuclear power plants, lunar rovers, lunar flying vehicles, fuel regeneration units, portable power units, cargo vehicles, radio-astronomical observatory, optical astronomical observatory, and numerous smaller components. The colony (described in the literature as LESA Base Model 4) is built up in modular fashion over a period of 2-1/2 years upon a previously established smaller base. All modules are predicated as no greater than Saturn V/Lunar Logistics Vehicle payloads, i.e., 28,000 lbm, and 6.7 meters (22 ft.) diameter. Personnel transfers are accomplished by modified Saturn V/Apollo equipment which will land three men on the lunar surface by a modified LEM. The Command and Service Modules of each Apollo delivery unit are assumed left in lunar orbit for the duration of the stay of their crew in the colony. Later personnel replacements may use a larger vehicle, but for the period considered here, Apollo is assumed. Anticipated useful lifetime of the colony is in the vicinity of five years or more, and the date of its establishment in the 1975 to 1985 time period.

(continued on Page 2-LD04)

CONCEPT MANNED LUNAR SCIENTIFIC COLONY

DESIGNATOR LD04(Page 2 of 2)

List of Systems

B	Booster (Saturn V)
E	* Maintenance Shelter
F	* Portable Power Unit
G	Ground Support Facility (Saturn V expanded)
K	* Lunar Cargo Vehicle
L	* Radio Telescope
Q	* Fuel Regeneration Unit
R	* Lunar Rover
T	Manned Logistics Vehicle (Apollo)
U	* Libration Point Communications Satellite
V	* Optical Astronomy Observatory
W	* Lunar Nuclear Power Plant
X	* Lunar Shelter
Y	* Lunar Logistics Vehicle
Z	* Lunar Flying Vehicle

* Detailed description follows.

References

1. "Initial Concept of Lunar Exploration Systems for Apollo," Boeing NASA CR-35.
2. "Deployment Procedures--LESA," Vol. II, Part I, Lockheed LMSC 665606-11, 15 Feb 1965.
3. "Nuclear Power Plant--LESA," Westinghouse, WANL-PR(S)-009A, 1 Oct 1964

SYSTEM DESCRIPTION

An enclosed work space for performing major maintenance on various colony equipment. A shirtsleeve environment is desired, although breathing air may be provided using individual masks to avoid possibly toxic fumes from welding operations or other tasks that may be required. A helium environment may be desirable within the maintenance shelter. A small machine shop and hand tools will be provided in the shop to perform sheetmetal work, machining, assembly and disassembly, bonding, welding, brazing, and soldering, for example. This shelter will also supply storage facilities for materials that would deteriorate in vacuum or outside storage on the moon.

DESIGNATOR LD04 E
CONCEPT MANNED LUNAR SCIENTIFIC COLONY
SYSTEM Maintenance Shelter

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
EA Aux. Power (S T)	Requirements not estimated at this time, but at any rate, power will be supplied by Lunar Nuclear Power Plant 6(LD04)W)			
EH Life Support (1 2 4 3 x)	AIR: 1.8 lb O_2/man/day WATER: 6.16 lb (drink), 9.84 lb (hygiene)/man/day TPH: 75±5 F, 46% RH, 3.5-14.7 PSIA RADIATION: inst. 100 rem. cumulative 350 rem 1 yr.	EH1 Air	EH11 Nitrogen/oxygen atmosphere	EH111 Leak detection & alarm (1 2 4 x) EH112 Contaminant detection (1 2 4 x) EH113 CO & CO_2 removal (1 2 4 x) EH114 Odor & contaminant removal (1 2 4 x)
			EH12 Helium or other inert gas atmosphere with breathing air supplied by mask	EH121 Leak detection & alarm (1 2 4 x) EH122 Odor & contaminant removal (1 2 4 2 x) EH123 Contaminant detection (1 2 4 2 x) EH124 Recovery of breathing O_2 (1 2 4 3 x) EH125 O_2 removal from helium atmosphere (1 2 4 3 x)
		EH2 Water	EH21 Tanked water for individual use. SOA	
		EH3 TPH	EH31 Automatic TPH	EH311 Fast action repressurization (1 2 4 2 x) EH312 Electrical discharge danger at low pressures (1 2 2 x) EH313 Fire extinguisher (1 2 4 2 x)
ER Comm.	Intercom and short-range radio for voice communication within the shelter and between the shelter and other portions of the lunar colony. SOA			
EV Vehicle (1 2 4 2 x)	A complete pressure vessel with shop area separate from major working space. Access provided by large door for Lunar Rover to enter. Personnel airlock provided for entry while shelter is pressurized.		EV11 Working space	EV11 Portal air loss (1 2 2 2 x) EV12 Environmental control (1 2 4 x) EV13 Atmosphere reclamation (1 2 4 3 x) EV14 Protection of work areas (1 2 2 2 x)

DESIGNATOR LD04 F LD04F

CONCEPT MANNED LUNAR SCIENTIFIC COLONY

SYSTEM Portable Power Unit

SYSTEM DESCRIPTION

Portable electrical power generation units composed of multiple fuel cells are desirable for base deployment, operation, and maintenance, and for use in support of extended lunar exploration. The unit is to be trailer mounted for towing by the Lunar Rover (6LD04R), will weigh in the vicinity of 5500 lbs., and will deliver about 25KW power for 50 hours of unrefueled operation.

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS / FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

FA Aux. Power

25KW continuous for 50 hours unrefueled
1250 KWH available for intermittent operation

- FA11 Fuel cells
  - FA111 Specific cost, fuel cell
  - FA112 High load efficiency, fuel cell
  - FA113 Specific power, fuel cell
  - FA114 Cryogenic storage
  - FA115 Reliability, fuel cells

FV Vehicle

Two-wheeled trailer to mount multiple fuel cells, quick disconnect drawbar for pulling by Lunar Rover. System mass breakdown has been estimated:

Fuel Cells	2390
Power cond.	250
Heat Rejection	580
Structure	300
Mobility	350
Tanks	730
Fuel	900
	5500 lbm

- FV11 Trailer mount
  - FV111 Waste heat rejection
  - FV112 Fuel handling
  - FV113 Reliability, structure
  - FV114 Meteoric protection

SYSTEM DESCRIPTION

For delivery of supplies and equipment for the Lunar Colony in addition to those carried in the shelters and special payloads. This system is a maximum payload for Saturn V/LLV of 28,000 lbs. and provides suitable space for stowage of the required supplies, tankage for fuel, breathing air, etc. It is desired to transport 24,000 lbs. of supplies in this vehicle.

DESIGNATOR LD04 K
CONCEPT MANNED LUNAR SCIENTIFIC COLONY
SYSTEM Lunar Cargo Vehicle

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
KA Aux. Power	Requirements undefined - power as necessary for pressurization if desired.			
KV Vehicle	A cylindrical shell 6.7 m in diameter (22 ft.) with weight and shape as appropriate to the launch requirements. Includes provision for tank mounting for cryogenic liquid storage, space for all desired supplies, hold down for restraint during boost and free fall periods, access doors, etc. Vehicle mounts atop the Lunar Logistics Vehicle 6(MD04)Y. It may be pressurized if the supplies require it, but at present this is not anticipated. SOA			

S
T

SYSTEM DESCRIPTION

A remote controlled dual radio telescope soft-landed on site by a Lunar Logistics Vehicle. The instrument is designed for radio astronomy in the millimeter and decameter range. It will be placed out of the line of sight from the earth to mask man-made RFI and earth emission. It will be remotely programmed from the earth on the lunar colony, but is available for manned installation, checkout, and maintenance if necessary. Output is telemetered via the Libration Point Satellite to the earth and lunar colony. The millimeter telescope operates below 2 mm wavelength, the decameter telescope operates above 30 m wavelength. Independent pointing and simultaneous operation of the two systems is not required. Daylight operation is not required.

DESIGNATOR LD04L

CONCEPT MANNED LUNAR SCIENTIFIC COLONY

SYSTEM Rad[illegible]

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
LA Aux. Power (S, T: 1 2 3 x)	800 watts during observations for 250 hours per month for two years		LA11 Solar cells with AgCd batteries for 1/2 month night	LA11 Aerosol [illegible] (S, T: 1 1 2 5 x); LA112 Specific energy AgCd battery (1 2 3 x)
LI Task Instr. (1 2 3 2 x)	A 10-ft. metal parabolic disk for low millimeter or submillimeter reception, extendable dipole for reception in high decametric band, scanning type radiometer.		LI11 Radio telescope	LI111 Local oscillator, min scan system (1 2 3 2 x); LI112 Transportation vibration and shock (1 2 3 2 x); LI113 Degradation of materials in lunar environment (1 2 2 2 x)
LR Comm. (1 1 1 4 x)	Trans. data rate 10^4 bits/sec during observations Range 380 (10^3) km		LR11 SHF Transceiver	LR111 Interference with observations (1 1 1 4 x)
LS Stab./Control (1 2 2 2 x)	Attitude reference: ±0.5° in elevation & azimuth Attitude stabilization: sidereal rate ±0.005 arc seconds	LS1 Attitude reference	Automatic gravity leveled to local vertical, star tracker azimuth after landing then locked. Subject to realignment on command.	LS111 Reliability, star tracker (1 2 3 x)
		LS2 Attitude stabilization	LS22 Servo controlled to pointing command and held to sidereal rate.	LS222 Precision angular measurement (2 2 2 4 x); LS223 Servo threshold & null (1 2 2 2 x); LS224 Degradation of materials in in lunar environment (1 2 2 2 x); LS225 Reliability, servo (1 2 3 x); LS226 Temperature distortion (1 2 2 2 x)
LV Vehicle	SOA			

SYSTEM DESCRIPTION

The Fuel Regeneration Unit reduces water electrolytically to H_2 and O_2 and then liquefies the gases for cryogenic storage and use as fuels. Water is reclaimed from all possible fuel burning sources for regeneration of fuel by this unit. The FRU weighs approximately 26,000 lb. and is a complete Saturn V/LLV payload. Production of 3 lb/hr of LH_2 and 24 lb. of LO_2 per hour is a goal of this system.

DESIGNATOR LD04 Q

CONCEPT MANNED LUNAR SCIENTIFIC COLONY

SYSTEM Fuel Regeneration Unit

SUBSYSTEMS	S	T	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES	S	T
QA Aux. Power	x	1 2 3	Continuous: 45 KW -- several years Peak: 53 KW -- occasional		Supplied by Lunar Nuclear Power Plant 6LD04W QA11 Solar cells	QA111 Specific power, solar cells	x	1 2 3
						QA112 Radiation damage, semiconductors	x	1 2 3
						QA113 Abrasion, solar cells	x	1 1 2 5
QM Check/Maint	x	1 2 3	Prelaunch checkout Post landing checkout and monitor of system operation Continuous performance monitor for lunar operation		QM11 Automatic failure monitor and fault isolation	QM111 Malfunction detection	x	1 2 3
						QM112 Fault isolation	x	1 2 3
						QM113 Failure alarm	x	1 2 3
QV Vehicle	x	1 2 4 5	Provides structural framework for mounting electrolytic cells, pumps, condensers, refrigerators, evaporators, radiators, and temporary storage tanks for regenerated fuel.		QV11 Fuel regeneration unit structure	QV111 R&D required, FR techniques	x	1 2 4 5
						QV112 Waste heat rejection	x	1 2 4
						QV113 Reliability, pumps	x	1 2 2 6
						QV114 Leakage	x	1 2 2
						QV115 Cryogenic storage	x	1 2 2 3

SYSTEM DESCRIPTION

A two-man enclosed and pressurized surface transportation vehicle which is landed on the moon with the Lunar shelter. Capable of moving large lunar logistics payloads with payload. Average speed 10 Km/hr for a maximum operating radius of 50 Km with life support for two men for five days. The 5K lb. Rover includes a 1.7K lb. extended mobility trailer which provides additional life support for a total trip of 14 days and 1000 Km.

DESIGNATOR CONCEPT SYSTEM

LD04 R

LUNAR SCIENTIFIC COLONY

Large Rover

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
RA Aux. Power	Peak Power 10 KW, 6 hrs., for heavy moving and scraping 2 KW, 30 hrs., for lunar surface travel Continuous power: 200 watts, 5 days for 2-man life support and communications With extended mobility trailer: 200 watts for 14 days for 2-man life support and communications	84 KW hrs. additional 183 KW hrs.		RA11 Fuel cell + AgZn battery	RA111 Reliability, Fuel Cell RA112 Specific power
RG Guid/Nav.	Visual pilotage plus RDF to base Earth alignment for azimuth reference	SOA			
RH Life Support	Tankage for air, food, water, power necessary for T.P.H. to supply astronauts' EVA suits		RH1 Air RH2 Water RH3 Food RH4 TPH RH5 Medical/psycho	RH11 Oxygen/nitrogen RH21 Fuel cell water RH31 Stored Food RH41 Automatic TPH RH51 Medical/psycho	RH111 Leak detection & alarm RH112 CO_2 monitor alarm, removal RH211 Psychological RH212 Ion removal & pH control RH213 Toxic contaminant removal RH311 Monotony RH411 Depressurization for EVA RH511 Sanitation RH512 Diagnosis and treatment
RI Task Instr.	Surface sampling Photography Seismology			RI11 Instrument package	RI111 Measurement techniques RI112 Accuracy RI113 Reliability, instrument pkg RI114 Spaceborne package
RP Propulsion	Propel vehicle at 10 km/hr over hard surface for up to 14 days or very low speed local load moving	SOA		RP11 Electric motor drive	
RR Comm.	Voice communications to base up to 500 Km			RR11 VHF/UHF transceiver LF/MF transceiver	RR111 Over-the-horizon radio propagation, LF/MF RR112 Reliability of communication equipment, LF/MF
RV Vehicle	Enclosed pressurized 2-man vehicle with steerable running gear for rough terrain and accessories for local moving and scraping			RV11 Enclosed two-man vehicle	RV111 Steerable running gear RV112 Crevice avoidance RV113 Weight RV114 Uncertainty in lunar terrain

SYSTEM DESCRIPTION

A 200-lb. (plus propulsion) satellite placed in one of the two stable libration (or La Grangian) points in the earth-moon system to provide a communications relay from the earth to lunar backside exploration (including the radio astronomy observatory) and relay from lunar base to exploration parties beyond the horizon.

DESIGNATOR LD04 U
CONCEPT MANNED LUNAR SCIENTIFIC COLONY
SYSTEM Libration Point Communications Satellite

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
UA Aux. Power (S: x; T: 1 2 3 2)	Continuous power 300 watts, 5 years		UA11 Isotope/thermoelectric 300 watt	UA111 Specific energy, isotope (S: x; T: 1 2 3); UA112 Waste heat rejection (x; 1 2 4); UA113 Isotope resources (x; 1 2 3 12); UA114 Radiation damage, semiconductors (x; 1 2 3 10); UA115 Temperature limited efficiency (x; 1 2 3 10)
UP Propulsion	ΔV=1 km/sec for deboost to libration point and for final stable velocity correction.	SOA	UA12 Photovoltiac silicon solar cell plus AgCd battery	UA121 Specific power, solar cells (x; 1 2 3); UA122 Specific cost, solar cells (x; 1 2 3); UA123 Specific cost, AgCd battery (x; 1 2 3); UA124 Degradation of materials in space (x; 1 2 2 2); UA125 Abrasion, solar cells (x; 1 1 2 5); UA126 Reliability, AgCd battery (x; 1 2 3)
UR Comm. (x; 1 2 3)	10^4 bits/sec digital relay of radio telescope data plus voice from astronauts.		UR11 UHF/SHF transceiver	UR111 Reliability, UHF/SHF equipment (x; 1 2 3); UR112 Antenna gain (x; 1 2 3); UR113 Transmitter efficiency (x; 1 2 3)
US Stab./Control (x; 1 2 3)	Attitude Control ±5° for antenna pointing		US11 Cold gas jet attitude control referenced to radio direction finder seeking beacon located at lunar radio telescope (for 2 axes), earth-seeker for third axis.	US111 Fuel consumption, CGJ (x; 1 2 3); US112 Reliability, RDF (x; 1 2 1)
			US12 Cold gas jet attitude control referenced to fixed-angle IR earth- and moon-tracker for 3-axis stabilization	US121 Fuel consumption, CGJ (x; 1 2 3); US122 Reliability, earth, moon tracker (x; 1 2 4)
UV Vehicle	200 lb. satellite, 5 year life	SOA		

SYSTEM DESCRIPTION

A 100-inch Cassegrain optical telescope for manned observation of the universe in the visible, ultraviolet, and [illegible] with resolution to the Hawes limit (0.05 arc seconds). This will permit resolving larger stars [illegible] Time exposures up to 250 hours will permit discovery of stars up to +100 magnitude. The instrument is soft-landed on the moon by a Lunar Logistics Vehicle.

DESIGNATOR [illegible]
CONCEPT [illegible]
SYSTEM [illegible]

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
VI Task Instr. (1 2 2 3 x)	A 100-inch telescope with provision for spectrography and photography. Resolution to 0.05 arc seconds during night observation, 1.0 arc seconds during day.	VI11	Kanigen-coated reinforced aluminum disc, Cassegrain with heat sink, polished to 1/4 wavelength.	VI.11 Temperature distortion (1 2 2 3 x); VI.12 Transportation shock and vibration (1 2 2 3 x); VI.13 Degradation of materials in space (1 2 2 2 x)
VS Stab./Control (1 2 2 2 x)	To point telescope ±5 arc seconds on command and maintain sidereal rate ±0.005 arc seconds.	VS11	Servo controlled to sidereal rate	VS111 Angular position sensing accuracy (2 2 2 4 x); VS112 Uncertainty in lunar surface vibration (1 1 1 5 x); VS113 Servo threshold and null angle (1 2 2 2 x)

SYSTEM DESCRIPTION

DESIGNATOR LD04 W
CONCEPT MANNED LUNAR SCIENTIFIC COLONY
SYSTEM Nuclear Power Plant

Three nuclear power plants are associated with the colony. Each of these units is remotely located from the base site, emplaced in a trench and covered with lunar surface material or integrally shielded. The power plant supplies sufficient electrical energy to maintain all life support requirements, communications, fuel regeneration, lighting, environmental control, mobility, scientific missions, etc.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
WA Aux. Power	Continuous 250KW two years or more for full colony operation Peak load 100 KW per unit	WA1 Power source	WA11 Nuclear reactor, thermionic	WA111 High temperature materials WA112 R&D req'd, nuclear reactor WA113 Reliability, nuclear reactor WA114 Shielding WA115 Waste heat rejection
			WA12 Nuclear reactor, dynamic	WA121 High temperature materials WA122 Waste heat rejection WA123 Wearout WA124 Abrasion, turbine blades WA125 Electrical noise
		WA2 Power conditioning, transmission lines	WA21 Electronic power conditioning and transmission lines, power distribution system	WA211 Arcing in vacuum WA212 Electrical noise WA213 Efficiency, line losses WA214 Reliability, EPC
WM Check/Maint.	Prelaunch checkout After landing, checkout and automatic status report to earth. Continuous remote monitor of performance of operating system.		WM11 Automatic failure monitoring and fault isolation	WM111 Malfunction detection WM112 Fault isolation WM113 Failure alarm
WR Comm.	Telemeter monitor data prior to base setup. Land lines after base is established.	SOA		
WV Vehicle	A 28,000 lb. maximum gross weight system deployed from a 22 ft. diameter shell. The vehicle provides integral shielding which may, in addition, be augmented by a layer of nuclear surface material. The structure may be emplaced in a trench or behind a natural shield, and will be located at considerable distance from the base (0.5 to 2 km). Completely automated operation is required.		WV11 Nuclear power plant structure	WV111 Protection from landing shock WV112 Structural integrity WV113 Ease of emplacement WV114 Shielding

SYSTEM DESCRIPTION

Same as the LD02 X Manned Lunar Survey Base. A 28K lb. LESA I type shelter which provides living and working accomodations for six men for a total of two years, with crew rotation every six months and resupply from cargo vehicle as required. Shelter with a Rover are delivered to the site by a Lunar Logistics Vehicle before the crew arrives. Three shelters are used for the 18-man base.

DESIGNATOR LD04 X

CONCEPT MANNED LUNAR SCIENTIFIC COLONY

SYSTEM Lunar Shelter (Page 1 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
XA Aux. Power (1 2 4 x)	Peak Power: 5K watts Continuous Power: 3.75K watts	XA11	Fuel cell and solar cells, NiCad batteries	XA111 Specific power, fuel cell (S/T 1 2 4 x) XA112 Specific area, solar cell (1 1 2 5 x) XA113 Service life, fuel cell (1 2 4 x) XA114 Reliability, NiCad battery (1 1 2 3 x)
XD Data Proc. (1 2 4 x)	Input data rate: 10^4 bits/sec digital plus real time TV Output communication rate: 10^4 bits/sec Output display rate: 10^4 bits/sec Recoverable storage: magnetic tape and film Temporary storage: 10^8 bits	XD11	Central digital computer, tape recorder, video encoder,	XD111 Radiation alteration of memory (1 2 2 3 x) XD112 Reliability, digital computer (1 2 4 x) XD113 Maintainability, digital computer (1 1 3 x) XD114 Reliability, tape recorder (1 2 4 x)
XH Life Support (1 2 4 3 x)	See Page 2			
XI Task Instr. (1 1 1 1 x)	Capable of carrying instruments in the following instrument groups: Manned Systems; Planet Oriented; TV Mapping; Surface and Subsurface; Manned Operations; Surface Surveillance & Micro TV; Radar Mapping; Radio Propagation Experiment; Gas Dynamic Behavior	XI11	Instrument package	XI111 Measurement techniques (1 1 1 1 x) XI112 Accuracy (1 1 1 1 x) XI113 Reliability, instr. package (1 1 1 1 x) XI114 Spaceborne packaging (1 1 1 1 x)
XM Check/Maint. (1 2 3 x)	Performance monitor, report Switching of redundant units Malfunction diagnosis	XM11	Automatic failure monitoring & fault isolation	XM111 Monitoring & switching (1 2 3 x) XM112 Reliability (1 2 3 x) XM113 Spares weight and interchangeability (1 2 3 x) XM114 Fault isolation (1 2 3 x) XM115 Technical data access (1 2 3 x)
XR Comm. (1 2 3 x)	With Rover and individuals - Voice communication VHF/UHF - 500 km For direct communication to earth - Digital data 10^4 bits/sec plus real time TV and voice - 380,000 km	XR11	LF/MF transceiver VHF/UHF transceiver SHF transceiver	XR111 Antenna directivity, SHF (1 1 2 x) XR112 Antenna tracking, SHF (1 2 3 x) XR113 Solar & cosmic noise, SHF (1 2 3 x) XR114 Reliability, VHF/UHF (1 2 3 x) XR115 Over-the-horizon radio propagation, LF/MF (1 1 1 5 x)
XV Vehicle (1 2 2 2 x)	Similar to LESA Base Model IV with integral mounting for Rover. Contains lab equipment and life support for six men for two years, with crew rotation and resupply available. Soft landed by Logistics Vehicle, remains on Lunar surface.	XV11	Living quarters	XV111 Portal air loss (1 2 2 2 x) XV112 Meteoric protection (1 2 2 2 x) XF113 Radiation protection (1 2 2 2 x)
XY Display	Ground displays of operation (mission and subsystem management) Subsystem status (equipment status monitoring and maintenance) SOA Task (scientific instrumentation and analysis)			

SYSTEM DESCRIPTION

DESIGNATOR LD04 X
CONCEPT MANNED LUNAR SCIENTIFIC COLONY
SYSTEM Lunar Shelter (Page 2 of 2)

SUBSYSTEMS

XH Life Support

SUBSYSTEM REQUIREMENTS

- Air: 1.8 lb. O_2/man/day
- Water: 6.16 lb (drink), 9.84 (hygiene)/man/day
- Food: 3,000 cal/man/day
- TPH: 75 ± 5° F, 46% RH, 3.5-14.7 PSIA
- Medical: medic., dental care, physiological monitoring
- Radiation: inst [illegible] rem, cumulative 350 rem 1 year

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

- XH1 Air
  - XH11 Nitrogen/oxygen low pressure closed oxygen system
    - XH111 Leak detection
    - XH112 CO_2 & CO monitor, alarm, removal
    - XH113 Contaminant detection
    - XH114 Odor and contaminant removal
    - XH115 Reclamation of breathing oxygen
  - XH12 Closed ecological system with botanical oxygen source
    - XH121 Leak detection
    - XH122 CO_2 & CO monitor, alarm removal
    - XH123 Contaminant detection
    - XH124 Odor and contaminant removal
    - XH125 Life support system integration
    - XH126 R&D required, botanical system
- XH2 Water
  - XH21 Recycled water
    - XH211 Psychological
    - XH212 Trace contaminants
    - XH213 Ion removal & pH control
    - XH214 Bacteria destruction
- XH3 Food
  - XH31 Stored food
    - XH311 Preservation
    - XH312 Monotony
    - XH313 Nutrient bulk ratio
    - XH314 Preparation and/or reconstitution
    - XH315 Biological gas and odor production
  - XH32 Closed ecological system with botanical food source
    - XH321 Selection & development of botanical system
    - XH322 Life support system integration
    - XH323 Trace contaminants
    - XH324 Psychological implications
    - XH325 Monotony
    - XH326 Preparation
    - XH327 Biological gas and odor production
- XH4 T P H
  - XH41 Automatic T P H
    - XH411 Fast action repressurization
    - XH412 Non-toxic fire extinguisher
    - XH413 Reliability of controls
- XH5 Medical/psycho
  - XH51 Medical/psycho
    - XH511 Surface g physiology
    - XH512 Diagnosis and treatment
    - XH513 Morale
    - XH514 Reduction in natural immunities
    - XH515 Surgical implant of bio-medical sensors

SYSTEM DESCRIPTION

[illegible] as the LD02 Y Lunar Logistics Vehicle. A high energy liquid propellant rocket for transporting the Lunar Shelter, Rover, Maintenance Shelter, Nuclear Power Plant, Fuel Regeneration Unit, and Cargo units to a soft landing on the lunar surface from Earth orbit. Contains own guidance for soft landing.

DESIGNATOR LD04Y — LD04Y
CONCEPT MANNED LUNAR SCIENTIFIC COLONY
SYSTEM Lunar Logistics V

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
YA Aux. Power (S/T)	SOA			
YG Guid/Nav. (1 2 3 2)	M/C: Velocity accuracy ± 1 m/sec. Angle accuracy ± 3° Deboost: Velocity accuracy ± 0.1 m/sec. Angle accuracy ± 0.25° Landing: Velocity accuracy: ± 0.5 m/sec. Altitude: ± 2 m or 5% Surface Position: ± 500 m. from selected spot	YG11	Inertial system with star tracker attitude reference, radar altimeter and altitude rate. Real time approach TV for final approach correction from earth.	YG111 Reliability inertial system (1 2 4) YG112 [illegible] reliability (1 2 3) YG113 R&D req'd. approach TV (1 2 3 2)
YP Propulsion (1 2 2)	Δ V 2.75 km/sec for 28K payload for midcourse, deboost to lunar orbit, and soft landing	YP11	Cryogenic liquid rocket with start/restart, requiring 60K lb. injected in lunar transfer orbit.	YP111 Specific impulse (1 2 2) YP112 Cutoff precision (1 2 2) YP113 Cryogenic storage (1 2 2) YP114 Throttleability (1 2 2) YP115 Restart reliability (1 2 2)
YR Comm. (1 2 3)	10^3 bits/sec. digital for system status plus real time TV	YR11	SHF transceiver VHF/UHF transceiver	YR111 Antenna directivity, SHF (1 1 2) YR112 Reliability, communication equipment (1 2 3)
YS Stab/Control	SOA			
YV Vehicle	SOA			

SYSTEM DESCRIPTION

An open platform type two-man vehicle with a maximum one-way range of about 95 km at a top speed of about 900 km/hr. It is capable of hovering and other helicopter-like maneuvering. Primary purpose of the LFV is exploration of peaks, crevasses and other areas inaccessible by walking or Lunar Rover operation.

DESIGNATOR LD04 Z
CONCEPT MANNED LUNAR SCIENTIFIC COLONY
SYSTEM Lunar Flying Vehicle

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES	S T
ZA Aux. Power (1 2 2 x)	Approximately 300 watts to provide lighting, rocket squib, and stability and control system operating power.	ZA11	AgZn storage battery	ZA111 Specific energy, AgZn (1 1 1 5 x) ZA112 Temperature control, battery (1 2 2 x)	
ZG Guid/Nav.	Manual, visual operation, charts, etc. Radio direction finder for locating base.	SOA			
ZM Check/Maint.	Performance monitor Failure warning and analysis	SOA			
ZP Propulsion (1 2 2 x)	Provide about 500 lb. thrust throttleable engine to support the vehicle and crew. Empty weight of vehicle is about 350 lb. Carries 650 lb. fuel and two astronauts.	ZP11	Cryogenic liquid rocket LH_2/LO_2	ZP111 Cryogenic storage (1 2 2 x) ZP112 Specific impulse (1 2 2 x) ZP113 Cutoff precision (1 2 2 x)	
ZR Comm.	Voice communications to base, UHF/VHF	SOA			
ZS Stab/Control (1 2 3 3 x)	VTOL flying qualities, manual control	ZS11	Thrust vector control plus hypergolic reaction jets for stability	ZS111 R&D required, TVC (1 2 4 3 x) ZS112 Throttleability, TVC (1 2 2 x) ZS113 Attitude stability, HRJ (1 2 3 x) ZS114 Reliability, TVC (1 2 4 x)	
ZV Vehicle (1 2 4 3 x)	An open vehicle providing seats for two occupants, control system, vectorable engine, fuel tanks attitude control jets, etc.	ZV11	Open two-man LFV	ZV111 R&D required, LFV (1 2 4 3 x) ZV112 Weight (1 2 4 3 x)	

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CONCEPT DESCRIPTION

CONCEPT MANNED LUNAR ORBITER

DESIGNATOR LO02

MISSION OBJECTIVES High resolution mapping by a manned orbiter of the entire lunar surface in order to select sites of practical scientific interest and to select landing and base sites in support of lunar surface operations. This concept precedes both the Manned Lunar Survey Base (LD02) and the Lunar Scientific Colony (LD04).

GENERAL DESCRIPTION A manned mission consisting of an Apollo-type command and re-entry module and a sensor and living area spacecraft. The spacecraft orbits in a 150 km lunar polar orbit for at least 28 days to map the entire lunar surface. Special systems include multispectral photography, radar mapping, spectrographic surveys, IR surveys, remote geochemical sensing, passive microwave radiometry and others. All systems are launched aboard a single Saturn V. The mission date lies in the 1970-1972 period.

LIST OF SYSTEMS

B Booster (Saturn V)
G Ground Support Facility
M *Command and Re-Entry Module
S *Spacecraft

REFERENCES

*Detailed description follows.

SYSTEM DESCRIPTION

This system consists of an Apollo-type three-man command module for use during thrust periods, and the service section containing the engines, propellant, and expendables. Total weight less propulsion - 25K - The service section is jettisoned before earth atmospheric re-entry.

DESIGNATOR CONCEPT SYSTEM

LO02 M

MANNED LUNAR ORBITER

Command and Re[illegible] Module
(Page 1 of 2)

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

MA Aux. Power (S: x; T: 1 2 4)

- Continuous Power 2 KW, 35 days

MD Data Proc.

- RATES
  - Input data rate 10^4 bits/sec
  - Output comm. rate 10^3 bits/sec
  - Output display rate 10^3 bits/sec
- STORAGE
  - Recoverable Tape and film
  - Temporary 10^8 bits

ME Escape/Recy

- Safe return of astronauts

MG Guid. /Nav. (S: x; T: 1 2 4)

- Midcourse correction: ±0.5 m/sec, ±5°
- Lunar orbit: ±1 m/sec, ±1°
- Lunar deorbit: ± 1 m/sec, ±1°

MH Life Support

- AIR: 1.8 lb O_2/man/day
- WATER: 6.16 lb (drink), 9.84 lb (hygiene)/man/day
- FOOD: 3,000 cal/man/day
- T, P, H: 75±5°F, 46% RH, 3.5-14.7 PSIA
- MED: medical, dental care, physiological monitoring
- RADIATION: inst. 100 rem., cumulative 350 rem 1 year

MM Check/Maint. (S: x; T: 1 2 3)

- Prelaunch checkout
- Performance monitor, report
- Switching of redundant units
- Malfunction diagnosis
- Orbital assembly checkout

MP Propulsion

- Payload 40K lbs. (spacecraft and task module)
- ΔV 0.7 km/sec for deboost into lunar orbit
- ΔV 0.7 km/sec for boost into lunar escape
- ΔV 0.2 km/sec for midcourse correction

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Subsystem	Functional Elements	Configurations	Technology Deficiencies	S	T
MA	SOA	MA11 Fuel cell plus NiCad Battery	MA111 Specific power, fuel cell	x	1 2 4
			MA112 High-load efficiency	x	1 2 4
			MA113 Service life, fuel cell	x	1 2 4
MD					
ME	SOA				
MG		MG11 DSIF with on-board star tracker and inertial system	MG111 Reliability, inertial system	x	1 2 4
			MG112 Reliability, star tracker	x	1 2 3
MH	SOA				
MM		MM11 Automatic failure monitor and fault isolation	MM111 Monitoring & switching	x	1 2 3
			MM112 Fault isolation	x	1 2 3
			MM113 Spares weight & interchangeability	x	1 2 3
			MM114 Zero-G work, tools	x	1 2 3
			MM115 Tech. Data Access	x	1 2 3
MP	SOA				

SYSTEM DESCRIPTION

DESIGNATOR CONCEPT SYSTEM

LO02 M

MANNED LUNAR ORBITER

Command and Re-Entry Module
(Page 2 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
MR Comm.	Voice and real time video to earth	SOA			
MS Stab. /Cont.	Attitude Control: ±0.25° during thrusting ±5° during coast ±.05° during precision mapping Local vertical reference: ±0.2°	SOA			
MT Sim/Training		SOA			
MV Vehicle	Apollo-type command and service module	SOA			
MY Display	Apollo type	SOA			

SYSTEM DESCRIPTION

A 15K [illegible] unit containing the inflight [illegible] and work areas used by the crew except during thrust periods. In addition, [illegible] life support equipment for 35 days, 28 of which is in lunar orbit, this system includes the [illegible] for multis[illegible]tral photography and mapping of the lunar surface.

DESIGNATOR LO02S

CONCEPT MANNED LUNAR [illegible]

SYSTEM Spacecraft (Page [illegible] of [illegible])

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S, T; 1 2 4 x)	Continuous power: 5 KW for 35 days		SA11 Fuel cell plus NiCad battery	SA111 Specific power, fuel cell (S, T; 1 2 4 x)
				SA112 Service life, fuel cell (1 2 4 x)
				SA113 High load efficiency (1 2 4 x)
SD Data Proc. (1 2 4 x)	RATES Input data rate 10^5 bits/sec Output comm. rate 10^4 bits/sec plus radar and TV Output display rate 10^5 bits/sec plus radar and TV STORAGE Recoverable Tape, film Temporary 10^6 bits		SD11 Digital computer, tape recorder, video encoder.	SD111 Memory density, digital computer (1 2 4 x)
				SD112 Reliability, digital computer (1 2 4 x)
				SD113 R&D required, high speed tape recorder (1 2 4 x)
				SD114 Data compression (1 2 4 5 x)
				SD115 Reliability, tape recorder (1 2 4 x)
SH Life Support (1 2 4 2 x)	AIR: 1.8 lb. O_2/man/day WATER: 6.16 lb. (drink), 9.84 lb (hygiene)/man/day FOOD: 3,000 cal/man/day TPH: 75±5°F, 46% RH, 3.5-14.7 PSIA MED: medical, dental care, physiological monitoring RADIATION: inst. 100 rem.	SH1 Air	SH11 Nitrogen/oxygen	SH111 Leak detection & alarm (1 2 4 x)
				SH112 CO_2&CO monitor, alarm, removal. (1 2 4 x)
				SH113 Contaminant detection (1 2 4 x)
				SH114 Odor & contaminant removal (1 2 4 x)
		SH2 Water	Stored water	SOA
		SH3 Food	SH31 Stored food	SH311 Monotony (1 1 3 x)
				SH312 Waste disposal (1 1 3 x)
				SH313 Preservation and storage (1 1 3 x)
				SH314 Nutrient/bulk ratio (1 1 3 x)
				SH315 Preparation and/or reconstitution, crumbs, outgassing (1 1 3 x)
				SH316 Biological gas and odor production. (1 1 3 x)
		SH4 TPH	SH41 Automatic TPH	SH411 Fast action repressurization (1 2 4 2 x)
				SH412 Non-toxic fire extinguisher (1 2 4 2 x)
				SH413 Comfort factors (1 2 4 x)
				SH414 Atmospheric circulation & cycling (1 2 4 x)
		SH5 Medical/Psycho	SH51 Medical/Psycho	SH511 Zero-g physiology (1 1 1 1 x)
				SH512 Morale (1 1 1 1 x)
				SH513 Sanitation (1 2 4 x)
				SH514 Diagnosis & treatment, health (1 2 4 x)
				SH515 Surgical implant of bio-medical sensors (1 2 4 4 x)
				SH516 Reduction in natural immunities (1 2 4 4 x)

SYSTEM DESCRIPTION

DESIGNATOR LO02 S
CONCEPT MANNED LUNAR ORBITER
SYSTEM Spacecraft (Page 2 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS		CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SI Task Instr.	Capable of carrying instruments in the following Instrument Groups: Manned Systems Planet Oriented TV Mapping Radar Mapping Radio Propagation Experiment				SI11 Instrument Package	SI111 Accuracy SI112 Calibration standard SI113 R&D, high resolution imagery SI114 Reliability, instr. package SI115 Spaceborne packaging
SM Check/Maint	Prelaunch checkout Performance monitor, report Switching of redundant units Malfunction diagnosis		Preflight SM1 Inflight	SOA	SM11 Automatic failure monitor and fault isolation	SM111 Monitoring & switching SM112 Fault isolation SM113 Spares weight & interchangeability SM114 Zero-g work, tools SM115 Tech. data access
SR Comm.	Trans data rate: 10^4 bits/sec digital + radar + TV	SOA				
ST Sim/Train	Prelaunch skill acquisition and inflight skill retention for vehicle operation and scientific work.	SOA				
SV Vehicle	Subsystem integration Magnetism Field of View Communications Shielding Thermal environment EVA portals Relocation - docking inflight				SV11 Living quarters	SV111 Leakage SV112 Meteoric protection SV113 Portal reaction thrust SV114 Optical window degradation SV115 Waste removal
SY Display	Ground & inflight displays of operation (mission & subsystem management) Subsystem Status (equip. status monitoring & maintenance) Task (scientific instrumentation & analysis)	SOA				

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CONCEPT DESCRIPTION

CONCEPT MARS ORBITER/ROVER

DESIGNATOR MD01

MISSION OBJECTIVES Unmanned exploration of the surface of Mars using a small roving vehicle. Primary objectives are the acquisition of data regarding surface structure and composition, atmospheric characteristics and the detection and characterization of biological forms. This concept is an essential step leading to manned landing missions on Mars and represents a significant step beyond the observational flyby mission (Mariner).

GENERAL DESCRIPTION An unmanned mission in which the Orbiter and Lander/Rover are first injected into a circular polar orbit around Mars, surface observations made and telemetered to earth. A landing site is designated for the Lander/Rover and on command, the Lander/Rover is detached and landed by atmospheric entry, parachute, and retro-braking as necessary. Upon landing, the Rover is activated, extending running gear, and is directed through transmitted photos to particular nearby areas of interest. Rover lifetime is about ten days on the surface, Orbiter about 15 days in orbit, plus about 250 days enroute. Lander/Rover weighs about 4000 lb., the Orbiter about 10,000 lbs., including propulsion for braking to Mars orbit. Mission date is about 1973.

LIST OF SYSTEMS

B *Booster
G Ground Support Facility
L *Lander/Rover
S *Orbiter Spacecraft

*Detailed description follows.

REFERENCES

1. General Electric, "Voyager Design Study", Vol. II, Doc. #63SD801, 15 Oct 1963.
2. AVCO Corp., "Voyager Design Studies", Vol. II, Doc. #RAD-TR-63-34, 15 Oct 1963.
3. JPL, "Study of Mars and Venus Orbiter Missions Launched by the 3-Stage Saturn C-1B Vehicle", Eng. Planning Doc. #139, 31 Dec 1963.

SYSTEM DESCRIPTION

A Saturn I-B type with high energy upper stage to place 14,000 lbs. into trajectory to Mars (11.5 km/sec). Parking orbit capability.

DESIGNATOR
CONCEPT
SYSTEM

MD01B

MARS ORBITER [illegible]

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
BA Aux. Power		SOA		
BG Guid./Nav.		SOA		
BP Propulsion	Total ΔV 11.5 km/sec; 14,000 lb. payload; for injection into Mars trajectory.		BP111 Saturn I-B with high energy (60K lb. thrust) upper stage H_2O_2 or FLOX.	BP111 R&D [illegible] upper stage BP112 Cryogen BP113 Corrosive fuel handling & storage BP114 Restart [illegible] BP115 Specific [illegible]
BS Stab./Cont.		SOA		
BV Vehicle		SOA		

SYSTEM DESCRIPTION

A 4,000 lb. unmanned probe to soft land on the Mars surface and make surface composition, structured, and biological measurements; photography of terrain features, atmospheric measurements during descent and while on surface. Transmits data to orbiter for relay to earth two times daily. Can relocate up to 150 m/day at command from earth.

DESIGNATOR MD01 L
CONCEPT MARS ORBITER ROVER
SYSTEM Lander Rover

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

LA Aux. Power (S: X; T: 1 2 4)
- Peak Power: 200 watts, 15 min., 2 times daily for 10 days
- Cont. Power: 50 watts, for 10 days

LD Data Proc. (X; 1 2 4)
- RATES
  - Input data rate: 2×10^3 bits/sec
  - Output comm rate: 10^4 bits/sec
- STORAGE
  - Temporary: 10^7 bits

LG Guid./Nav (X; 1 1 2)
- Pulse duration and deorbit time command from earth. No acceleration sensing required. For surface roving, accepts earth commands for heading and distance. Needs onboard heading reference and gross distance measurement.

LI Task Instr. (X; 1 1 1 1)
- Capable of carrying instruments in the following instrument Groups:
  - Atmospheric Entry
  - Surface Weather and Space Oriented
  - Surface and Subsurface
  - Life Detection
  - Surface Surveillance & Micro TV
  - Radio Propagation Experiment

LP Propulsion (X; 1 2 2)
- ΔV 250 m/sec; payload 4,000 lb. for deboost.
- 150 m/day for 10 days surface transport.

LR Comm. (X; 1 1 2)
- Trans. data rate: 10^4 bits/sec
- Range: 5,000 km
- Temporal requirements: 15 mins. 2 times per day for 10 days

LS Stab./Cont. (X; 1 2 2)
- Attitude control: ±5° for deorbit

LV Vehicle (X; 1 2 2)
- Atmospheric entry
- Parachute soft landing
- Running gear, steerable
- Subsystem integration: field of view, communications

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Functional element	Configuration	Technology deficiencies	S	T
	LA11 Fuel cell plus Ag/Zn battery	LA111 Specific power, fuel cell		X
		LA112 Service life, fuel cell		X
		LA113 Reliability, shutdown		X
	LD11 Small digital data processor and variable speed tape recorder.	LD111 Reliability, digital processor		X
		LD112 Reliability, tape recorder		X
		LD113 Memory density, tape recorder		X
		LD114 R&D required, tape recorder		X
	LG11 Heading reference; scanning radar	LG111 R&D required, heading reference		X
		LG112 R&D required, scanning radar		X
	LI11 Instrument package.	LI111 Spaceborne packaging		X
		LI112 Accuracy		X
		LI113 Measurement techniques		X
		LI114 Reliability, instr. package		X
		LI115 Sterilization		X
LP1 Surface	LP11 Electric motor driven by fuel cell	LP111 Mechanical reliability		X
		LP112 Weight of electric drive		X
LP2 Deboost	LP21 Storable liquid rocket for deboost and parachute for soft landing.	LP211 Impulse accuracy		X
		LP212 Reliability, long storage		X
	LP22 Solid rocket for deboost and parachute for soft landing.	LP221 Impulse accuracy		X
	LR11 UHF/SHF Transceiver	LR111 Antenna directivity		X
	LS11 Hypergolic reaction jets and simple gyro ref.	LS111 Reliability, long storage		X
	LV11 Atmospheric reentry body parachute terminal descent, extendable and inflatable running gear, steerable	LV111 Uncertain characteristics of Martian atmosphere		X
		LV112 Meteorite protection		X
		LV113 Landing shock		X
		LV114 Mechanical reliab. of running gear		X
		LV115 Weight of running gear		X

SYSTEM DESCRIPTION

A 10,000 lb. unmanned spacecraft (including fuel) to fly to Mars with the Lander Rover, to deboost into Mars polar orbit, make complete wide area photographic coverage of Mars and limited detailed photography. When Rover is deboosted from orbit, orbiter relays Rover signals to Earth.

DESIGNATOR MD01S — MD01S -110

CONCEPT MARS ORBITER ROVER

SYSTEM Orbiter Spacecraft — Stage 1 of 2

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S/T 1 2 3 x)	Peak power: 1K watts, 12 hours/day for 15 days in Mars orbit Continuous power: 500 watts, for 15 days in Mars orbit Continuous power: 50 watts enroute to Mars		SA11 Solar cells plus NiCad battery	SA111 Abundance, solar cells SA112 Specific area, solar cells SA113 Radiation damage, semiconductors
SD Data Proc. (1 2 4 x)	To process slow scan photography and Lander/Rover data Input data rate: 10^4 bits/sec. Output communication rate: 2×10^3 bits/sec. Temporary storage: 10^8 bits		SD11 Small digital data processor with variable speed tape recorder	SD111 Data compression SD112 Memory density, digital processor SD113 Reliability, digital processor SD114 Reliability, tape recorder SD115 R&D tape recorder
SG Guid./Nav. (1 2 2 3 x)	M/C: Velocity accuracy ± 0.[illegible] m/sec; Angle ± 5 degree Orbit Injection: Velocity ± 1 m/sec; Angle ± 1 degree	SG1 Midcourse SG2 Orbit injection	SG11 DSIF command with onboard star-tracker and inertial acceleration sensor SG31 Doppler radar range rate to determine nearest approach, switched to radar altimeter function to determine ΔV, impulse.	SG111 Reliability of inertial acceleration sensor SG211 R&D for long range doppler radar SG212 Reliability of doppler radar
SI Task Instr. (1 1 1 1 1 x)	Capable of carrying instruments in the following instrument Groups: Interplanetary Planet Oriented TV Mapping Surface Surveillance Radio Propagation Experiment		SI11 Instrument package.	SI111 Spaceborne packaging SI112 Accuracy SI113 Measurement techniques SI114 Reliability, instr. package SI115 Sterilization
SP Propulsion (1 2 2 x)	ΔV 7 km/sec Payload ~ 6000 lb.		SP11 Cryogenic liquid rocket SP12 Storable liquid rocket	SP111 Cryogenic storage SP112 Reliability, long storage SP121 Specific impulse SP122 Reliability, long storage
SR Comm. (1 2 3 x)	Trans. data rate 2×10^3 bits/sec to earth, 10^4 bits/sec from Lander/Rover Range up to 350×10^6 km to earth, 5,000 km to Martian surface		SR11 RF - UHF/SHF Transceiver through DSIF network to earth; and Rover communications	SR111 Antenna directivity SR112 Antenna pointing SR113 Transmitter power SR114 Reliability

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SS Stab/Control (1 2 3 x)	Attitude control ± 5° during enroute phase Pointing accuracy ± 0.2° in orbit Body rate 0.02°/sec for motion compensation		SS11 Hypergolic reaction jets Horizon sensors and star tracker	SS111 Reliability, reaction jet (1 2 3 x) SS112 Star tracker reliability (1 2 3 x) SS113 Horizon scanner reliability (1 2 4 x) SS114 Horizon definition, Mars (1 2 2 3 x)
SV Vehicle	Arrange for field of view for cameras, sensors and antennas	SOA		

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CONCEPT DESCRIPTION

CONCEPT MANNED MARS LANDER

DESIGNATOR MD02

MISSION OBJECTIVES Accomplishment of the first manned landing on Mars in order to conduct scientific investigations and to observe the general environment within a limited area. Manned searching for life forms and clues to the origin and history of the planet; analysis of the atmosphere, meteorology and surface composition; and a return with actual samples of matter are the chief projects.

GENERAL DESCRIPTION A manned mission assembled from multiple earth launched packages into an orbital launch booster, a 6-man spacecraft, two precursor probes, a Mars excursion module (MEM), and a Command and Re-Entry Module. The assembly is launched from earth orbit to Mars and braked into Mars orbit where landing sites are selected and examined with precursor probes. Mars orbit stay time will be 10 to 30 days in an equatorial orbit. The MEM descends with three men to the surface and returns to orbit after 3 to 4 days on the surface. The MEM is left in Mars orbit while the crew returns in the spacecraft, braking in the earth re-entry module. Atmospheric entry at earth is assumed from parabolic velocity. If higher velocity can be tolerated, earth orbital launch weight can be considerably reduced. Gross earth orbital weight depends on orbital propulsion but should lie between 585K lb. and 5.2M lb. Mission is 420 to 520 days, while the mission date lies in the 1980-onward period.

LIST OF SYSTEMS

B Booster (Saturn V)
G Ground Support Facility
J *Orbital Booster
L *Mars Excursion Module
M *Command and Re-Entry Module
P *Precursor Probe
S *Spacecraft
X *Extra-Vehicular Activity Unit

*Detailed description follows.

REFERENCES

1. AW&ST, 16 Nov 1964, p. 53
2. "A Study of Early Manned Interplanetary Missions" AOK 63-0001, 31 Jan 1963, General Dynamics Astronautics
3. AW&ST, 20 Apr 1964, p. 54

DESIGNATOR MD02 J — MD02J

CONCEPT MANNED MARS LANDER

SYSTEM Orbital Booster

SYSTEM DESCRIPTION

Similar to Manned Mars Probe Orbiter - MO04 J. This is a massive system, assembled with the spacecraft in earth orbit. It provides four major thrusting increments: earth orbital launch, Mars orbital capture, Mars orbital launch, and deboost to earth parabola, and also propulsion for midcourse corrections enroute. Nuclear propulsion is required to minimize earth launch weight. The total gross weight of this system with the Spacecraft, Command & Re-Entry Module, and Mars Excursion Module is approximately 5.2M lbs., or 585 thousand lbs. into earth orbit depending on whether solid core nuclear or gaseous fission rockets are used.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
JA Aux. Power (S T)	Continuous Power: 1 KW during thrusting. Chemical dynamic system	SOA		
JG Guid. /Nav.	Supplied by Command Module	Supplied by Command Module		
JM Check /Maint (1 2 3 x)	Prelaunch checkout Performance monitor, report Switching of redundant units		JM11 Automatic failure monitor and fault isolation	JM111 Monitoring & switching (1 2 3 x)
JP Propulsion (2 2 4 2 x)	Nuclear Solid I_{sp}=900 / Nuclear Gaseous I_{sp}=3000 1. ΔV = 7 km/sec — 1.6M lbs — 375K lbs. — for escape from earth orbit 2. ΔV = 6 km/sec — 525K lbs — 245K lbs. — for deboost into Mars orbit 3. ΔV = 6 km/sec — 170K lbs. — 113K lbs. — for escape from Mars orbit 4. ΔV = 9 km/sec — 20K lbs. — 20K lbs. — for deboost to earth parabola		JP11 Solid core nuclear fission rocket at I_{sp} = 900 sec., requiring 5.2M lbs gross into earth orbit JP12 Gaseous core nuclear fission rocket at I_{sp} = 3000, requiring 585K lbs. gross into earth orbit.	JP111 High temperature materials (2 2 4 2 x) JP112 Shielding (1 1 2 4 x) JP113 R&D required (2 2 4 2 x) JP114 Cryogenic storage (1 2 2 x) JP115 Cooldown and restart (2 2 4 2 x) JP121 Thrust vectoring (2 2 4 4 x) JP122 Startup (2 2 4 8 x) JP123 Shielding (1 1 2 4 x) JP124 R&D required (2 2 4 6 x) JP125 Cryogenic storage (1 2 2 x)
JS Stab. /Cont.	Attitude: .25° Thrust Vector Control Roll Control	Main propulsion Hypergolic reaction jets	SOA SOA	
JV Vehicle (1 2 2 2 x)	Shielding Docking Orbital Assembly	JV11 Open frame structure, Tankage assembled in orbit		JV111 Meteoric protection (1 2 2 2 x) JV112 Material degradation (1 2 2 2 x) JV113 Shielding for on/off operation (1 2 4 4 x) JV114 Dock shock (1 2 2 x)

SYSTEM DESCRIPTION

A three-section vehicle to carry three men from Mars orbit to the surface for ten days. The Command Module returns to Mars orbit to rendezvous with the orbiting Spacecraft - MD02 S. The service area contains the descent engine, landing propellants, and most vehicle subsystems. The living/work area contains laboratory, hygiene, rest, and eating area. The service area and living/work area remain on the Martian surface.

DESIGNATOR CONCEPT SYSTEM

MD02 L

MANNED MARS LANDER

Mars Excursion Module
(Page 1 of 3)

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

LA Aux. Power (S: x; T: 1 2 4)

Continuous Power: 2 KW, 10 days.

LD Data Proc. (x; 1 2 4)

RATES
- Input data rate: 10^3 bits/sec digital plus 3 photos per 1 1/2 hr
- Output comm. rate: 10^4 bits/sec digital plus 10^7 bits/sec video--(real time TV)
- Output display rate: 10^3 bits/sec

STORAGE
- Recoverable: Tapes and film
- Temporary: 10^7 bits

LG Guid. /Nav. (x; 1 2 4)

- Deorbit velocity: ±1 m/sec
- Position accuracy: ±3 km
- Angle: ±1 degree

Rendezvous injection:
- Velocity: 1 m/sec
- Altitude: 5 km
- Angle: 0.5 degree
- Phase distance: 15 km

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Subsystem	Functional Element	Configuration	Technology Deficiency	S	T
LA		LA11 Fuel cell plus NiCad battery	LA111 Reliability, long storage	x	1 2 4
			LA112 Specific power, fuel cell	x	1 2 4
			LA113 Service life, fuel cell	x	1 2 4
			LA114 High-load efficiency	x	1 2 4
LD	LD1 Digital data	LD11 Digital data processor with tape recorder and video encoder	LD111 Data compression	x	1 2 4 5
			LD112 Memory density, digital processor	x	1 2 4
			LD113 Reliability, digital processor	x	1 2 4
			LD114 Reliability, tape recorder	x	1 2 4
			LD115 Maintainability, digital processor	x	1 1 3
	LD2 Photographic data	LD21 Color and black/white still and motion photography; onboard processing of stills for selected relay to earth; return of unprocessed movie photographic film.	LD211 Radiation protection of unprocessed film	x	1 2 3
			LD212 R&D for onboard film processing	x	1 2 3 2
		LD22 Thermoplastic color photography	LD221 R&D required, T.P. color photography	x	1 2 3 2
			LD222 Spaceborne packaging	x	1 2 3 1
LG	LG1 Inertial guidance for deboost and ascent	LG11 Inertial system	LG111 Reliability, long storage	x	1 2 4
			LG112 Deboost & ascent calculation	x	1 1 1 2
			LG113 Weight, inertial system	x	1 2 4
	LG2 Approach and docking guidance for landing and docking	LG21 Docking radar and visual	LG211 Reliability, radar	x	1 2 3

SYSTEM DESCRIPTION

DESIGNATOR MD02L
CONCEPT MANNED MARS [illegible]
SYSTEM Mars Exc[illegible] (Page 2 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
LH Life Support (1 2 4 2 x)	AIR: 1.8 lb. O_2/man/day WATER: 6.16 lb. (drink), 9.84 lb. (hygiene)/man/day FOOD: 3,000 cal/man/day TPH: 75±5°F, 46% RH, 3.5 - 14.7 PSIA MED: medical, physiological monitoring RADIATION: inst. 100 rem.	LH1 Air	LH11 Nitrogen/oxygen low pressure	LH111 [illegible] detection (5/7) LH112 CO_2 & [illegible] monitor, alarm, removal LH113 Contaminant detection LH114 Odor and contaminant removal
		LH2 Water	LH21 Tanked water	LH211 Ion removal & pH control LH212 Bacteria destruction
		LH3 Food	LH31 Stored food	LH311 Preservation LH312 Nutrient bulk ratio LH313 Preparation and/or reconstitution, crumbs, outgassing LH314 Biological gas & odor production
		LH4 TPH	LH41 Automatic TPH	LH411 Fast acting repressurization (1 2 x) LH412 Non-toxic fire extinguisher (1 2 4 2 x) LH413 Reliability of controls (1 2 4 x)
		LH5 Medical/psycho	LH51 Medical/psycho	LH511 Re-entry-g physiology (1 1 1 1 x) LH512 Diagnosis & treatment (1 2 4 x) LH513 Surface g physiology (1 1 1 1 x)
LI Task Instr. (1 1 1 1 x)	Capable of carrying instruments in the following Instrument Groups: Manned Systems Atmospheric Entry Surface Weather & Space Oriented Surface and Subsurface Manned Operations Life Detection Surface Surveillance & Micro TV Radio Propagation Experiment		LI11 Instrument package	LI111 Spaceborne packaging (1 1 1 1 x) LI112 Accuracy (1 1 1 1 x) LI113 R&D required, high resolution image (1 1 1 1 x) LI114 Reliability, instr. package (1 1 1 1 x) LI115 Sterilization (1 1 1 1 x)
LM Check/Maint (1 2 3 x)	Prelaunch checkout Performance monitor, report Switching of redundant units Malfunction diagnosis Orbital assembly checkout		LM11 Automatic failure monitor and fault isolation.	LM111 Monitoring & switching (1 2 3 x) LM112 Fault isolation (1 2 3 x) LM113 Spares weight & interchangeability (1 2 3 x) LM114 Zero g work, tools (1 2 3 x) LM115 Tech data access (1 2 3 x)
LP Propulsion (1 2 2 x)	ΔV250 m/sec 60,000 lbs. — for deboost from orbit ΔV4 km/sec 36,000 lbs. — for orbital rendezvous from Mars surface ΔV100 m/sec. 58,000 lbs. — for landing		LP11 Hypergolic storable liquid rockets for both landing engine and ascent engine.	LP111 Specific impulse (1 2 2 x) LP112 Throttleability (1 2 2 x) LP113 Restart reliability (1 2 2 x)

SYSTEM DESCRIPTION

DESIGNATOR MD02 L
CONCEPT MANNED MARS LANDER
SYSTEM Mars Excursion Module
(Page 3 of 3)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
LR Comm.	FOR RELAY TO ORBITAL STATION Trans data rate: 10^3 bits/sec digital + 10^4 bits/sec video + voice channels Range: 35 km FOR DIRECT COMMUNICATION TO EARTH 10^3 bits/sec digital 380 (10^6 km)		LR11 UHF/SHF Transceiver	LR111 Antenna directivity LR112 Antenna tracking LR113 Solar and cosmic noise
LS Stab./Cont.	Attitude control ±1° for deboost Body rates ±45°/sec max. during landing Attitude control ±0.25° during ascent	LS1 Aerodynamic control LS2 Gimballed engines	LS11 Aerodynamic Surfaces LS21 Thrust Vector Control (deboost, landing, ascent) plus storable hypergolic fuel reaction jets (glide attitude)	LS111 Re-entry heating LS112 Rotary bearings LS113 Stability dynamic range LS211 Reliability, TVC
LV Vehicle	Three-section vehicle (Command module, service area, living/work area) designed for atmospheric entry, soft landing, and egress for extra-vehicular surface exploration. Biological sterilization required both to prevent contamination of Mars and exotic contamination of earth.	LV1 Inflight requirements LV2 Surface requirements	LV11 Atmospheric entry body LV21 Living quarters	LV111 Re-entry heating LV112 Aerodynamic configuration LV113 Structural weight LV211 Portal air loss LV212 Biological sterilization and back contamination
LY Display	Ground and in-flight displays of operation (mission & sub system management) Subsystem Status (equip. status monitoring and maintenance) Task (Scientific instrumentation & analysis)	SOA		

SYSTEM DESCRIPTION

DESIGNATOR MD02M

CONCEPT

SYSTEM

The system serves as an Earth re-entry capsule for the astronauts, and [illegible] instrumentation, photographic film, taped data, etc., to return the results of the Mars [illegible] by Earth. [illegible] it will [illegible] the vehicle for bringing the crew to the assembled space [illegible] and [illegible] temporary quarters for the crew during period of thrusting for Earth [illegible] orbit entry, and Mars orbit launch. The Command and Re-entry Module will include retro-propulsion for control landing point during atmospheric re-entry. The re-entry portion will resemble the Apollo command module though larger, and the entire system will weigh approximately 20,000 lbs., including the propulsion unit.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
MA Ang. Power (S, T; 1 2 4)	Continuous power: 3 Kw; one week.		MA11 Fuel cell + NiCd battery	MA111 [illegible]; MA112 [illegible] power, [illegible]; MA113 [illegible]; MA114 [illegible]
MD Data Proc. (1 2 4)	RATES: Input data rate 10^3 bits/sec; Output comm. rate 10^3 bits/sec; Output display rate 10^3 bits/sec. STORAGE: Recoverable None; Temporary 10^5 bits		MD11 Central digital computer	MD111 [illegible]; MD112 [illegible]
ME Escape/Recy	Safe return of astronauts during earth launch. This is the primary function of this system.			
MG Guid./Nav. (1 2 4)	Escape from orbit: Velocity ±1 m/sec; Angle ±0.1 degree. M/C: Vel. Accuracy ±0.5 m/sec; Angle ±5 degrees. Approach: Position ±50 km. Deboost: Velocity ±1 m/sec; Angle ±1 degree. Rendezvous & Docking: Rel. Pos. 0.3 (m); Rel. Vel 0.3 m/sec; Acquisition Cond. 200 km	MG1 Escape from planet orbit	MG11 Star tracker and inertial system with laser ranging orbit determination.	MG111 Reliability, star tracker; MG112 Reliability, laser ranging; MG113 R&D required, laser ranging; MG114 Reliability, inertial system
		MG2 Midcourse	MG21 DSIF & star tracker & inertial system	MG211 Reliability, inertial system
		MG3 Planet Approach	MG31 Planet horizon scanner with laser ranging.	MG311 Horizon definition, Mars; MG312 Reliability, horizon scanner; MG313 R&D required, laser ranging; MG314 Reliability, laser ranging
		MG4 Deboost	MG41 Inertial system	MG411 Reliability, inertial system
		MG5 Rendezvous & Docking	MG51 Radar, rendezvous	MG511 Reliability, radar
MH Life Support (1 2 4 2)	AIR: 1.8 lb. O_2/man/day; WATER: 5.16 lb. (drink), 9.84 lb. (hygiene)/man/day; FOOD: 3,000 cal/man/day; TPH: 75±5°F, 46% RH, 3.5 - 14.7 PSIA; MED: physiological monitoring; RADIATION: inst. 100 rem	MH1 Air	MH11 Nitrogen/oxygen	MH111 Leak detection & alarm; MH112 CO_2 & CO monitor, alarm removal
		MH2 TPH	MH21 Automatic TPH	MH211 Waste heat rejection; MH212 Fast action repressurization & leak alarm
		MH3 Medical/Psycho	MH31 Medical/psycho	MH311 Reentry g physiology; MH312 Reduction in natural immunities
MM Check/Maint (1 2 3)	Prelaunch checkout (ground/orbit); Performance monitor, report; Switching of redundant units; Malfunction diagnosis	MM1 Inflight	MM11 Automatic failure monitor and fault isolation	MM111 Monitoring & switching; MM112 Reliability of checkout & maintenance equipment
		MM2 Prelaunch (ground & orbit)	MM21 Automatic checkout	MM211 Reliability of c&M equip.; MM212 Simplification; MM213 Monitoring & switching

SYSTEM DESCRIPTION

DESIGNATOR MD02 M
CONCEPT MANNED MARS LANDER
SYSTEM Command & Re-Entry Module (Page 2 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
MP Propulsion (S, T; 1 2 2 x)	ΔV 200 m/sec; pay oad 20,000 lb., for final control of re-entry point.			MP11 Storable liquid rocket	MP111 Reliability, long storage (1 2 2 x); MP112 Cutoff precision (1 2 2 x); MP113 Specific impulse (1 2 2 x); MP114 Restart reliability (1 2 2 x)
MR Comm.	Trans. data rate: 10^3 bits/sec digital plus voice Range: 3,500 miles	SOA			
MS Stab/Control	Attitude control: ±.25 degrees	SOA			
MT Sim/Train (1 2 2 4 x)	Prelaunch skill acquisition, retention of earth return skills.			MT11 Re-entry training	MT111 Skill retention (1 2 2 4 x)
MV Vehicle (2 2 4 4 x)	Atmospheric entry from earth orbit Shielding Thermal environment EVA portals, access to spacecraft and to MEM Docking			MV11 Atmospheric entry body	MV111 High velocity re-entry (2 2 4 x)
MY Display	Inflight displays of operation (mission & subsystem management), rendezvous and docking. Subsystem Status (equip. status monitoring and maintenance)	SOA			

SYSTEM DESCRIPTION

A [illegible] precursor [illegible] to be soft [illegible] by parachute on the selected manned landing site. [illegible] be launched from the orbiter on successive passes of the landing site. The [illegible] determine suitability of the [illegible] for landing and EVA operations and [illegible] as a beacon for the landing approach.

DESIGNATOR [illegible] MD02P 12
CONCEPT MANNED MA[illegible]
SYSTEM [illegible]

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
A Aux. Power (S, T)	Peak power: 25 watts for surface sampling and on demand Continuous power: 5 watts, 10 days	SOA		
D Data Proc.	Transmit landing shock profile	SOA	Simple analog modulation of carrier frequency as a function of impact acceleration, to be recorded and analyzed onboard orbiter.	
I Task Instr	Surface impact jerk measurement Gross dust composition measurement	SOA		
P Propulsion (1 2 x 2)	ΔV 250 m/sec for deorbit Payload 100-200 lbs.		PP11 Fixed pulse hypergolic storable liquid rocket. PP12 Fixed pulse solid rocket	PP111 Impulse accuracy PP112 Reliability, long storage PP121 Impulse accuracy
R Comm. (1 1 x 2)	Radio beacon transponder, omni-directional azimuth pattern, vertical profile to permit spacecraft approach		PR11 UHF Transceiver	PR11 Antenna directivity PR12 Automatic erection and alignment
S Stab/Control	Attitude stabilization ± 1° during deboost	SOA		
V Vehicle (1 1 2 x 4)	Atmospheric entry vehicle plus parachute to survive 15 m/sec impact		PV11 Atmospheric entry body.	PV111 Uncertain characteristics of Martian atmosphere PV112 Uncertain characteristics of Martian surface

SYSTEM DESCRIPTION

Similar to the spacecraft for the Manned Mars Probe Orbiter - MD04 S. The spacecraft provides living quarters for six men for the duration of the mission (500 to 600 days) except for periods of thrusting. A shirtsleeve environment is required. Observational sensors will be mounted on the spacecraft as well as communications antennas. Communications equipment, data processing, display and other mission oriented equipment will be carried in the spacecraft. An artificial gravity environment may be attained during enroute phases by spinning the entire assembly. Provision for mounting, launching, and monitoring several atmospheric and surface probes will be made. A radiation "storm cellar" environment suitable for a few days will be required. The spacecraft will weigh in the vicinity of 75,000 lbs. Guidance and navigation contained in Command and Re-Entry Module.

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS / FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

SA Aux. Power (S: X; T: 1 2 4 5)

- Continuous power: 25 K watts, 600 days

SD Data Proc. (X; 1 2 4)

- Input data rate: 10^5 bits/sec digital, 8 min/orbit, + 10^4 bits/sec video
- Output communication rate: 10^4 to 10^5 bits/sec
- Recoverable storage: Tape and film
- Temporary storage: 10^7 bits

SE Escape/Recy.

- Safe return of astronauts.

SH L. Support (X; 1 2 4 2)

- SEE PAGE 2.

SI Task Instr. (X; 1 1 1 1)

- Capable of carrying instruments in the following Instrument Groups:
  - Manned Systems
  - Interplanetary
  - Planet Oriented
  - TV Mapping
  - Radar Mapping
  - Radio Propagation Experiment

SM Check/Maint. (X; 1 2 3)

- Prelaunch checkout in orbit
- Performance monitor, report
- Switching of redundant units
- Malfunction diagnosis
- Orbital assembly checkout

SR Comm. (X; 1 2 3)

- Transmission data rate: max. 10^4 to 10^5 bits/sec digital
- Range: Maximum ~ 2.5×10^8 km to earth, voice to MEM

FUNCTIONAL ELEMENTS

- SOA
- SM2 Orbital assembly and prelaunch from orbit
- SM3 Inflight

CONFIGURATIONS

- SA11 Solar dynamic
- SA12 Nuclear fission, reactor dynamic (SNAP-8)
- SD11 Digital computer, tape recorder, video encoder
- Use normal command module for reentry from earth orbit, no provision for abort during interplanetary flight and during Mars orbit.
- SI11 Instrument package
- SM21 Automatic checkout
- SM31 Automatic failure monitor and fault isolation.
- SR11 UHF/SHF Transceiver

TECHNOLOGY DEFICIENCIES

		S	1	2	3	4	10
SA111	High temperature materials					X	
SA112	Waste heat rejection			X			
SA113	Wearout					X	
SA121	High temperature materials					X	
SA122	R&D required, nuclear reactor			X	X	X	
SA123	Wearout					X	
SA124	Welding					X	
SA125	Waste heat rejection			X		X	
SD111	Memory density, tape recorder				X	X	
SD112	Reliability, digital computer				X		
SD113	Reliability, tape recorder				X	X	
SD114	Data compression					X	
SD115	Radiation alteration of memory			X	X	X	
SI111	Spaceborne packaging					X	
SI112	Accuracy				X		
SI113	E&D, high resolution image					X	
SI114	Reliability, instr. package					X	
SI115	Sterilization				X		
SM211	Reliability of c&m equip				X		
SM212	Simplification				X		
SM311	Monitoring & switching				X		
SM312	Fault isolation				X		
SM313	Spares weight and interchangeability				X		
SM314	Zero-g work, tools				X		
SM315	Technical data access				X		
SR111	Power requirement				X		
SR112	Transmitter efficiency				X		
SR113	Antenna directivity					X	
SR114	Low signal/noise ratio				X		

SYSTEM DESCRIPTION

DESIGNATOR MD02 S MD02 S 122
CONCEPT MANNED MARS LANDER
SYSTEM Spacecraft (Page 2 of 3)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SH Life Support (1 2 4 2 x)	AIR: 1.8 lb. O_2/man/day WATER: 6.16 lb. (drink), 9.84 lb. (hygiene)/man/day FOOD: 3,000 cal/man/day TPH: 75±5°F, 46% RH, 3.5 - 14.7 PSIA MEDICAL: medical, dental care, physiological monitoring RADIATION: inst. 100 rem, cumulative 350 rem 1 year	SH1 Air	SH11 Nitrogen/oxygen	SH111 Leak detection & alarm (5 1 2 4 x) SH112 CO_2 & CO monitor, alarm, removal (1 2 4 x) SH113 Contaminant detection (1 2 4 x) SH114 Odor & contaminant removal (1 2 4 x)
		SH2 Water	SH21 Recycled water	SH211 Psychological (1 1 1 1 x) SH212 Ion removal & pH control (1 2 4 x) SH213 Trace contaminants (1 2 3 3 x)
		SH3 Food	SH31 Stored food	SH311 Monotony (1 1 3 x) SH312 Waste disposal (1 1 1 x) SH313 Preservation & storage (1 1 3 x) SH314 Nutrient/bulk ratio (1 1 3 x) SH315 Preparation and/or reconstitution, crumbs, outgassing (1 1 3 x) SH316 Biological gas & odor production (1 1 3 x)
		SH4 TPH	SH41 Automatic TPH	SH411 Fast action repressurization (1 2 4 2 x) SH412 Non-toxic fire extinguisher (1 2 4 2 x) SH413 Comfort factors (1 2 4 x) SH414 Atmospheric circulation & cycling (1 2 4 x)
		SH5 Medical/psycho	SH51 Medical/psycho	SH511 Zero-g physiology (1 1 1 1 x) SH512 Morale (1 1 1 1 x) SH513 Sanitation (1 2 4 x) SH514 Diagnosis & treatment health (1 2 4 x) SH515 Surgical implant of bio-medical sensors (1 2 4 4 x) SH516 Reduction in natural immunities (1 2 4 4 x)
SS Stab. Control (1 2 3 x)	Attitude Control: ±0.25° during thrusting; ± 5° during coast Mars local vertical ±0.2°	SS1 Moment generators	SS11 Thermo-electric thrusters	SS111 R&D required, thermo-electric thruster (2 2 2 2 x) SS112 Non-linear performance (1 2 3 3 x) SS113 Reliability, TE thrusters (2 2 2 3 x)
			SS12 Hypergolic reaction jets	SS121 Dead zone (1 2 3 x) SS122 Attitude resolution (1 2 3 x) SS123 Propellant limited (1 2 3 x) SS124 Reliability (1 2 3 x)
		SS2 Sensors	SS21 Horizon scanner; attitude and rate gyros	SS211 Reliability, horizon scanners (1 2 4 x) SS212 Reliability, rate gyros (1 2 3 x)

SYSTEM DESCRIPTION

DESIGNATOR MD02 S
CONCEPT MANNED MARS LANDER
SYSTEM Spacecraft

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

ST Sim/Train.

			x	
1	1	1	1	1

- Prelaunch skill requisition and inflight skill retention for vehicle operation and scientific work

SV Vehicle

			x	
1	2	2	2	

- Subsystem integration
  - Magnetism
  - Field of view
  - Communications
  - Boom extension
- Atmospheric entry
- Shielding
- Thermal environment
- EVA portals
- Docking
- Orbital assembly

SY Display

- Inflight displays of operation (mission and subsystem management)
- Subsystem status (equipment status, monitoring and maintenance)
- Task (scientific instrumentation and analysis)

FUNCTIONAL ELEMENTS / CONFIGURATIONS

- ST11 Inflight skill retention
- SV1 Docking and assembly
  - SV11 Closed spacecraft structure
- SV2 Inflight
  - SV21 Living Quarters
- SOA

TECHNOLOGY DEFICIENCIES

		$	T
ST111	Crew mix	x	1
ST112	Redundancy	x	1
SV111	Large vehicle assembly operations	x	4
SV112	Docking shock	x	2
SV211	Meteoric protection	x	2
SV212	Material degradation	x	3
SV213	Portal reaction thrust	x	2
SV214	Optical window degradation	x	3
SV215	Waste disposal	x	3

SYSTEM DESCRIPTION

Same as Manned Mars Probe Orbiter, MO04 X. This is a non-pressurized one-man space tug used for major assembly jobs in earth orbit. The operator will wear a conventional EVA space suit. It should be usable for: 10 hours rechargeable from spacecraft. Must have adequate propulsion for self and equipment. Must be able to control attitude in orbit. Must be capable of performing any necessary work in assembling the various systems. Communications for voice to 500 miles.

DESIGNATOR CONCEPT SYSTEM

MO02 X

MANNED MARS PROBE

Extra-Vehicular Vehicle

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
XA Aux. Power (S/T)	Continuous power 200 W, 10 hrs.	SOA			
XH Life Support	Tankage for oxygen, water, food, waste.	SOA			
XP Propulsion (1 2 2 x)	Total ΔV 2.0 m/aec, 250 000 lb. payload, to maneuver units for docking. Acceleration impulse limited to 0.5 m/sec ΔV. Throttleable.		XP11 Cryogenic liquid rockets XP12 Hypergolic storable liquid rockets	XP111 Specific Impulse (1 2 2 x) XP112 Cryogenic storage (1 2 2 x) XP113 Restart reliability (1 2 2 x) XP114 Throttleability (1 2 2 x) XP121 Specific impulse (1 2 2 x) XP122 Restart reliability (1 2 2 x) XP123 Throttleability (1 2 2)	
XR Comm. (1 1 2 x)	4 channel voice 200 km 10 hrs. 1 channel voice 2000 km 10 min. 1 channel biomed. digital data link 200 km 10 hrs.		XR1 Voice, local — SOA XR2 Voice, long range, biomed data link — XR21 VHF/UHF transceiver	XR211 Antenna directivity (1 1 2 x) XR212 Power (1 1 2 x) XR213 Coding (1 1 2 3)	
XS Stab/Control (1 1 1 1)	0.25°/sec 3-axis angular rate sensor, display only, manual control of attitude jets.	SOA			
XT Sim/Train. (1 1 1 1 x)	Prelaunch skill acquisition for vehicle maneuvering and docking operation and docking crew coordination.		XT11 Assembly training	XT111 Realism of zero-g work (1 1 1 1 x) XT112 Crew mix (1 1 1 1 x)	
XV Vehicle (1 2 2 x)	Unpressurized open one-man vehicle with propulsion and life support tankage to support one worker in space suit. Grapplers and shock absorbers for maneuvering and docking operations.		XV11 Open one-man space vehicle	XV111 Docking shock (1 2 2 x) XV112 Grappling of large masses (1 2 2 1 x)	
XY Display	Display of attitude rate, propulsion and life support supply status, biomedical monitor display	SOA			

CONCEPT DESCRIPTION

CONCEPT MANNED MARS INVESTIGATION LANDER

DESIGNATOR MD04

MISSION OBJECTIVES The landing of six men on the Martian surface for 40 days. The men study the surface, taking samples, investigating for life forms, atmosphere and changes in atmosphere in a major scientific effort. Four men remaining in the spacecraft will perform mapping, spectrographic analysis, and other general observations of the Martian planet. The concept follows the Manned Mars Lander MD02.

GENERAL DESCRIPTION A ten-man mission, assembled in a 550 km earth orbit, consisting of a Command and Re-Entry Module, a Spacecraft for enroute living space, a six-man Mars Lander, and a nuclear orbital booster. The spacecraft, orbital booster, and command and re-entry module orbit Mars at 500km altitude while the Lander descends to an atmosphere and retro-thrust braked landing on the surface. A two-man Rover is used for exploring the vicinity of the landing site. At the completion of the surface exploration, the command portion of the lander returns to the orbiting vehicle and the crew is returned to earth. Total mission duration will range from 400 to 600 days, depending upon the launch year which will be near 1985.

LIST OF SYSTEMS

B Booster (Saturn V)
G Ground Support Facility
J *Orbital Booster
L *Mars Lander
M *Command and Re-Entry Module
P *Precursor Probe
R *Mars Rover
S *Spacecraft
X *Extra-Vehicular Activity Unit

*Detailed description follows.

REFERENCES

1. "A Study of Early Manned Interplanetary Missions", AOK 63-0001, 31 Jan 1963, GD/A.

SYSTEM DESCRIPTION

DESIGNATOR MD04J — MD04J

CONCEPT MANNED MARS INVESTIGATION [illegible]

SYSTEM Orbital Booster

Similar to Manned Mars Probe Orbiter MD04 J. This is a massive system, assembled with the spacecraft in [illegible] orbit. It provides four major thrusting increments earth orbital launch, Mars orbital capture, Mars orbital launch, and deboost to earth parabola, and also propulsion for midcourse corrections enroute. Nuclear propulsion is required to minimize earth launch weight. The total gross weight of this system with the Spacecraft, Command and Re-Entry Module, and Mars lander is approximately 8 million lbs. or 1 million lbs. into earth orbit, depending on whether solid core nuclear or gaseous fission rockets are used. The orbital launch booster will be launched in sections, each approximately the maximum payload of a Saturn V vehicle.

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS / FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

JA Aux. Power (S/T)

- Continuous Power: 1 KW during thrusting; Chemical dynamic system — SOA

JG Guid./Nav.

- Supplied by Command Module — Supplied by Command Module

JM Check/Maint (1 2 3 x)

- Prelaunch checkout; Performance monitor, report; Switching of redundant units
  - JM11 Automatic failure monitor and fault isolation
    - JM111 Monitoring & switching (1 2 3 x)

JP Propulsion (2 2 4 2 x)

	Nuclear Solid I_{sp} = 900 sec	Nuclear Gaseous I_{sp} = 3000 sec	
1. ΔV=7 km/sec	2.4M lbs.	540K lbs	for escape from earth orbit
2. ΔV=6 km/sec	800K lbs.	365K lbs	for deboost into Mars orbit
3. ΔV=6 km/sec	270K lbs.	163K lbs	for escape from Mars Orbit
4. ΔV=9 km/sec	35K lbs.	35K lbs.	for deboost into earth parabola

- JP11 Solid core nuclear fission rocket at I_{sp} = 900 sec, requiring 8M lbs gross into earth orbit.
  - JP111 High temperature materials (2 2 4 2 x)
  - JP112 Shielding (1 1 2 4 x)
  - JP113 R&D required (2 2 4 2 x)
  - JP114 Cryogenic storage (1 2 2 x)
  - JP115 Cooldown and restart (2 2 4 2 x)
- JP12 Gaseous core nuclear fission rocket at I_{sp} = 3000 sec, requiring 350K lbs. gross into earth orbit.
  - JP121 Thrust vectoring (2 2 4 4 x)
  - JP122 Startup (2 2 4 8 x)
  - JP123 Shielding (1 1 2 4 x)
  - JP124 R&D required (2 2 4 6 x)
  - JP125 Cryogenic storage (1 2 2 x)

JS Stab./Cont

- Attitude: .25°
  - Thrust Vector Control — Main propulsion — SOA
  - Roll Control — Hypergolic reaction jets — SOA

JV Vehicle (1 2 2 2 x)

- Shielding; Docking; Orbital assembly
  - JV11 Open frame structure; Tankage assembled in orbit.
    - JV111 Meteoric protection (1 2 2 2 x)
    - JV112 Material degradation (1 2 2 2 x)
    - JV113 Shielding for on/off operation (1 2 4 4 x)
    - JV114 Dock Shock (1 2 2 x)

SYSTEM DESCRIPTION

A landing vehicle composed of three sections plus a surface rover - MD04 R. This vehicle carries six men from Mars orbit to the Mars surface and provides accommodations for 40 days. The service area and living/work area remain on the surface. The command area returns to rendezvous with the spacecraft - MD04 S, in Martian orbit. The living/work area includes an inflatable structure to increase the living area during the Martian stay. Total landed weight is approximately 100,000 lbs.

DESIGNATOR MD04 L
CONCEPT MANNED MARS INVESTIGATION LANDER
SYSTEM Mars Lander (Page 1 of 3)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
LA Aux. Power (S: x; T: 1 2 4)	Continuous power: 3 Kw for 40 days.		LA11 Isotope Thermoelectric	LA111 Specific energy (S: x; T: 1 2 3) LA112 Isotope resources (x: 1 2 3 12) LA113 Shielding (x: 1 2 3 3) LA114 Waste heat rejection (x: 1 2 4) LA115 Temperature limited efficiency (x: 1 2 3 10)
LD Data Proc. (x: 1 2 4)	RATES Input data rate: 10^3 bits/sec digital plus 3 photos per 1 1/2 hr Output comm. rate: 10^3 bits/sec digital plus 10^7 bits/sec video, (real time TV) Output display rate: 10^3 bits/sec STORAGE Recoverable: Tapes and film Temporary: 10^7 bits	LD1 Digital data LD2 Photographic data	LD11 Digital data processor with tape recorder, video encoder. LD21 Color and black/white still and motion photography; onboard processing of stills for selected relay to earth; return of unprocessed movie photographic film. LD22 Thermoplastic color photography	LD111 Data compression (x: 1 2 4 5) LD112 Memory density, digital processor (x: 1 2 4) LD113 Reliability, digital processor (x: 1 2 4) LD114 Reliability, tape recorder (x: 1 2 4) LD115 Maintainability digital processor (x: 1 1 3) LD211 Radiation protection of unprocessed film (x: 1 2 3) LD212 R&D for onboard film processing (x: 1 2 3 2) LD221 R&D required, thermoplastic color photography (x: 1 2 3 2) LD222 Spaceborne packaging (x: 1 2 3 1)
LG Guid./Nav. (x: 1 2 4)	Deorbit velocity: ±1 m/sec Position accuracy: ±3 km Angle: ±1 degree Rendezvous injection: Velocity: 1 m/sec Altitude: 5 km Angle: 0.5 degree Phase distance: 15 km	LG1 Inertial guidance for deboost and ascent LG2 Approach and docking guidance for landing and docking.	LG11 Inertial system LG21 Docking radar and visual	LG111 Reliability, long storage (x: 1 2 4) LG112 Deboost & ascent calculation (x: 1 1 1 2) LG113 Weight, inertial system (x: 1 2 4) LG211 Reliability, radar (x: 1 2 3)

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

LH Life Support

			x	
1	2	4	2	

AIR: 1.8 lb. O_2/man/day
WATER: 3.16 lb. (drink), 9.84 lb (hygiene)/man/day
FOOD: 3,000 cal/man/day
TPH: 75±5°F, 46% RH, 3.5 - 14.7 PSIA
MED: medical, physiological monitoring
RADIATION: inst. 100 rem.

LI Task. Instr.

			x	
1	1	1	1	1

Capable of carrying instruments in the following instruments:
- Manned Systems
- Atmospheric Entry
- Surface Weather & Space Oriented
- Surface and Subsurface
- Manned Operations
- Life Detection
- Surface Surveillance & Micro TV
- Radio Propagation Experiment

LM Check/Maint

		x		
1	2	3		

Prelaunch checkout
Performance monitor, report
Switching of redundant units
Malfunction diagnosis
Orbital assembly checkout

LP Propulsion

		x		
1	2	2		

- ΔV 250 m/sec, 105,000 lbs. — for deboost from orbit
- ΔV 4 km/sec, 55,000 lbs. — for orbital rendezvous from Mars surface
- ΔV 100 m/sec, 160,000 lbs. — for Mars landing

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Functional Element	Configuration	Technology Deficiencies	$	T	1	2	3	4	5
LH1 Air	LH11 Nitrogen/oxygen low pressure	LH111 Leak detection					x		
					1	2	4		
		LH112 CO_2 & CO monitor, alarm, removal					x		
					1	2	4		
		LH113 Contaminant detection					x		
					1	2	4		
		LH114 Odor and contaminant removal					x		
					1	2	4		
LH2 Water	LH21 Recycled water	LH211 Psychological							x
					1	1	1	1	1
		LH212 Trace contaminants							x
					1	2	3	3	
		LH213 Ion removal & pH control					x		
					1	2	4		
		LH214 Bacteria destruction					x		
					1	2	4		
LH3 Food	LH31 Stored food	LH311 Preservation					x		
					1	1	3		
		LH312 Nutrient/bulk ratio					x		
					1	1	3		
		LH313 Preparation and/or reconstitution, crumbs, outgassing					x		
					1	1	3		
		LH314 Biological gas & odor production					x		
					1	1	3		
LH4 TPH	LH41 Automatic TPH	LH411 Fast acting repressurization						x	
					1	2	4	2	
		LH412 Non-toxic fire extinguisher						x	
					1	2	4	2	
		LH413 Reliability of controls					x		
					1	2	4		
LH5 Medical/psycho	LH51 Medical/psycho	LH511 Re-entry g physiology						x	
					1	1	1	1	
		LH512 Diagnosis & treatment					x		
					1	2	4		
		LH513 Surface g physiology						x	
					1	1	1	1	
	LI11 Instrument package	LI111 Spaceborne packaging						x	
					1	1	1	1	
		LI112 Accuracy						x	
					1	1	1	1	
		LI113 R&D required, high resolution image							x
					1	1	1	1	
		LI114 Reliability instr. package						x	
					1	1	1	1	
		LI115 Sterilization						x	
					1	1	1	1	
	LM11 Automatic failure monitor and fault isolation	LM111 Monitoring & switching					x		
					1	2	3		
		LM112 Fault isolation					x		
					1	2	3		
		LM113 Spares weight & interchangeability					x		
					1	2	3		
		LM114 Zero g work, tools					x		
					1	2	3		
		LM115 Tech. data access					x		
					1	2	3		
	LP11 Hypergolic storable liquid rockets for both landing engine and ascent engine.	LP111 Specific impulse					x		
					1	2	3		
		LP112 Throttleability					x		
					1	2	2		
		LP113 Restart reliability					x		
					1	2	2		

SYSTEM DESCRIPTION

DESIGNATOR MD04 L
CONCEPT MANNED MARS INVESTIGATION LANDER
SYSTEM Mars Lander
(Page 3 of 3)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
LR Comm. (S, T; 1 2 3 x)	FOR RELAY TO ORBITAL STATION: Trans. data rate: 10^3 bits/sec digital + 10^4 bits/sec video + voice channels Range: 3500 km FOR DIRECT COMMUNICATION TO EARTH: 10^3 bits/sec digital 380 (10^6) km Voice link to Rover and to each EVA man		LR11 UHF/SHF Transceiver	LR111 Antenna directivity (S, T; 1 1 2 x) LR112 Antenna tracking (1 2 3 x) LR113 Solar and cosmic noise (1 2 3 x)
LS Stab/Cont. (1 2 3 3 x)	Attitude control ±1° for deboost Body rates ±45°/sec. max. during landing Attitude control ±0.25° during ascent	LS1 Aerodynamic Control LS2 Gimballed engines LS3 Inertial system attitude reference	LS11 Aerodynamic Surfaces LS21 Thrust Vector Control (deboost, landing, ascent) plus storable hypergolic fuel reaction jets (glide attitude) LS31 Inertial system	LS111 Re-entry heating (1 2 3 3 x) LS112 Rotary bearings (1 2 3 3 x) LS113 Stability dynamic range (1 2 3 3 x) LS211 Reliability, TVC (1 2 4 x) LS311 Shutdown reliability, inertial system (1 2 3 x)
LV Vehicle (1 2 3 3 x)	Three-section vehicle (Command module, service area, living/work area) designed for atmospheric entry, soft landing, and egress for extra-vehicular surface exploration. Biological sterilization required both to prevent contamination of Mars and exotic contamination of earth. Inflatable living quarters for extended stay on Martian surface. Provision for carrying and debarking Rover.	LV1 Inflight requirements LV2 Surface requirements	LV11 Atmospheric entry body LV21 Living quarters	LV111 Re-entry heating (1 2 3 3 x) LV112 Aerodynamic configuration (1 2 3 3 x) LV113 Structural weight (1 2 3 3 x) LV211 Portal air loss (1 2 2 2 x) LV212 Biological sterilization and back contamination (1 1 1 4 x) LV213 Leakage, inflatable structure (1 2 2 x) LV214 Portals, inflatable structure (1 2 2 2 x)
LY Display	Ground & inflight displays of operation (mission & subsystem management) Subsystem status (equip. status monitoring and maintenance) SOA Task (scientific instrumentation & analysis)			

SYSTEM DESCRIPTION

This system serves as an Earth re-entry capsule for the astronauts, and all necessary instrumentation, photographic film, taped data, etc., to return the results of the Mars expedition to Earth. In addition, it will serve as the vehicle for bringing the crew to the assembled space vehicle in orbit and as temporary quarters for the crew during period of thrusting for Earth orbit launch, Mars orbit entry, or Mars orbit launch. The Command and Re-Entry Module will include retropropulsion for first control landing point during atmospheric re-entry. The re-entry portion will resemble the Apollo Command Module, though larger, and the entire system will weigh approximately 20,000 lbs., including the propulsion unit.

DESIGNATOR

MD04M

CONCEPT

MANNED MARS INVESTIGATION LANDER

SYSTEM

Command and Re-Entry Module (Page 1 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
MA Aux. Power (S T 1 2 4 x)	Cont. power, 5 kw, one week		MA11 Fuel cell + NiCad battery	MA111 Shuttle reliability (S T 1 2 4 x)
				MA112 Specific power, fuel cell (1 2 4 x)
				MA113 Service life, fuel cell (1 2 4 x)
				MA114 High load efficiency (1 2 4 x)
MD Data Proc.	RATES Input data rate 10^3 bits/sec Output comm. rate 10^3 bits/sec Output display rate 10^3 bits/sec STORAGE Recoverable None Temporary 10^5 bits		MD11 Central digital computer	MD111 Reliability, digital computer (1 2 4 x)
				MD112 Memory density, digital computer (1 2 4 x)
ME Escape/Recov.	Safe return of astronauts during earth launch This is the primary function of this system.	SOA		
MG Guid/Nav. (1 2 4 x)	Escape from orbit. Velocity ± 1 m/sec Angle ± 0.1 degree	MG1 Escape from planet orbit	MG11 Star tracker and inertial system with laser ranging orbit determination	MG111 Reliability, star tracker (1 2 3 x)
				MG112 Reliability, laser ranging (1 2 4 x)
				MG113 R&D req'd. laser ranging (1 2 4 3 x)
				MG114 Reliability, inertial system (1 2 3 x)
	M/C: Vel. Accuracy ± 0.5 m/sec Angle ± 5 degrees	MG2 Midcourse	MG21 DSIF, star tracker and inertial system	MG211 Reliability, inertial system (1 2 4 x)
	Approach Position ± 50 km	MG3 Planet approach	MG31 Planet horizon scanner with laser ranging	MG311 Horizon definition, Mars (1 2 4 x)
				MG312 Reliability, horizon scanner (1 2 4 x)
				MG313 R&D req'd. laser ranging (1 2 4 3 x)
				MG314 Reliability, laser ranging (1 2 4 x)
	Deboost: Velocity ± 1 m/sec Angle ± 1 degree	MG4 Deboost	MG41 Inertial system	MG411 Reliability, inertial system (1 2 4 x)
	Rendezvous & Docking: Rel. Pos. 0.3 (m) Rel. Vel. 0.3 m/sec Acquisition Cond. 200 km	MG5 Rendezvous & docking	MG51 Radar, rendezvous	MG511 Reliability, radar (1 2 3 x)
MH Life Support (1 2 4 2 x)	AIR: 1.8 lb. O_2/man/day WATER: 6.16 lb (drink), 9.84 lb (hygiene)/man/day FOOD: 3,000 cal/man/day	MH1 Air	MH11 Nitrogen/oxygen	MH111 Leak detection & alarm (1 2 4 x)
				MH112 CO_2 & CO monitor, alarm, removal (1 2 4 x)
		MH2 TPH	MH21 Automatic TPH	MH211 Waste heat rejection (1 2 4 x)
				MH212 Fast action repressurization and leak alarm (1 2 4 3 x)
		MH3 Medical/Psycho	MH31 Medical/Psycho	MH311 Re-entry g physiology (1 2 1 1 x)
				MH312 Reduction in natural immunities (1 2 4 x)
	T P H: 75±5°F, 46%RH, 3.5-14.7 PSIA	MM1 Inflight	MM11 Automatic failure monitor and fault isolation	MM111 Monitoring & switching (1 2 3 x)
				MM112 Reliability of checkout & maintenance equipment (1 2 3 x)
	MED: physiological monitoring RADIATION: inst. 100rem	MM2 Prelaunch (ground & orbit)	MM21 Automatic checkout	MM211 Reliability of C/M equipment (1 2 3 x)
				MM212 Simplification (1 2 3 x)
MM Check/Maint. (1 2 3 x 1)	Prelaunch checkout (ground/orbit) Performance monitor, report Switching of redundant units Malfunction diagnosis			MM213 Monitoring & switching (1 2 3 x)

SYSTEM DESCRIPTION

DESIGNATOR MD04 M
CONCEPT MANNED MARS INVESTIGATION LANDER
SYSTEM Command and Re-Entry Module (Page 2 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
MP Propulsion	Δ V 500m/sec; payload 35,000 lb., for transfer from Earth, return flight to earth orbit, and to deboost from earth orbit.		MP11 Storable liquid rocket	MP111 Reliability long storage MP112 Cutoff precision MP113 Specific impulse MP114 Restart reliability
MR Comm.	Trans. data rate: 10^3 bits/sec digital plus voice Range: 3,500 miles SOA			
MS Stab/Control	Attitude control: ±.25 degrees SOA			
MT Sim/Train	Prelaunch skill acquisition, retention of earth return skills.		MT11 Re-entry training	MT111 Skill retention
MV Vehicle	Atmospheric entry from earth orbit Shielding Thermal environment EVA portals Docking		MV11 Atmospheric entry body	MV111 High velocity re-entry
MY Display	Inflight displays of operation (mission & subsystem management), rendezvous and docking. Subsystem Status (equip. status monitoring and maintenance). SOA			

SYSTEM DESCRIPTION

DESIGNATOR CONCEPT SYSTEM MD041

This is the same as MANNED MARS LANDER (MD02). A 100-200 lb [illegible] probe to be soft-landed by parachute on the selected manned [illegible]. Two [illegible] probes may be launched from the orbiter on success [illegible] landing site. The probe will determine suitability of the surface for landing and EVA operations and will serve as a beacon for the landing approach.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
PA Aux. Power (S T)	Peak Power: 25 watts for surface sampling and on demand Continuous power: 5 watts, 10 days	SOA			
PD Data Proc.	Transmit landing shock profile	SOA		Simple analog modulation of carrier frequency as a function of impact acceleration, to be recorded and analyzed onboard orbiter.	
PI Task Instr.	Surface impact jerk measurement Gross dust composition measurement	SOA			
PP Propulsion (1 2 x 2)	Δ V 250 m/sec for deorbit Payload 100-200 lbs.		PP11 Fixed pulse hypergolic storable liquid rocket PP12 Fixed pulse solid rocket	PP111 Impulse accuracy PP112 Reliability, long storage PP121 Impulse	
PR Comm. (1 1 x 2)	Radio beacon transponder, omni-directional azimuth pattern, vertical profile to permit spacecraft approach		PR11 UHF transceiver	PR111 Antenna Directivity PR112 Automatic erection and alignment	
PS Stab/Control	Attitude stabilization ± 1° during deboost	SOA			
PV Vehicle (1 1 2 x 4)	Atmospheric entry vehicle plus parachute to survive 15 m/sec impact		PV11 Atmospheric entry body	PV111 Uncertain characteristics of Martian atmosphere PV112 Uncertain characteristics of Martian surface	

SYSTEM DESCRIPTION

DESIGNATOR MD04R
CONCEPT MANNED MARS INVESTIGATION LANDER
SYSTEM Rover

A Mars surface roving vehicle to transport two men at 20 Km/hr. with life support and fuel provisions for 1-day excursions from the Lander. Capable of negotiating 45° slopes, rocky surfaces, and rills. Emergency provisions to sustain life for an additional day. Open configuration; men remain in EVA suits. Weight of the Rover will be 500 to 750 lbs.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
RA Aux. Power	Continuous power 200 watts for two days unless electric onboard power generation is used, then 1 KW peak and 200 watts continuous for 2 days.		RA11 NiCad storage battery recharged with primary rover propulsion system	RA111 Specific energy, NiCad; RA112 Reliability, NiCad
			RA12 Fuel cell, refuelable, AgZn battery	RA121 Reliability, fuel cell; RA122 Specific power, fuel cell; RA123 Specific cost, AgZn battery
RG Guid./Nav.	Visual pilotage plus RDF to base, northfinder gyro az. ref. to ±5°	SOA		
RH Life Support	Tankage for air, water, food, power necessary for TPH in EVA space suit. Environment maintenance in suit through umbilical.	SOA		
RI Task Instr.	Surface and atmospheric sampling, photography, biological sampling.	SOA		
RP Propulsion	Propel vehicle at 20 Km/hr. over hard surface for 12 hr. mission. Power capability for rough terrain.		RP11 Piston engine with hypergolic fuel	RP111 R&D required
			RP12 Turbine engine with hypergolic fuel	RP121 R&D required
			RP13 Electric motor, storage battery, or fuel cell.	RP131 Weight
RR Comm.	Voice communication to Lander and to Orbiter 3500 Km range		RR11 LF/MF transceiver UHF transceiver	RR111 Over-the-horizon radio propagation LF/MF
RV Vehicle	Open two-man vehicle with steerable running gear, steering over unfamiliar rough terrain.		RV11 Open two-man space vehicle	RV111 Steerable running gear; RV112 Sterilization; RV113 Crevice avoidance; RV114 Weight

SYSTEM DESCRIPTION

[illegible] spacecraft provides [illegible] for [illegible] for the [illegible] 00 to 00 [illegible] [illegible] thrusting. A shirtsleeve environment [illegible] required. Observational sensors [illegible] on the spacecraft as well as communications [illegible]. Communications [illegible] data processing, display and other mission oriented equipment will be carried in the spacecraft. An artificial gravity environment may be attained during enroute phases by spinning the entire assembly. Provision for mounting, launching and monitoring several atmospheric and surface probes will be made. A radiation storm cellar environment suitable for a few days will be required. The spacecraft will weigh in the vicinity of 75,000 lbs. Guidance and navigation contained in Command and Re-Entry Module.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S/T 1 2 4 5)	Continuous power: 35 K watts, 600 days		SA11 Solar dynamic	SA111 [illegible]
				SA112 [illegible]
				SA113 [illegible]
			SA12 Nuclear fission reactor dynamic (SNAP-8)	SA121 High temperature materials
				SA122 R&D required [illegible]
				SA123 Wearout
				SA124 Shielding
				SA125 Waste heat rejection
SD Data Proc. (1 2 4)	Input data rate: 10^5 bits/sec digital, 8 min. per orbit, plus 10^4 bits video Output communication rate 10^4 to 10^5 bits/sec. Recoverable storage: tape and film Temporary storage: 10^7 bits		SD11 Digital computer, tape recorder, video encoder	SD111 Memory density, tape recorder
				SD112 Reliability, digital computer
				SD113 Reliability, tape recorder
				SD114 Data compression
				SD115 Radiation operation of memory
SE Escape/Recy.	Safe return of astronauts.	SOA	Use normal command module for re-entry from earth orbit, no provision for abort during interplanetary flight and during Mars orbit.	
SI Task Instr. (1 1 1 1)	Capable of carrying instruments in the following instrument groups: Manned Systems Interplanetary Planet Oriented TV mapping Radar Mapping Radio Propagation Experiment		SI11 Instrument package	SI111 Spaceborne packaging
				SI112 Accuracy
				SI113 R&D, high resolution image
				SI114 Reliability, instr. package
				SI115 Sterilization
SH Life Support (1 2 4 2)	SEE PAGE 2.			
SM Check/Maint. (1 2 3)	Prelaunch checkout in orbit Performance monitor, report Switching of redundant units Malfunction diagnosis Orbital assembly checkout	SM2 Orbital assembly and prelaunch from orbit	SM21 Automatic checkout	SM211 Reliability of c&m equip
				SM212 Simplification
		SM3 [illegible]	SM31 Automatic failure monitor and fault isolation	SM311 Monitoring & switching
				SM312 Fault isolation
				SM313 Spares weight and interchangeability
				SM314 Zero-g work, tools
				SM315 Technical data access
SR Comm. (1 2 3)	Transmission data rate: 10^5 bits/sec digital Range: maximum 2.5×10^8 km to earth, plus voice to lander		SR11 UHF/SHF Transceiver	SR111 Power requirement
				SR112 Transmitter efficiency
				SR113 Antenna directivity
				SR114 Low signal/noise ratio

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

LH Life Support

S				x	
T	1	2	4	2	

AIR: 1.8 lb O_2/man/day
WATER: 6.16 lb (drink), 9.84 lb (hygiene)/man/day
FOOD: 3,000 cal/man/day
TPH: 75±5°F, 46% RH, 3.5 - 14.7 PSIA
MEDICAL: medical, dental care, physiological monitoring
RADIATION: inst. 100 rem., cumulative 350 rem / year

SS Stab. /Control

			x		
	1	2	3		

Attitude Control: ±0.25° during thrusting
±5° during coast
Mars local vertical: ±0.2°

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Functional Element	Configuration	Technology Deficiency	S	1	2	3	4
SH1 Air	SH11 Nitrogen/oxygen	SH111 Leak detection & alarm				x	
		SH112 CO_2 & CO monitor, alarm, removal				x	
		SH113 Contaminant detection				x	
		SH114 Odor & contaminant removal				x	
SH2 Water	SH21 Recycled water	SH211 Psychological				x	
		SH212 Ion removal & pH control				x	
		SH213 Trace contaminants				x	x
SH3 Food	SH31 Stored food	SH311 Monotony				x	
		SH312 Waste disposal				x	
		SH313 Preservation & storage				x	
		SH314 Nutrient/bulk ratio				x	
		SH315 Preparation and/or reconstitution, crumbs, outgassing				x	
		SH316 Biological gas & odor production				x	
SH4 TPH	SH41 Automatic TPH	SH411 Fast action repressurization					x
		SH412 Non-toxic fire extinguisher					x
		SH413 Comfort factors				x	
		SH414 Atmospheric circulation & cycling				x	
SH5 Medical/psycho	SH51 Medical/psycho	SH511 Zero-g physiology					x
		SH512 Morale					x
		SH513 Sanitation				x	
		SH514 Diagnosis & treatment health				x	
		SH515 Surgical implant of bio-medical sensors					x
		SH516 Reduction in natural immunities					x
SS1 Moment generators	SS11 Thermo-electric thrusters	SS111 R&D required, thermo-electric thruster					x
		SS112 Non-linear performance					x
		SS113 Reliability, TE thrusters					x
	SS12 Hypergolic reaction jets	SS121 Dead zone				x	
		SS122 Attitude resolution				x	
		SS123 Propellant limited				x	
		SS124 Reliability				x	
SS2 Sensors	SS21 Horizon scanner, attitude and rate gyros	SS211 Reliability, horizon scanners				x	
		SS212 Reliability, rate gyros				x	

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
ST Sim/Training	Prelaunch skill requisition and inflight skill retention for vehicle operation and scientific work		ST11 Inflight skill retention	ST111 Crew [illegible]; ST112 Break area
SV Vehicle	Subsystem integration; Magnetism; Field of view; Communications; Boom extension; Shielding; Thermal environment; EVA portals; Docking; Orbital assembly	SV1 Docking and assembly	SV11 Closed space craft structure	SV111 Large vehicle assembly operations; SV112 Docking shock
		SV2 Inflight	SV21 Living quarters	SV211 Meteoric protection; SV212 Material degradation; SV213 Portal reaction thrust; SV214 Optical window degradation; SV215 Waste disposal
SY Display	Inflight displays of operation (mission and subsystem management); Subsystem status (equipment status, monitoring and maintenance); Task (scientific instrumentation and analysis)	SOA		

SYSTEM DESCRIPTION

Same as Manned Mars Probe Orbiter MO04 X. This is a non-pressurized one-man space tug used for major assembly jobs in earth orbit. The operator will wear a conventional EVA space suit. It should be usable for 10 hours, rechargeable from spacecraft. Must have adequate propulsion for self and equipment. Must be able to control attitude in orbit. Must be capable of performing any necessary work in assembling the various systems. Communications for voice to 500 miles.

DESIGNATOR CONCEPT SYSTEM

MD04 X

MANNED MARS INVESTIGATION LANDER

Extra Vehicular Activity Unit

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
XA Aux. Power (S/T)	Continuous power 200 W, 10 hrs.	SOA		
XH Life Support	Tankage for oxygen, water, food, waste.	SOA		
XP Propulsion (1 2 2)	Total ΔV 2.0 m/sec, 250,000 lb. payload, to maneuver units for docking. Acceleration impulse limited to 0.5 m/sec ΔV. Throttleable.		XP11 Cryogenic liquid rockets XP12 Hypergolic storable liquid rockets	XP111 Specific impulse (1 2 2) XP112 Cryogenic storage (1 2 2) XP113 Restart reliability (1 2 2) XP114 Throttleability (1 2 2) XP121 Specific impulse (1 2 2) XP122 Restart reliability (1 2 2) XP123 Throttleability (1 2 2)
XR Comm. (1 1 2)	4 channel voice 200 km 10 hrs. 1 channel voice 2000 km 10 min. 1 channel biomed. digital data link 200 km. 10 hrs.	XR1 Voice, local — SOA XR2 Voice, long range, biomed data link	XR21 VHF/UHF transceiver	XR211 Antenna directivity (1 1 2) XR212 Power (1 1 2) XR213 Coding (1 1 2 3)
XS Stab/Control	0.25°/sec 3-axis angular rate sensor, display only, manual control of attitude jets.	SOA		
XT Sim/Train. (1 1 1 1)	Prelaunch skill acquisition for vehicle maneuvering and docking operation and docking crew coordination.		XT11 Assembly training	XT11 Realism of zero-g work (1 1 1 1) XT12 Crew mix (1 1 1 1)
XV Vehicle (1 2 2)	Unpressurized open one-man vehicle with propulsion and life support tankage to support one worker in space suit. Grapplers and shock absorbers for maneuvering and docking operation.		XV11 Open one-man space vehicle	XV111 Docking shock (1 2 2) XV112 Grappling of large masses (1 2 2 1)
XY Display	Display of attitude rate, propulsion and life support supply status, biomedical monitor display	SOA		

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CONCEPT DESCRIPTION

CONCEPT MANNED MARS FLYBY

DESIGNATOR MF02

MISSION OBJECTIVES Manned, close observation of the Martian atmosphere and surface. The mission allows full spectrum, high-resolution photography of Mars and delivers a probe to examine atmospheric conditions as well as evaluating the atmosphere and surface conditions for future manned landings. This is the first manned approach to Mars.

GENERAL DESCRIPTION A manned mission, assembled in a 550 km earth orbit, earth launched by multiple Saturn V boosters. Gross orbital weight varies between 460K and 2.5M lbs., depending on the performance of the nuclear orbital booster. It carries three men on a 700-day trip to Mars and return. Observations, photographs and spectrographic measurements are made at two to five radii from Mars during a several-hour pass. A soft-landing probe penetrates the Martian atmosphere to the surface to monitor density, temperature, composition of the atmosphere and make surface observations. The mission date lies in the 1975 period.

LIST OF SYSTEMS

B Booster (Saturn V)
G Ground Support Facility
J *Orbital Booster
M *Command and Re-Entry Module
P *Planet Probe
S *Spacecraft
X *Extra-Vehicular Activity Unit

REFERENCES

1. "Powered Flybys of Mars", R.R. Titus, United Aircraft Corp., AIAA paper 65-515.

*Detailed description follows.

SYSTEM DESCRIPTION

This is a massive system, assembled into the spacecraft in earth orbit. It provides three major thrusting increments: earth orbital launch, Mars type orbit transfer, and deboost to earth parabola, and also provides for midcourse and approach corrections enroute. Nuclear propulsion, if available, [illegible] the earth orbital weight required. The total gross weight of this system is approximately 2.5M lbs., or 450K lbs. into earth orbit, depending on whether high energy chemical or solid core nuclear rockets are used. This gross weight is the total earth orbital weight, including the Command and Re-Entry Module, the Spacecraft, and the Planet Probe. The orbital launch booster will be launched in sections, each approximately the maximum payload of a Saturn V.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
JA Aux. Power (S T)	Continuous Power 1KW during thrusting Chemical dynamic system	SOA		
JG Guid./Nav.	Supplied by Command Module			
JM Check/Maint. (x; 1 2 3)	Prelaunch checkout Performance monitor, report Switching of redundant units		JM11 Automatic failure monitor and fault isolation	JM111 Monitoring & switching (x; 1 2 3)
JP Propulsion (x; 2 2 4 2)	High Energy Chemical I_{sp}=455 / Nuclear Solid I_{sp}=900 1. ΔV= 4 km/sec — 726K lb. / 241K lb. — for escape from earth orbit 2. ΔV= 3.75 km/sec — 240K lb. / 115K lb. — for hyperbolic transfer at Mars 3. ΔV= 8.5 km/sec — 15K lb. / 15K lb. — for deboost to earth parabola		JP11 Cryogenic liquid rocket at I_{sp} = 455 sec. requiring 2.5M lb. gross into earth orbit JP12 Solid core nuclear fission rocket at I_{sp} = 900 sec. requiring 450K lb. gross into earth orbit	JP111 Cryogenic propellant stge. (x; 2 2 4) JP112 Specific impulse (x; 2 2 4) JP113 Reliability, long storage (x; 2 2 4) JP121 High temperature materials (x; 2 2 4 2) JP122 Shielding (x; 2 1 2 4) JP123 R&D required (x; 2 2 4 2) JP124 Cryogenic storage (x; 1 2 2) JP125 Cooldown and restart (x; 2 2 4 2)
JS Stab./Cont.	Attitude: .25° Thrust Vector Control Roll Control		Main Propulsion — SOA Hypergolic reaction jets — SOA	
JV Vehicle (x; 1 2 2 2)	Shielding Docking Orbital Assembly		JV11 Open frame structure. Tankage assembled in orbit	JV111 Meteoric protection (x; 1 2 2 2) JV112 Material degradation (x; 1 2 2 2) JV113 Shielding (x; 1 2 4 4) JV114 Dock shock (x; 1 2 2)

SYSTEM DESCRIPTION

This system serves as an earth re-entry capsule for the astronauts, and all necessary instrumentation, photographic film, taped data, etc., to return the results of the Mars expedition to earth. In addition, it will serve as the vehicle for bringing the crew to the assembled space vehicle in orbit and as temporary quarters for the crew during periods of thrusting for earth orbit launch, and deboost to earth parabola and atmospheric entry. The Command and Re-entry Mdoule will include retropropulsion for final control of the landing point during atmospheric re-entry. The re-entry portion will resemble the Apollo command module, and the entire system will weigh approximately 12,000 lbs. including the propulsion unit.

DESIGNATOR CONCEPT SYSTEM

MF02 M

MANNED MARS FLYBY

Command and Re-Entry Module
(Page 1 of 2)

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

MA Aux. Power (S: x; T: 1 2 4)

- Continuous power: 2 kw, one week

MD Data Proc. (x; 1 2 4)

- RATES:
  - Input data rate — 10^3 bits/sec
  - Output comm. rate — 10^3 bits/sec
  - Output display rate — 10^3 bits/sec
- STORAGE
  - Recoverable — None
  - Temporary — 10^5 bits

ME Escape/Recy.

- Safe return of astronauts during earth launch
- This is the primary function of this system

MG Guid/Nav. (x; 1 2 4)

Escape from orbit:	Velocity	± 1 m/sec
	Angle	± 0.1 degree
Midcourse:	Velocity Accuracy	± 0.5 m/sec
	Angle	± 5 degrees
Approach:	Position	± 50 km
Deboost:	Velocity	± 1 m/sec
	Angle	± 1 degree
Rendezvous & Docking:	Relative Position	0.3 (m)
	Relative Velocity	0.3 m/sec
Acquisition Condition:		200 km

MH Life Support (x; 1 2 4 2)

Air:	1.8 lb. O_2/man/day
Water:	6.16^2 lb. (drink), 9.84 lb. (hygiene)/man/day
Food:	3,000 cal/man/day
T.P.H.:	75±5° F, 46% RH, 3.5-14 PSIA
Med.:	physiological monitoring
Radiation:	inst. 100 rem

MM Check/Maint. (x; 1 2 3)

- Prelaunch checkout (ground/orbit)
- Performanace monitor, report
- Switching of redundant units
- Malfunction diagnosis

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

SOA

- MA11 Fuel cell + NiCad battery
  - MA111 Shutdown reliability (x; 1 2 4)
  - MA112 Specific power, fuel cell (x; 1 2 4)
  - MA113 Service life, fuel cell (x; 1 2 4)
  - MA114 High-load efficiency (x; 1 2 4)
- MD11 Central digital computer
  - MD111 Reliability, digital computer (x; 1 2 4)
  - MD112 Memory density, digital computer (x; 1 2 4)

- MG1 Escape from earth orbit
  - MG11 Star tracker and inertial system with laser ranging orbit determination
    - MG111 Reliability, star tracker (x; 1 2 3)
    - MG112 Reliability, laser ranging (x; 1 2 4)
    - MG113 R&D req'd., laser ranging (x; 1 2 4 3)
    - MG114 Reliability, inertial system (x; 1 2)
- MG2 Midcourse
  - MG21 DSIF & star tracker & inertial system
    - MG211 Reliability, inertial system (x; 1 2 4)
- MG3 Planet approach
  - MG31 Planet horizon scanner with laser ranging
    - MG311 Horizon definition, Mars (x; 1 2 2 3)
    - MG312 Reliability, horizon scanner (x; 1 2 4)
    - MG313 R&D req'd., laser ranging (x; 1 2 4 3)
    - MG314 Reliability, laser ranging (x; 1 x 4)
- MG4 Deboost for earth re-entry
  - MG41 Inertial system
    - MG411 Reliability, inertial system (x; 1 2 4)
- MG5 Rendezvous & docking
  - MG51 Radar, rendezvous
    - MG511 Reliability, radar (x; 1 2 3)

- MH1 Air
  - MH11 Nitrogen/oxygen
    - MH111 Leak detection & alarm (x; 1 2 4)
    - MH112 CO_2 & CO monitor, alarm removal (x; 1 2 4)
- MH2 TPH
  - MH21 Automatic TPH
    - MH211 Waste heat rejection (x; 1 2 4)
    - MH212 Fast action repressurization & leak alarm (x; 1 2 3)
- MH3 Medical/psycho
  - MH31 Medical/psycho
    - MH311 Re-entry g physiology (x; 1 1 1 1)
    - MH312 Reduction in natural immunities (x; 1 2 4 3)
- MM1 Inflight
  - MM11 Automatic failure monitor and fault isolation
    - MM111 Monitoring & switching (x; 1 2 3)
    - MM112 Reliability of checkout & maintenance equipment (x; 1 2 3)
- MM2 Prelaunch (ground & orbit)
  - MM21 Automatic checkout
    - MM211 Reliability of C/M equip (x; 1 2 3)
    - MM212 Simplification (x; 1 2 3)
    - MM213 Monitoring & switching (x; 1 2 3)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
MP Propulsion (S, T; 1 2 3 x)	ΔV 200 m/sec, payload, 12,000 lbs., for final re-entry control			MP11 [illegible]	MP[illegible] [illegible] MP[illegible] [illegible] MP[illegible] [illegible] MP111 Restart [illegible]
MR Comm.	Trans. data rate: 10^3 bits/sec digital, plus voice	SOA			
MS Stab/Control	Attitude control: ± .25 degree	SOA			
MT Sim/Train. (1 2 2 4 x)	Prelaunch skill acquisition, retention of earth return skills.			MT11 Re-entry training	MT111 Skill retention
MV Vehicle (2 2 4 4 x)	Atmospheric entry from earth orbit Shielding Thermal environment EVA portals, access to spacecraft and to MEM Docking			MV11 Atmospheric entry body	MV111 High velocity re-entry
MY Display	Inflight displays of operation (mission & subsystem management), rendezvous and docking. Subsystem status (equip. status monitoring and maintenance).	SOA			

SYSTEM DESCRIPTION

DESIGNATOR MF02 P
CONCEPT MANNED MARS FLYBY
SYSTEM Planet Probe

One or two small 500 lb. probes will be launched by the spacecraft crew to soft land at a site selected during the Mars approach flight. The selected site is coordinated with both the probe ejection and the spacecraft arrival time and position so that the spacecraft flys approximately over the target site as the probe alights. The probe transmits atmospheric, impact, and surface information to the flyby. One 360° panoramic medium resolution horizontal photograph is transmitted.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
PA Aux. Power (S 1 2 3 x)	Peak Power: 100 watts, 1 hour Continuous Power: 10 watts, 5 days		PA11 Silver-zinc battery	PA111 Specific energy, AgZn (S 1 1 1 5 x) PA112 Specific cost, battery (1 2 3 x)
PD Data Proc. (1 2 4 x)	RATES Input data rate: 10^4 bits/sec digital Output comm. rate: 10^5 bits/sec digital STORAGE: None		PD11 Small digital data processor	PD111 Reliability, digital processor (1 2 4 x)
PI Task Instr. (1 1 1 1 x)	Capable of Carrying Instruments in the Following Instrument Groups: Atmospheric Entry Surface Weather and Space Oriented Surface and Subsurface Surface Surveillance Radio Propagation Experiment		PI11 Instrument package	PI111 Spaceborne packaging (1 1 1 1 x) PI112 Accuracy (1 1 1 1 x) PI113 Reliability, instr. pkg. (1 1 1 1 x)
PP Propulsion (1 2 2 x)	ΔV 150 m/sec for deorbit Payload: 500 lbs.		PP11 Hypergolic storable liquid rocket for deboost & parachute for soft landing	PP111 Impulse accuracy (1 2 2 x) PP112 Reliability, long storage (1 2 2 x)
PR Comm. (1 1 2 x)	Trans. data rate: 10^4 bits/sec digital plus slow-scan analog video Range: 15,000 km Temporal Requirements: 1 hour		PP12 Solid rocket for deboost and parachute for soft landing	PP121 Impulse accoracy (2 2 3 x)
PS Stab./Cont. (1 2 2 x)	Attitude Control: ±5° for deorbit		PR11 UHF/SHF transceiver	PR111 Antenna directivity (1 1 2 x)
			PS11 Hypergolic reaction jets and simple gyro ref.	PS111 Reliability, long storage (1 2 2 x)
PV Vehicle (1 2 2 2 x)	Subsystem Integration Field of View Communications Atmospheric entry		PV11 Hyperbolic atmospheric entry body with parachute terminal descent.	PV111 Uncertain characteristics of Martian atmosphere (1 1 2 4 x) PV112 Meteoric protection (1 2 2 2 x) PV113 Landing shock (1 2 2 x) PV114 High temperature materials (1 2 3 3 x)

SYSTEM DESCRIPTION

DESIGNATOR [illegible] MF02S - 144
CONCEPT [illegible]
SYSTEM [illegible]

[illegible] spacecraft provide living quarters for three men for the duration of the mission (500 - 600 days) except [illegible]. A short [illegible] environment is required. Observational sensors will be mounted [illegible] communications antennas. Communications equipment, data processing, [illegible] other mission oriented equipment will be carried in the spacecraft. Artificial gravity [illegible] may be attained during enroute phases by spinning the entire assembly. Provisions for mounting, launching and monitoring several atmospheric and surface probes will be made. A radiation storm cellar environment is stable for a few days will be required. The spacecraft will weigh in the vicinity of 56,000 lbs. Guidance and navigation contained in Command and Re-Entry Module.

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

SA Aux. Power (S 1 2 4 5 / T 1 2 4 5 / x)
- Continuous power 15 KW - 600 days.

SD Data Proc. (1 2 4 / x)
- Input data rate: 10^5 bits/sec
- Output communication rate: 10^4 to 10 bits/sec
- Recoverable storage: tape and film
- Temporary storage: 10^6 bits

SE Escape/Recy
- Safe return of astronauts

SH Life Support (1 2 4 2 / x)
- SEE PAGE 2

SI Task Instr. (1 1 1 1 / x)
- Capable of carrying instruments in the following instrument groups:
  - Manned Systems
  - Interplanetary
  - Planet Oriented
  - TV Mapping
  - Radar Mapping
  - Radio Propagation Experiment

SM Check/Maint. (1 2 3 / x)
- Prelaunch checkout in orbit
- Performance monitor, report
- Switching of redundant units
- Malfunction diagnosis
- Orbital assembly checkout

SR Com. (1 2 3 / x)
- Transmission data rate: Max. 10^4 to 10^5 bits/sec
- Range: Maximum ~ 2.5×10^8 km

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

SA Aux. Power

- SA11 Solar dynamic
  - SA12 Waste heat rejection
  - SA13 Weight
- SA21 High temperature materials
  - SA22 R&D required nuclear reactor
  - SA23 Weight
  - SA24 Shielding
  - SA25 Waste heat rejection

SD Data Proc.

- SD11 Digital computer, tape recorder, video encoder
  - SD111 Memory density, tape recorder
  - SD112 Reliability, digital computer
  - SD113 Reliability, tape recorder
  - SD114 Data compression
  - SD115 Radiation alteration of memory

SE Escape/Recy

- Use normal command module for re-entry, no provision for abort during interplanetary flight and during Mars flyby.

SI Task Instr.

- SI11 Instrument package
  - SI111 Spaceborne packaging
  - SI112 Accuracy
  - SI113 R&D, high resolution image
  - SI114 Reliability, instr. package

SM Check/Maint.

- SM2 Orbital assembly and prelaunch from orbit.
  - SM21 Automatic checkout
    - SM211 Reliability of c&m equipment
    - SM212 Simplification
- SM3 Inflight
  - SM31 Automatic failure monitor and fault isolation
    - SM311 Monitoring & switching
    - SM312 Fault isolation
    - SM313 Spares weight and interchangeability
    - SM314 Zero-g work, tools
    - SM315 Technical data access

SR Com.

- SR11 UHF/SHF Transceiver
  - SR111 Power requirement
  - SR112 Transmitter efficiency
  - SR113 Antenna directivity
  - SR114 Low signal/noise ratio

SYSTEM DESCRIPTION

DESIGNATOR MF02 S
CONCEPT MANNED MARS FLYBY
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SH Life Support (1 2 4 2 x)	AIR: 1.8 lb. O_2/man/day WATER: 6.16 lb. (drink), 9.84 lb. (hygiene)/man/day FOOD: 3,000 cal/man/day TPH: 75±5°F, [illegible]% RH, 3.5 - 14.7 PSIA MEDICAL: medical, dental care, physiological monitoring RADIATION: inst. 100 rem, cumulative 350 rem 1 year	SH1 Air	SH11 Nitrogen/oxygen	SH111 Leak detection & alarm (S 1 2 4 x) SH112 CO_2 & CO monitor, alarm, removal (1 2 4 x) SH113 Contaminant detection (1 2 4 x) SH114 Odor & contaminant removal (1 2 4 x)
		SH2 Water	SH21 Recycled water	SH211 Psychological (1 1 1 1 x) SH212 Ion removal & pH control (1 2 4 x) SH213 Trace contaminants (1 2 3 3 x)
		SH3 Food	SH31 Stored food	SH311 Monotony (1 1 3 x) SH312 Waste disposal (1 1 3 x) SH313 Preservation & storage (1 1 3 x) SH314 Nutrient/bulk ratio (1 1 3 x) SH315 Preparation and/or reconstitution, crumbs, outgassing (1 1 3 x) SH316 Biological gas & odor production (1 1 3 x)
		SH4 TPH	SH41 Automatic TPH	SH411 Fast action repressurization (1 2 4 2 x) SH412 Non-toxic fire extinguisher (1 2 4 2 x) SH413 Comfort factors (1 2 4 x) SH414 Atmospheric circulation & cycling (1 2 4 x)
		SH5 Medical/psycho	SH51 Medical/psycho	SH511 Zero-g physiology (1 1 1 1 x) SH512 Morale (1 1 1 1 x) SH513 Sanitation (1 2 4 x) SH514 Diagnosis & treatment, health (1 2 4 x) SH515 Surgical implant of biomedical sensors (1 2 4 4 x) SH516 Reduction in natural immunities (1 2 4 4 x)
SS Stab/Control (1 2 3 x)	Attitude control: 0.25° during thrusting, ±5° during coast Mars local vertical: ±0.2°	SS1 Moment generators	SS11 Thermo-electric thrusters	SS111 R&D required, thermo-electric thruster (2 2 2 2 x) SS112 Non-linear performance (1 2 3 3 x) SS113 Reliability, TE thrusters (2 2 2 3 x)
			SS12 Hypergolic reaction jets	SS121 Dead zone (1 2 3 x) SS122 Attitude resolution (1 2 3 x) SS123 Propellant [illegible] (1 2 3 x) SS124 Reliability (1 2 x)
		SS2 Sensors	SS21 Horizon scanner, attitude and rate gyros	SS211 Reliability, horizon scanners (1 2 4 x) SS212 Reliability, rate gyros (1 2 3 x)

SYSTEM DESCRIPTION

DESIGNATOR [illegible]
CONCEPT [illegible]
SYSTEM [illegible]

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
ST Sim/Training (S, T)	Prelaunch skill acquisition and inflight skill retention for vehicle operation and scientific work		ST11 Inflight skill retention	ST11 [illegible]; ST112 [illegible]
SV Vehicle	Subsystem integration; Magnetism; Field of view; Communications; Boom extension; Shielding; Thermal environment; EVA portals; Docking; Orbital assembly	SV1 Docking and assembly	SV11 [illegible]	SV111 Large vehicle assembly operations; SV112 Docking [illegible]
		SV2 Inflight	SV21 Living quarters	SV211 Meteoric protection; SV212 Material degradation; SV213 Portal reaction thrust; SV214 Optical window degradation; SV215 Waste removal
SY Display	Inflight displays of operation (mission and subsystem management); Subsystem status (equipment status, monitoring and maintenance); Task (scientific instrumentation and analysis)	SOA		

SYSTEM DESCRIPTION

Same as MO04 X. This is a non-pressurized one-man space tug used for major assembly jobs in earth orbit. The operator will wear a conventional EVA space suit. It should be usable for 10 hours, rechargeable from spacecraft. Must have adequate propulsion for self and equipment. Must be able to control attitude in orbit. Must be capable of performing any necessary work in assembling the various systems. Communications for voice to 500 miles.

DESIGNATOR MF02 X
CONCEPT MANNED MARS FLYBY
SYSTEM Extra-Vehicular Activity Unit

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
XA Aux. Power (S/T)	Continuous power 200 W, 10 hours.	SOA		
XE Escape/Recy	To vacate unit in emergency and rely on EVA suit until rescue.	SOA		
XH Life Support	Tankage for oxygen, water, food, waste.	SOA		
XP Propulsion (1 2 2 x)	Total ΔV 2.0 m/sec, 250,000 lb. payload, to maneuver units for docking. Acceleration impulse limited to 0.5 m/sec ΔV. Throttleable.	XP11 Cryogenic liquid rockets XP12 Hypergolic storable liquid rockets	XP111 Specific impulse (1 2 2 x) XP112 Cryogenic storage (1 2 2 x) XP113 Restart reliability (1 2 2 x) XP114 Throttleability (1 2 2 x) XP121 Specific impulse (1 2 2 x) XP122 Restart reliability (1 2 2 x) XP123 Throttleability (1 2 2 x)	
XR Comm. (1 1 2 x)	4 channel voice 200 km 10 hrs. 1 channel voice 2000 km 10 min. 1 channel biomed. digital data link 200 km 10 hrs.	XR1 Voice, local — SOA XR2 Voice, long range, biomed data link — XR21 VHF/UHF Transceiver	XR211 Antenna directivity (1 1 2 x) XR212 Power (1 1 2 x) XR213 Coding (1 1 2 3 x)	
XS Stab./Control	0.25°/sec 3-axis angular rate sensor, display only, manual control of attitude jets.	SOA		
XT Sim/Train (1 1 1 1 x)	Prelaunch skill acquisition for vehicle maneuvering and docking operation and docking crew coordination.	XT11 Assembly training	XT111 Realism of zero-g work (1 1 1 1 x) XT112 Crew mix (1 1 1 1 x)	
XV Vehicle (1 2 2 x)	Unpressurized open one-man vehicle with propulsion and life support tankage to support one worker in space suit. Grapplers and shock absorbers for maneuvering and docking operations.	XV11 Open one-man space vehicle	XV111 Docking shock (1 2 3 x) XV112 Grappling of large masses (1 2 2 1 x)	
XY Display	Display of attitude rate, propulsion and life support supply status, biomedical monitor display	SOA		

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CONCEPT DESCRIPTION

CONCEPT MANNED MARS PROBE ORBITER

DESIGNATOR MO04

MISSION OBJECTIVES Manned observation of Mars from a polar orbit at 1000 km altitude, for a period of ten days. The orbiter inspects Mars and its atmosphere with instruments such as radiation detectors, magnetometers, spectrographs, radar, etc., and delivers one or more probes to the surface. This is the second manned step toward putting a human on the surface. This precedes other missions such as Manned Mars Lander (MD02), Manned Mars Investigation Lander (MD04), and follows such missions as Manned Mars Flyby (MF02).

GENERAL DESCRIPTION A manned mission consisting of a six-man spacecraft and a command and re-entry module assembled to an orbital booster in a 500 km earth orbit. Gross orbital weight varies between 450K lb. and 4.5M lb, depending on the performance of the nuclear orbital booster. The 10-day stay in 550 km Mars polar orbit allows acquisition of excellent data concerning the atmosphere and surface using means such as optics, high-resolution radar, IR, and spectrography. One or two unmanned probes will penetrate the atmosphere to telemeter back more direct measurements of atmospheric composition, density, temperature and other parameters. Soft landing probes will permit observation and measurements of surface data pertinent to a manned landing. The mission duration is 500 to 600 days. The mission date lies in the 1978 period.

LIST OF SYSTEMS

B Booster (Saturn V)
G *Ground Support Facility
J *Orbital Booster
M *Command and Re-Entry Module
P *Planet Probe
S *Spacecraft
X *Extra-Vehicular Activity Unit

REFERENCES

*Detailed description follows.

SYSTEM DESCRIPTION

DESIGNATOR CONCEPT SYSTEM

[illegible] assembled in the spacecraft in earth orbit. It provides [illegible] for thrusting [illegible] Mars orbital capture, Mars orbital launch, and deboost to earth parabola, and also [illegible] [illegible] to minimize earth launch weight. The [illegible] of this system with the spacecraft, Command and Re-entry Module, and Mars probes is approximately [illegible], or 450 [illegible], into earth orbit depending on whether solid core nuclear or gaseous fission rockets are used. The orbital launch booster will be launched in sections, each approximately the maximum payload of a Saturn V vehicle.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
JA Aux. Power (S, T)	Continuous Power 1 KW during thrusting, chemical dynamic system SOA			
JG Guid./Nav.	Supplied by Command Module SOA			
JM Check/Maint. (x; 1 2 3)	Prelaunch checkout Performance monitor, report Switching of redundant units, monitor and possible repair of nuclear engine		JM11 Automat[illegible] fault [illegible]	
JP Propulsion (x; 2 2 4 2)	Nuclear Solid I_{sp}=900 sec. / Nuclear Gaseous I_{sp}=3000 sec. 1. ΔV=7 km/sec — 1.3M lb. / 280K lb. — for escape from earth orbit 2 ΔV=6 km/sec — 426K lb. / 182K lb. — for deboost into Mars orbit 3. ΔV=6 km/sec — 170K lb. / 113K lb — for escape from Mars orbit 4. ΔV=9 km/sec — 20K lb. / 20K lb — for deboost into earth parabola		JP11 Solid co[illegible] I_{sp} = 90[illegible] gross [illegible] JP12 Gaseous [illegible] at I_{sp} = [illegible] gross [illegible]	
JS Stab./Cont.	Attitude: .25° Thrust Vector Control Roll Control		Main propulsion Hypergolic [illegible]	
JV Vehicle (x; 1 2 2 2)	Shielding Docking Orbital Assembly		JV11 Open [illegible] Tank[illegible]	

SYSTEM DESCRIPTION

This system serves as an Earth re-entry capsule for the astronauts, and all necessary instrumentation, photographic film, taped data, etc., to return the results of the Mars expedition to Earth. In addition, it will serve as the vehicle for bringing the crew to the assembled space vehicle in orbit and as temporary quarters for the crew during period of thrusting for Earth orbit launch, Mars orbit entry, and Mars orbit launch. The Command and Re-entry Module will include retropropulsion for final control of landing point during atmospheric re-entry. *The re-entry portion will resemble the Apollo command module,* though larger, and the entire system will weigh approximately 20,000 lbs., including the propulsion unit.

DESIGNATOR CONCEPT SYSTEM

MO04 M

MANNED MARS PROBE ORBITER

Command and Re-Entry Module
(Page 1 of 2)

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

MA Aux. Power (S: x; T: 1 2 4)

- Cont. power: 3 kw; one week

MD Data Proc. (x; 1 2 4)

- RATES
  - Input data rate 10^3 bits/sec
  - Output comm. rate 10^3 bits/sec
  - Output display rate 10^3 bits/sec
- STORAGE
  - Recoverable None
  - Temporary 10^5 bits

ME Escape/Recy

- Safe return of astronauts during earth launch
- This is the primary function of this system

MG Guid. /Nav. (x; 1 2 4)

- Escape from orbit: Velocity ± 1 m/sec; Angle ± 0.1 degree
- M/C. Vel. Accuracy ±0.5 m/sec; Angle ± 5 degrees
- Approach: Position ± 50 km
- Deboost: Velocity ± 1 m/sec; Angle ± 1 degree
- Rendezvous & Docking: Rel. Pos. 0.3 (m); Rel. Vel 0.3 m/sec; Acquisition Cond. 200 km

MH Life Support (x; 1 2 4 2)

- AIR: 1.8 lb O_2/man/day
- WATER: 5.16 lb (drink), 9.84 lb (hygiene)/man/day
- FOOD: 3,000 cal/man/day
- T. P. H 75±5°F, 46%RH, 3.5-14.7 PSIA
- MED: physiological monitoring
- RADIATION inst. 100rem

MM Check/Maint (x; 1 2 3)

- Prelaunch checkout (ground/orbit)
- Performance monitor, report
- Switching of redundant units
- Malfunction diagnosis

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

SOA

- MA11 — Fuel cell + NiCad battery
  - MA111 Shutdown reliability (S: x; T: 1 2 4)
  - MA112 Specific power, fuel cell (x; 1 2 4)
  - MA113 Service life, fuel cell (x; 1 2 4)
  - MA114 High-load efficiency (x; 1 2 4)
- MD11 — Central digital computer
  - MD111 Reliability, digital computer (x; 1 2 4)
  - MD112 Memory density, digital computer (x; 1 2 4)
- MG1 Escape from planet orbit — MG11 — Star tracker and inertial system with laser ranging orbit determination
  - MG111 Reliability, star tracker (x; 1 2 3)
  - MG112 Reliability, laser ranging (x; 1 2 4)
  - MG113 R&D req'd, laser ranging (x; 1 2 4 3)
  - MG114 Reliability, inertial system (x; 1 2 4)
- MG2 Midcourse — MG21 — DSIF, star tracker, inertial system
  - MG211 Reliability, inertial system (x; 1 2 4)
  - MG311 Horizon definition, Mars (x; 1 2 2 3)
- MG3 Planet approach — MG31 — Planet horizon scanner with laser ranging
  - MG312 Reliability, horizon scanner (x; 1 2 4)
  - MG313 R&D req'd, laser ranging (x; 1 2 4 3)
  - MG314 Reliability, laser ranging (x; 1 2 4)
- MG4 Deboost to earth re-entry — MG41 — Inertial system
  - MG411 Reliability, inertial system (x; 1 2 4)
- MG5 Rendezvous & docking — MG51 — Radar, rendezvous
  - MG511 Reliability, radar
- MH1 Air — MH11 — Nitrogen/oxygen
  - MH111 Leak detection & alarm (x; 1 2 4)
  - MH112 CO_2 & CO monitor, alarm removal (x; 1 2 4)
- MH2 TPH — MH21 — Automatic TPH
  - MH211 Waste heat rejection (x; 1 2 4)
  - MH212 Fast action repressurization & leak alarm (x; 1 2 4 3)
- MH3 Medical/psycho — MH31 — Medical/psycho
  - MH311 Re-entry physiology (x; 1 1 1 1)
  - MH312 Reduction in natural immunities (x; 1 2 4 4)
- MM1 Inflight — MM11 — Automatic failure monitor and fault isolation
  - MM111 Monitoring & switching (x; 1 2 3)
  - MM112 Reliability of checkout & maintenance equipment (x; 1 2 3)
- MM2 Prelaunch (ground & orbit) — MM21 — Automatic checkout
  - MM211 Reliability of C/M equip (x; 1 2 3)
  - MM212 Simplification (x; 1 2 3)
  - MM213 Monitoring & switching (x; 1 2 3)

SYSTEM DESCRIPTION

DESIGNATOR [illegible]
CONCEPT [illegible]
SYSTEM [illegible]

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
MP Propulsion (S T 1 2 2 x)	ΔV 200 [illegible]/sec, payload 20,000 lb., for final control of re-entry point.			MP11 Storable liquid rocket	MP11 [illegible] (1 2 2 x); MP12 [illegible] (1 2 2 x); MP13 Specific impulse (1 2 2 x); MP14 Restart reliability (1 2 2 x)
MR Comm.	Trans. data rate 10^3 bits/sec [illegible] Range 3,500 miles	SOA			
MS Stab/Control	Attitude control ± 25 degrees	SOA			
MT Sim/Train (1 2 2 4 x)	Prelaunch skill acquisition, retention of earth return skills.			MT11 Re-entry training	MT111 Skill retention (1 2 2 4 x)
MV Vehicle (2 2 4 4 x)	Atmospheric entry from earth orbit Shielding Thermal environment EVA portals Docking			MV11 Atmospheric entry body	MV111 High velocity re-entry (2 2 4 4 x)
MY Display	Inflight displays of operation (mission & subsystem management), rendezvous and docking. Subsystem Status (equip. status monitoring and maintenance).	SOA			

SYSTEM DESCRIPTION

Several small probes (500 to 1000 lbs.) will be launched to sound out the atmosphere and surface conditions of Mars. Measurements of atmosphere (density, temperature, composition) will be made during fall. The probe will soft land [illegible] parachute and measure surface data (temperature, pressure, minerals, bearing strength, etc.). Data to be telemet[illegible] to orbiting spacecraft. Probe will transmit one high resolution photo per orbiter pass.

DESIGNATOR MO04 P

CONCEPT MANNED MARS PROBE ORBITER

SYSTEM Planet Probe

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
PA Aux. Power (S/T 1 2 3 x)	Peak Power: 100 watts, 15 min., 2 times per day for 10 days Cont. Power: 50 watts, 10 days		PA11 Silver-zinc battery	PA111 Specific energy, AgZn (S/T 1 1 1 x) PA112 Specific cost (1 2 3 x)
PD Data Proc. (1 2 4 x)	RATES Input data rate 10^4 bits/sec Output comm. rate 10^4 bits/sec STORAGE Recoverable - none Temporary - 10^7 bits		PD11 Small digital data processor and variable speed tape recorder	PD111 Reliability, digital processor (1 2 4 x) PD112 Reliability, tape recorder (1 2 4 x) PD113 Memory density, tape recorder (1 2 4 x) PD114 Data compression (1 2 4 5 x) PD115 R&D required, variable speed tape recorder (1 2 4 x)
PI Task Instr. (1 1 1 1 x)	Capable of carrying instruments in the following Instrument Groups: TV Mapping Atmospheric Entry Surface Weather and Space Oriented Surface and Subsurface Life Detection Surface Surveillance & Micro TV Radio Propagation Experiment		PI11 Instrument package	PI111 Spaceborne packaging (1 1 1 1 x) PI112 Accuracy (1 1 1 1 x) PI113 Reliability, instr. pkg. (1 1 1 1 x)
PP Propulsion (1 2 2 x)	ΔV 250 m/sec for deorbit Payload 500 1000 lbs.		PP11 Hypergolic storable liquid rocket for deboost and parachute for soft landing PP12 Solid rocket for deboost and parachute for soft landing	PP111 Impulse accuracy (1 2 2 x) PP112 Reliability long storage (1 2 2 x) PP121 Impulse accuracy (2 2 3 x)
PR Comm. (1 1 2 x)	Trans. data rate: 10^4 bits/sec Range: 5,000 km Temporal requirements: 15 mins. 2 times per day for 10 days		PR11 UHF/SHF transceiver	PR111 Antenna directivity (1 1 2 x)
PS Stab. /Cont. (2 2 2 x)	Attitude control: ±5° for deorbit		PS11 Hypergolic reaction jets and simple gyro ref.	PS111 Reliability, long storage (1 2 2 x)
PV Vehicle (1 2 2 2 x)	Subsystem Integration Field of view Communications Atmospheric entry		PV11 Atmospheric entry body with parachute terminal descent	PV111 Uncertain characteristics of Martian atmosphere (1 1 2 4 x) PV112 Meteoric protection (1 2 2 2 x) PV113 Landing shock (1 [illegible] 2 x)

SYSTEM DESCRIPTION

DESIGNATOR [illegible] MO04S [illegible]
CONCEPT [illegible]
SYSTEM [illegible]

[illegible] for the orbiter of the mission [illegible] concept [illegible] A [illegible] is required. [illegible] will be [illegible] data processing, [illegible] equipment will be carried [illegible] probe. [illegible] to be attached during [illegible] process by spinning the entire assembly. [illegible] monitoring several atmospheric and surface probes will be made. A radiative "storm cellar" [illegible] for [illegible] days will be required. The spacecraft will weigh in the vicinity of 7,000 lbs. [illegible] navigation contained in Command and Re-Entry Module.

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS / FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

SA — Solar Dynamic

- Continuous power: 25 kW, 600 days

SD — Data Proc.

- Input data rate: 10^5 bits/sec, 8 min. twice daily
- Output communication rate: 10^4 to 10^5 bits/sec
- Recoverable storage: tape and film
- Temporary storage: 10^{10} bits

SH — Life Support

- SEE PAGE 2

SI — Task Instr.

- Capable of carrying instruments in the following instrument groups
  - Manned Systems
  - Interplanetary
  - Planet Oriented
  - TV Mapping
  - Radar Mapping
  - Radio Propagation Experiment

SM — Check/Maint

- Prelaunch checkout in orbit
- Performance monitor, report
- Switching of redundant units
- Malfunction diagnosis
- Orbital assembly checkout

SR — Comm.

- Transmission data rate: Max. 10^4 to 10^5 bits/sec
- Range: Maximum ~ 2.5×10^8 km

FUNCTIONAL ELEMENTS

- SA11 — Solar dynamic
- SA — Nuclear assisted solar dynamic (SNAP-8)
- SD11 — Digital computer, tape recorder video encoder
- SI11 — Instrument package
- SM2 — Orbital assembly and prelaunch from orbit
- SM3 — Inflight
- SR11 — UHF/SHF Transceiver

CONFIGURATIONS

- SM21 — Automatic checkout
- SM31 — Automatic [illegible] monitor and fault isolation

TECHNOLOGY DEFICIENCIES

- SA11 — [illegible]
- SA21 — [illegible]
- SA22 — [illegible]
- SA123 — Wearout
- SA124 — Shelf life
- SA125 — Waste heat rejection
- SD111 — Memory [illegible] tape recorder
- SD112 — Reliability, digital computer
- SD113 — Reliability, tape recorder
- SD114 — Data compression
- SD115 — Radiation alteration of [illegible]
- SI111 — Spaceborne packaging
- SI112 — Accuracy
- SI113 — R&D, high resolution image
- SI114 — Reliability, instr. package
- SM2.1 — Reliability of O&M equipment
- SM212 — Simplification
- SM311 — Monitoring & switching
- SM312 — Fault isolation
- SM313 — Various weight and inter changeability
- SM314 — Zero g work, tools
- SM315 — Technical data access
- SR111 — Power requirement
- SR112 — Transmitter efficiency
- SR113 — Antenna diameter limits
- SR114 — Low signal to noise ratio

SYSTEM DESCRIPTION

DESIGNATOR MO04 S
CONCEPT MANNED MARS PROBE ORBITER
SYSTEM Spacecraft

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

SH Life Support (1 2 4 2)

- AIR: 1.8 lb O_2/man/day
- WATER: 6.16 lb. (drink), 9.84 lb. (hygiene)/man/day
- FOOD: 3,000 cal/man/day
- TPH: 75±5°F, 46% RH, 3.5 - 14.7 PSIA
- MEDICAL: medical, dental care, physiological monitoring
- RADIATION: inst. 100 rem, cumulative 350 rem 1 year

SS Stab./Control (1 2 3)

- Attitude control: ±0.25° during thrusting; ±5° during coast
- Mars local vertical: ±0.2°

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Functional Element	Configuration	Technology Deficiency	$	1	2	3	4
SH1 Air	SH11 Nitrogen/oxygen	SH111 Leak detection & alarm					x
		SH112 CO_2 & CO monitor, alarm, removal					x
		SH113 Contaminant detection					x
		SH114 Odor & contaminant removal					x
SH2 Water	SH21 Recycled water	SH211 Psychological					x
		SH212 Ion removal & pH control					x
		SH213 Trace contaminants				x	x
SH3 Food	SH31 Stored food	SH311 Monotony				x	
		SH312 Waste disposal				x	
		SH313 Preservation & storage				x	
		SH314 Nutrient/bulk ratio				x	
		SH315 Preparation and/or reconstitution, crumbs outgassing				x	
		SH316 Biological gas & odor production				x	
SH4 TPH	SH41 Automatic TPH	SH411 Fast action repressurization					x
		SH412 Non-toxic fire extinguisher					x
		SH413 Comfort factors				x	
		SH414 Atmospheric circulation & cycling				x	
SH5 Medical/psycho	SH51 Medical/psycho	SH511 Zero-g physiology					x
		SH512 Morale					x
		SH513 Sanitation				x	
		SH514 Diagnosis & treatment, health				x	
		SH515 Surgical implant of biomedical sensors					x
		SH516 Reduction in natural immunities					x
SS1 Moment generators	SS11 Thermo-electric thrusters	SS111 R&D required, thermo-electric thrusters					x
		SS112 Non-linear performance					x
		SS113 Reliability, I.E. thrusters					x
	SS12 Hypergolic reaction jets	SS121 Dead zone				x	
		SS122 Attitude resolution				x	
		SS123 Propellant [illegible]				x	
		SS124 Reliability				x	
SS2 Sensors	SS21 Horizon scanner, attitude and rate gyros	SS211 Reliability, horizon scanner				x	
		SS212 Reliability, rate gyros					

SYSTEM DESCRIPTION

DESIGNATOR MO04S -156
CONCEPT [illegible]
SYSTEM [illegible]

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
ST Sim./Training (S, T)	Precision skill acquisition and inflight skill retention for vehicle operation and scientific work.		SV11 Inflight skill retention	SV111 [illegible]; SV112 [illegible]
SV Vehicle (1 2 2 3)	Subsystem integration Magnetism Field of view Communications Boom extension Shielding Thermal environment EVA portals Docking Orbital assembly	SV1 Docking and assembly	SV11 Closed spacecraft structure	SV111 [illegible]; SV112 Docking
		SV2 Inflight	SV21 Living quarters	SV211 Meteoric protection; SV212 Material degradation; SV213 Portal reaction thrust; SV214 Optical window degradation; SV215 Waste disposal
SY Display	Inflight displays of operation (mission and subsystem management) Subsystem status (equipment status, monitoring and maintenance) Task (scientific instrumentation and analysis) SOA			

SYSTEM DESCRIPTION

This is a non-pressurized one-man space tug used for major assembly jobs in earth orbit. The operator will wear a conventional EVA space suit. It should be usable for 10 hours, rechargeable from spacecraft. Must have adequate propulsion for self and equipment. Must be able to control attitude in orbit. Must be capable of performing any necessary work in assembling the various systems. Communications for voice to 500 miles.

DESIGNATOR M004X
CONCEPT MANNED MARS PROBE ORBITER
SYSTEM Extra-Vehicular Activity Unit

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS		CONFIGURATIONS		TECHNOLOGY DEFICIENCIES	
XA Aux. Power (S/T)	Continuous power 200 W, 10 hrs.	SOA						
XE E·cape/Recy.	To vacate unit in emergency and rely on EVA suit until rescue.	SOA						
XH Life Support	Tankage for oxygen, water, food, waste.	SOA						
XP Propulsion (1 2 2 x)	Total Δ V 2.0 m/sec, 250,000 lb. payload, to maneuver units for docking. Acceleration impulse limited to 0.5 m/sec Δ V. Throttleable.				XP11 Cryogenic liquid rockets		XP111 Specific impulse (1 2 2 x)	
							XP112 Cryogenic storage (1 2 2 x)	
							XP113 Restart reliability (1 2 2 x)	
							XP114 Throttleability (1 2 2 x)	
					XP12 Hypergolic storable liquid rockets		XP121 Specific impulse (1 2 2 x)	
							XP122 Restart reliability (1 2 2 x)	
							XP123 Throttleability (1 2 2 x)	
XR Comm. (1 1 2 x)	4 channel voice 200 km 10 hrs. 1 channel voice 2000 km 10 min. 1 channel biomed. digital data link 200 km 10 hrs.		XR1 Voice, local	SOA				
			XR2 Voice, long range, biomed data link		XR21 VHF/UHF transceiver		XR211 Antenna directivity (1 1 2 x)	
							XR212 Power (1 1 2 x)	
							XR213 Coding (1 1 2 3 x)	
XS Stab/Control	0.25°/sec 3-axis angular rate sensor, display only, manual control of attitude jets.	SOA						
XT Sim/Train (1 1 1 1 x)	Prelaunch skill acquisition for vehicle maneuvering and docking operation and docking crew coordination.				XT11 Assembly training		XT111 Realism of zero-g work (1 1 1 1 x)	
							XT112 Crew mix (1 1 1 1 x)	
XV Vehicle (1 2 2 x)	Unpressurized open one-man vehicle with propulsion and life support tankage to support one worker in space suit. Grapplers and shock absorbers for maneuvering and docking operations.				XV11 Open one-man space vehicle		XV111 Docking shock (1 2 2 x)	
							XV112 Grappling of large masses (1 2 2 1 x)	
XY Display	Display of attitude rate, propulsion and life support supply status, biomedical monitor display	SOA						

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CONCEPT DESCRIPTION

CONCEPT MANNED MARS/VENUS FLYBY

DESIGNATOR PF02

MISSION OBJECTIVES Manned, close observation of both Mars and Venus during a single non-stop trip from earth. This mission takes advantage of the heliocentric orbital positions of Venus, Earth and Mars to achieve the dual observation with relatively little (if any) additional propulsion and small increase in mission duration. Primary observations will be directed at surface and atmosphere features and composition, using photography, radar, IR, UV, radiometers, spectrography, etc.

GENERAL DESCRIPTION A manned mission assembled in a 550 km earth orbit, earth-launched by multiple Saturn V boosters. Gross orbital weight varies between 250K lb and 1.4M lb depending on performance of the nuclear or chemical orbital booster. It carries three men on a 450 to 600 day two-planet flyby, passing both Mars and Venus on the lighted side. Probes are delivered at each planet to monitor density, temperature, and composition of the atmosphere and, if possible, make surface observations. Specific near in opportunities for this mission occur in 1970 and 1972, but these are too early and this mission is anticipated to occur in 1975 or subsequent.

LIST OF SYSTEMS

B Booster (Saturn V)
G Ground Support Facility
J *Orbital Booster
M *Command and Re-Entry Module
P *Planet Probe
S *Spacecraft
X *Extra-Vehicular Activity Unit

*Detailed description follows.

REFERENCES

1. "Empire Dual Planet Flyby Missions", by Franklin P Dixon, Engr. Problems in Manned Interplanetary Exploration, p. 3.
2. "Sizing of Nuclear Orbit Launch Vehicles for Interplanetary Missions", John F. McLaughlin, AIAA paper 63-256.

SYSTEM DESCRIPTION

DESIGNATOR PF02J -16[illegible]-
CONCEPT [illegible]
SYSTEM [illegible]

This is a massive system assembled with the spacecraft in earth orbit [illegible] thrusting increments: earth orbital launch and braking to earth parabola, and also propulsion [illegible] approach corrections enroute. Nuclear propulsion, if available, would greatly reduce the [illegible] weight required. The total gross weight of this system is approximately 1.4M lbs. (if chemical propulsion is used), 250K lbs. (if all nuclear is used), or 340K lb. (if nuclear is used for earth escape and chemical is used for the rest of the flight). This gross weight is the total earth orbital weight, including the Command and Re-Entry Module, the Spacecraft, and the Planet Probe. The orbital launch booster will be launched in sections each approximately the maximum payload of a Saturn V.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL REQUIREMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
JA Aux. Power (S, T)	Continuous Power: 1 KW during thrusting Chemical dynamic system	SOA		
JG Guid./Nav.	Supplied by Command Module			
JM Check/Maint (1, 2, 3, x)	Prelaunch checkout Performance monitor, report Switching of redundant units		JM11 Automatic failure monitor and fault isolation	JM111 Monitoring & switching (1, 2, 3, x)
JP Propulsion (2, 2, 4, 2, x)	Chemical I_{sp}=455 / Nuclear I_{sp}=900 1. ΔV=5.3 km/sec — 130K lb — 94K lb — for escape from earth orbit 2. ΔV=0.6 km/sec — 109K lb. — 85K lb — total midcourse & approach 3. ΔV=4.5 km/sec — 15K lb — 15K lb — deboost to earth parabola		JP11 Cryogenic liquid rocket at I_{sp} = 455 sec., requiring 1.4M lbs. into earth orbit.	JP111 Cryogenic storage (2, 2, 4, x) JP112 Specific impulse (2, 2, 4, x) JP113 Reliability, long storage (2, 2, 4, x)
			JP12 Solid core nuclear fission rocket at I_{sp} = 900 sec, requiring 250K lb. into earth orbit	JP121 High temperature materials (2, 2, 4, 2, x) JP122 Shielding (1, 1, 2, 4, x) JP123 R&D required (2, 2, 4, 2, x) JP124 Cryogenic storage (1, 2, 2, x) JP125 Cooldown and restart (2, 2, 4, 2, x)
			JP13 Solid core nuclear fission rocket for earth escape, and cryogenic liquid rocket for midcourse, approach and deboost to earth parabola, requiring 340K lb. into earth orbit.	JP131 Cryogenic storage (2, 2, 4, x) JP132 Specific impulse (2, 2, 4, x) JP133 Reliability, long storage (2, 2, 4, x) JP134 High temperature materials (2, 2, 4, 2, x) JP135 Shielding (1, 1, 2, 4, x) JP136 R&D required (2, 2, 4, 2, x) JP137 Cooldown and restart (2, 2, 4, 2, x)
JS Stab./Cont.	Attitude: .25° — Thrust Vector Control		Main propulsion	SOA
	Roll Control		Hypergolic reaction jets	SOA
JV Vehicle (1, 2, 2, 2, x)	Shielding Docking Orbital Assembly		JV11 Open frame structure. Tankage assembled in orbit.	JV111 Meteoric protection (1, 2, 2, 2, x) JV112 Material degradation (1, 2, 2, 2, x) JV113 Shielding (1, 2, 4, 4, x) JV114 Dock shock (1, 2, 2, x)

SYSTEM DESCRIPTION

This is a 3-man Apollo-type module. This system serves as an earth re-entry capsule for the astronauts, and all necessary instrumentation, photographic film, taped data, etc., to return the results of the Mars/Venus expedition to earth. In addition, it will serve as the vehicle for bringing the crew to the assembled space vehicle in orbit and as temporary quarters for the crew during periods of thrusting for earth orbit launch, and deboost to earth parabola and atmospheric entry. The Command and Re-Entry Module will include retropropulsion for final control of the landing point during atmospheric re-entry. The re-entry portion will resemble the Apollo command module, and the entire system will weigh approximately 12,000 lbs., including the propulsion unit.

DESIGNATOR CONCEPT SYSTEM PF02 M

MANNED MARS/VENUS FLYBY

Command and Re-Entry Module
(Page 1 of 2)

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

MA Aux. Power (S: x; T: 1 2 4)

Continuous power: 2 kw, one week.

MD Data Proc. (1 2 4)

RATES
- Input data rate — 10^3 bits/sec
- Output comm. rate — 10^3 bits/sec
- Output display rate — 10^3 bits/sec

STORAGE
- Recoverable — None
- Temporary — 10^5 bits

ME Escape/Recy

Safe return of astronauts during earth launch
This is the primary function of this system

MG Guid./Nav. (1 2 4)

Escape from orbit.	Velocity	±1 m/sec
	Angle	±0.1 degree
Midcourse:	Vel. Accuracy	±0.5 m/sec
	Angle	±5 degrees
Approach:	Position	±50 km
Deboost:	Velocity	±1 m/sec
	Angle	±1 degree
Rendezvous & Docking:	Rel. Pos.	0.3 (m)
	Rel. Velocity	0.3 m/sec
	Acquisition Condition	200 km

MH Life Support (1 2 4 2)

AIR: 1.8 lb. O_2/man/day
WATER: 6.16 lb (drink), 9.84 lb (hygiene)/man/day
FOOD: 3,000 cal/man/day
T, P, H: 75±5°F, 46% RH, 3.5-14, 7 PSIA
MED: physiological monitoring
RADIATION: inst. 100 rem

MM Check/Maint (1 2 3)

Prelaunch checkout (ground/orbit)
Performance monitor, report
Switching of redundant units
Malfunction diagnosis

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

SOA

- MA11 — Fuel cell + NiCad battery
  - MA111 Shutdown reliability (S: x; T: 1 2 4)
  - MA112 Specific power, fuel cell (1 2 3 4)
  - MA113 Service life, fuel cell (1 2 4)
  - MA114 High-load efficiency (1 2 4)
- MD11 — Central digital computer
  - MD111 Reliability, digital computer (1 2 4)
  - MD112 Memory density, digital computer (1 2 4)

- MG1 Escape from planet orbit
  - MG11 — Star tracker and inertial system with laser ranging orbit determination
    - MG111 Reliability, star tracker (1 2 3)
    - MG112 Reliability, laser ranging (1 2 4)
    - MG113 R&D req'd, laser ranging (1 2 4 3)
    - MG114 Reliability, inertial system (1 2 4)
- MG2 Midcourse
  - MG21 — DSIF, star tracker and inertial system
    - MG211 Reliability, inertial system (1 2 4)
- MG3 Planet approach
  - MG31 — Planet horizon scanner with laser ranging
    - MG311 Horizon definition, planet (1 2 2 3)
    - MG312 Reliability, horizon scanner (1 2 4)
    - MG313 R&D req'd, laser ranging (1 2 4 3)
    - MG314 Reliability, laser ranging (1 2 4)
- MG4 Deboost
  - MG41 — Inertial system
    - MG411 Reliability, inertial system (1 2 4)
- MG5 Rendezvous & docking
  - MG51 — Radar, rendezvous
    - MG511 Reliability, radar (1 2 3)

- MH1 Air
  - MH11 — Nitrogen/oxygen
    - MH111 Leak detection & alarm (1 2 4)
    - MH112 CO_2 & CO monitor, alarm removal (1 2 4)
- MH2 TPH
  - MH21 — Automatic TPH
    - MH211 Waste heat rejection (1 2 4)
    - MH212 Fast action repressurization & leak alarm (1 2 4 3)
- MH3 Medical/Psycho
  - MH31 — Medical/Psycho
    - MH311 Re-entry g physiology (1 1 1 1)
    - MH312 Reduction in natural immunities (1 2 4 4)
- MM1 Inflight
  - MM11 — Automatic failure monitor and fault isolation
    - MM111 Monitor [illegible] & switching (1 2 3)
    - MM112 Reliability of checkout and maintenance equipment (1 2 3)
- MM2 Prelaunch (ground & orbit)
  - MM21 — Automatic checkout
    - MM211 Reliability of checkout equipment (1 2 3)
    - MM212 Simplification (1 2 3)
    - MM213 Monitor [illegible] (1 3 3)

SYSTEM DESCRIPTION

DESIGNATOR PF02M

CONCEPT MANNED MAN[illegible]

SYSTEM Command and [illegible] (Page 2 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
MP Propulsion (S, T: 1 2 2 x)	ΔV 200 m/sec, payload, 12,000 lbs., for final re-entry control		MP11 Storable liquid rocket	MP111 [illegible] storage (S, T: 1 2 2 x); MP112 Cutoff precision (1 2 2 x); MP113 Specific impulse (1 2 2 x); MP114 Restart reliability (1 2 2 x)
MR Comm	Trans. data rate 10^3 bits/sec digital, plus voice	SOA		
MS Stab/Control	Attitude control: ±.25 degrees	SOA		
MT Sim/Train (1 2 2 4 x)	Prelaunch skill acquisition, retention of earth return skills.		MT11 Re-entry training	MT111 Skill retention (1 2 2 4 x)
MV Vehicle (2 2 4 4 x)	Atmospheric entry from earth orbit Shielding Thermal environment EVA portals, access to spacecraft Docking		MV11 Atmospheric entry body	MV111 High velocity re-entry (2 2 4 4 x)
MY Display	Inflight displays of operation (mission & subsystem management), rendezvous and docking. Subsystem status (equip. status monitoring and maintenance).	SOA		

SYSTEM DESCRIPTION

One or two small 500 lb. probes will be launched by the spacecraft crew to soft land at a site selected during the Mars or Venus approach flight. The selected site is coordinated with both the probe ejection and the spacecraft arrival time and position so that the spacecraft flys approximately over the target site as the probe alights. The probe transmits atmospheric, impact, and surface information to the flyby. One 369° panoramic medium resolution horizontal photograph is transmitted.

DESIGNATOR PF02 P

CONCEPT MANNED MARS/VENUS FLYBY

SYSTEM Planet Probe

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

PA Aux. Power

Peak Power 100 watts, 1 hour
Continuous Power: 10 watts, 5 days

PD Data Proc.

RATES
Input data rate: 10^4 bits/sec digital
Output comm. rate 10^5 bits/sec digital
STORAGE: None

PI Task Instr.

Capable of Carrying Instruments in the Following Instrument Groups
Atmospheric Entry
Surface Weather and Space Oriented
Surface and Subsurface
Surface Surveillance
Radio Propagation Experiment

PP Propulsion

ΔV150 m/sec for deorbit
Payload: 500 lbs.

PR Comm.

Trans. data rate: 10^4 bits/sec digital plus slow-scan analog video
Range 15,000 km
Temporal Requirements 1 hour

PS Stab. /Cont.

Attitude Control: ±5° for deorbit

PV Vehicle

Subsystem Integration
Field of View
Communications
Atmospheric Entry

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

PA11 Silver-zinc battery
- PA111 [illegible]
- PA112 Specific cost AgZn

PD11 Small digital data processor
- PD111 [illegible]

PI11 Instrument package
- PI111 Spaceborne package
- PI112 Accuracy
- PI113 Reliability, instr. pkg

PP11 Hypergolic storable liquid rocket for deboost and parachute for soft landing
- PP111 [illegible]
- PP112 Reliability, long storage

PP12 Solid rocket for deboost and parachute for soft landing
- PP12 [illegible]

PR11 UHF SHF transceiver
- PR111 [illegible]

PS11 Hypergolic ejection [illegible] simple gyro ref.
- PS111 Reliability [illegible]

PV11 Hyperbolic atmospheric entry body with parachute terminal descent
- PV111 [illegible]
- [illegible]
- [illegible]
- [illegible]

SYSTEM DESCRIPTION

[illegible] for the duration [illegible] 30 to [illegible] [illegible] will be [illegible] passing [illegible] equipment will be carried in the spacecraft. A artificial gravity [illegible] attained during enroute phases by spinning the entire assembly. Provision for mounting, launching and monitoring several atmospheric and surface probes will be made. A radiation storm cellar environment [illegible] a few days will be required. The spacecraft will weigh in the vicinity of 30,000 lb. Guidance and navigation contained in Command and Re-Entry Module.

DESIGNATOR CONCEPT SYSTEM

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S T 1 2 4 5 x)	Continuous power 15 kW, 500 days		SA11 Solar dynamic; SA12 Nuclear fission reactor dynamic SNAP-8	SA111 [illegible]; SA112 Waste [illegible]; SA113 Weight; SA121 [illegible]; SA122 R&D [illegible]; SA123 Wearout; SA124 Shielding; SA125 Waste heat rejection
SD Data Proc. (1 2 4 x)	Input data rate: 10^5 bits/sec, 8 min twice daily; Output communication rate: 10^4 to 10^5 bits/sec; Recoverable storage: tape and film; Temporary storage: 10^6 bits	SD11 Digital computer, tape recorder, video encoder		SD111 Memory density tape recorder; SD112 Reliability digital computer; SD113 Reliability tape recorder; SD114 Data compression; SD115 Radiation alteration of memory
SE Escape/Recy	Safe return of astronauts	Use normal command module for re-entry from earth orbit, no provision for abort during interplanetary flight and during Mars/Venus flyby		
SH Life Suppor. (1 2 4 2 x)	SEE PAGE 2			
SI Task Inst. (1 1 1 1 1 x)	Capable of carrying instruments in the following instrument groups: Manned Systems; Interplanetary; Planet Oriented; TV Mapping; Radar Mapping; Radio Propagation Experiment	SI11 Instrument package		SI111 Spacecraft packaging; SI112 Accuracy; SI113 [illegible] high resolution image; SI114 Reliability, instr. package
SM Check/Maint (1 2 3 x)	Prelaunch checkout in orbit; Performance monitor, report; Switching of redundant units; Malfunction diagnosis; Orbital assembly checkout	SM2 Orbital assembly and prelaunch from orbit; SM3 Inflight	SM21 Automatic checkout; SM31 Automatic failure monitor and fault isolation	SM211 Reliability of c&m equipment; SM212 Simplification; SM311 Monitoring & switching; SM312 Fault isolation; SM313 Spares weight and interchangeability; SM314 Zero-g work, tools; SM315 Technical data access
SR Comm. (1 2 3 x)	Transmission data rate: Max. 10^4 to 10^5 bits/sec; Range: Maximum ~ 2.5×10^8 km	SR11 UHF/SHF Transceiver		SR111 Power requirement; SR112 Transmitter efficiency; SR113 Antenna directivity; SR114 Low signal/noise ratio

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

SH Life Support

			x	
1	2	4	2	

- AIR: 1.8 lb. O_2/man/day
- WATER: 6.16 lb. (drink), 9.84 lb. (hygiene)/man/day
- FOOD: 3,000 cal/man/day
- TPH: 75±5°F, 45% RH, 3.5 - 14.7 PSIA
- MEDICAL: medical, dental care, physiological monitoring
- RADIATION: inst. 100 rem, cumulative 350 rem 1 year

SS Stab./Control

		x		
1	2	3		

- Attitude control: ±0.25° during thrusting; ±5° during coast
- Local vertical: ±0.2° 1σ

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Functional Element	Configuration	Technology Deficiency	S	T	1	2	3	4	
SH1 Air	SH11 Nitrogen/oxygen	SH111 Leak detection & alarm			1	2		4	x
		SH112 CO_2 & CO monitor, alarm, removal			1	2		4	x
		SH113 Contaminant detection			1	2		4	x
		SH114 Odor & contaminant removal			1	2		4	x
SH2 Water	SH21 Recycled water	SH211 Psychological			1	1	1	1	x
		SH212 Ion removal & pH control			1	2		4	x
		SH213 Trace contaminants			1	2	3	3	x
SH3 Food	SH31 Stored food	SH311 Monotony			1	1	3		x
		SH312 Waste disposal			1	1	3		x
		SH313 Preservation & storage			1	1	3		x
		SH314 Nutrient/bulk ratio			1	1	3		x
		SH315 Preparation and/or reconstitution, crumbs, outgassing			1	1	3		x
		SH316 Biological gas & odor production			1	1	3		x
SH4 TPH	SH41 Automatic TPH	SH411 Fast action repressurization			1	2	4	2	x
		SH412 Non-toxic fire extinguisher			1	2	4	2	x
		SH413 Comfort factors			1	2	4		x
		SH414 Atmospheric circulation & cycling			1	2	4		x
SH5 Medical/psycho	SH51 Medical/psycho	SH511 Zero-g physiology			1	1	1	1	x
		SH512 Morale			1	1	1	1	x
		SH513 Sanitation			1	2	4		x
		SH514 Diagnosis & treatment, health			1	2	4		x
		SH515 Surgical implant of biomedical sensors			1	2	4	4	x
		SH516 Reduction in natural immunities			1	2	4	4	x
SS1 Moment generators	SS11 Thermo-electric thrusters	SS111 R&D required, thermo-electric thruster			2	2	2	2	x
		SS112 Non-linear performance			1	2	3	3	x
		SS113 Reliability, TE thrusters			2	2	2	3	x
	SS12 Hypergolic reaction jets	SS121 Dead zone			1	2	3		x
		SS122 Attitude resolution			1	2	3		x
		SS123 Propellant limited			1	2	3		x
		SS124 Reliability			1	2	3		x
SS2 Sensors	SS21 Horizon scanner, attitude and rate gyros	SS211 Reliability, horizon scanners			1	2	4		x
		SS212 Reliability, rate gyros			1	2	3		x

SYSTEM DESCRIPTION

DESIGNATOR PF02S 166
CONCEPT MANNED MAR [illegible]
SYSTEM [illegible]

SUBSYSTEMS	SUBSYSTEM REQUIREMENT	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
ST Sim/Training (S, T)	Preflaunch skill acquisition and inflight skill retention for vehicle operation and scientific work		ST11 Inflight skill retention	ST111 Crew; ST112 Recursion
SV Vehicle	Subsystem integration; Magnetism; Field of view; Communications; Boom extension; Shielding; Thermal environment; EVA portals; Docking; Orbital assembly	SV1 Docking and assembly	SV11 Closed spacecraft [illegible]	SV111 Large [illegible] assembly operation; SV112 Docking [illegible]
		SV2 Inflight	SV21 Living quarters	SV211 Meteoric protection; SV212 Material degradation; SV213 Portal reaction thrust; SV214 Optical window degradation; SV215 Waste disposal
Display	Inflight displays of operation (mission and subsystem management); Subsystem status (equipment status, monitoring and maintenance); Task (scientific instrumentation and analysis)	SOA		

SYSTEM DESCRIPTION

This is the same as MO04 X. This is a non-pressurized one-man space tug used for major assembly jobs in earth orbit. The operator will wear a conventional EVA space suit. It should be usable for 10 hours, rechargeable from spacecraft. Must have adequate propulsion for self and equipment. Must be able to control attitude in orbit. Must be capable of performing any necessary work in assembling the various systems. Communications for voice to 500 miles.

DESIGNATOR PF02 X
CONCEPT MANNED MARS/VENUS FLYBY
SYSTEM Extra-Vehicular Activity Unit

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
XA Aux. Power	Continuous power 200 W, 10 hours	SOA		
XH Life Support	Tankage for oxygen, water, food, waste.	SOA		
XP Propulsion	Total ΔV 2.0 m/sec, 250,000 lb. payload, to maneuver units for docking. Acceleration impulse limited to 0.5 m/sec ΔV. Throttleable.		XP11 Cryogenic liquid rockets XP12 Hypergolic storable liquid rockets	XP111 Specific impulse XP112 Cryogenic storage XP113 Restart reliability XP114 Throttleability XP121 Specific impulse XP122 Restart reliability XP123 Throttleability
XR Comm.	4 channel voice 200 km 10 hrs. 1 channel voice 2000 km 10 min. 1 channel biomed, digital data link 200 km 10 hrs.	XR1 Voice, local — SOA XR2 Voice, long range, biomed data link	XR21 VHF/UHF transceiver	XR211 Antenna directivity XR212 Power XR213 Coding
XS Stab./Control	0.25°/sec 3-axis angular rate sensor, display only, manual control of attitude jets.	SOA		
XT Sim./Train	Prelaunch skill acquisition for vehicle maneuvering and docking operation and docking crew coordination.		XT11 Assembly training	XT111 Realism of zero-g work XT112 Crew mix
XV Vehicle	Unpressurized open one-man vehicle with propulsion and life support tankage to support one worker in space suit. Grapplers and shock absorbers for maneuvering and docking operations.		XV11 Open one-man space vehicle	XV111 Docking shock XV112 Grappling of large masses
XY Display	Display of attitude rate, propulsion and life support supply status, biomedical monitor display.	SOA		

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CONCEPT DESCRIPTION

CONCEPT VENUS ORBITER/ROVER

DESIGNATOR VD01

MISSION OBJECTIVES Unmanned exploration of the surface of Venus using a small roving vehicle. Primary objectives are the acquisition of data regarding the surface structure and composition, atmospheric characteristics and the detection and characterization of biological forms.

GENERAL DESCRIPTION An unmanned mission in which the Orbiter and the Lander/Rover are first injected into a circular equatorial orbit around Venus, observations are made and telemetered to earth. A landing site is designated and on command the Lander/Rover is detached and landed by atmospheric entry and parachute. Upon landing, the Rover is activated, extending running gear, and is directed through transmitted radar images to particular nearby areas of interest. Rover lifetime is about ten days on the surface, Orbiter 15 days in orbit, plus about 110 days enroute. Lander/Rover weighs about 4000 lb. and the Orbiter about 8,000 lb., including propulsion for braking to Venus orbit. Mission date is about 1975.

LIST OF SYSTEMS

B Booster (Saturn I-B/Centaur)
G Ground Support Facility
L *Lander Rover
S *Orbiter Spacecraft

REFERENCES

1. GE, "Voyager Design Study," Vol. II, Doc. #63SD801, 15 Oct 1963.
2. AVCO Corp., "Voyager Design Studies," Vol. II, Doc. #RAD-TR-63-34, 15 Oct 1963.
3. JPL, "Study of Mars & Venus Orbiter Missions Launched by the 3-Stage Saturn C-1B Vehicle," Eng. Planning Doc. #139.
4. "Surveyor Lunar Roving Vehicle," Final Report Vol. I, GM TR-64-26, 23 Apr 1964

*Detailed description follows.

SYSTEM DESCRIPTION

A 4,000 lb. unmanned probe to soft [illegible] of [illegible] surface composition, structure and [illegible] measurements, [illegible] and [illegible] observations [illegible] Future atmospheric measurements during descent and while on the surface. Transmit data to orbiter for relay to earth at each orbit pass. Can relocate up to 150 m/day at command from earth.

DESIGNATOR [illegible] VD011 170

CONCEPT [illegible]

SYSTEM [illegible]

SUBSYSTEMS		SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
LA	Aux. Power (S T: 1 2 4)	Peak Power: 200 watts, 15 min., [illegible] hours for 10 [illegible] Cont. Power: 50 watts, for 10 days		LA11 Fuel cell + AgO_2 batteries	LA1 [illegible] LA11 [illegible]
LD	Data Proc. (1 2 4)	Input data rate: 2×10^3 bits/sec. Output communication rate: 10^4 bits/sec. Temporary storage: 10^7 bits		LD11 Static high speed data [illegible]	LD111 [illegible] LD112 [illegible] LD113 [illegible] LD114 R&D req'd, tape recorder
LG	Guid/Nav. (1 1 2)	Pulse duration and deorbit time command from earth. No acceleration sensing required. For surface roving, accepts earth commands for heading and distance. Needs onboard heading reference and gross distance measurement.		LG11 Heading reference, cross distance measurement, scanning radar	LG111 R&D required, heading reference LG112 R&D required scanning radar
LI	Task Instr. (1 1 1 1)	Capable of carrying instruments in the following instrument groups Atmospheric Entry Surface Weather and Space Oriented Surface and Subsurface Life Detection Surface Surveillance & Micro TV Radio Propagation Experiment		LI11 Instrument package	LI111 spaceborne packaging LI112 Accuracy LI113 Measurement techniques LI114 Reliability, instr. pkg LI115 Sterilization
LP	Propulsion (1 2 2)	Δ V 250 m/sec.; payload 4,000 lb. for deboost 150 m/day for 10 days surface transport.	LP1 Surface LP2 Deboost	LP11 Electric motor driven by fuel cell LP21 Storable liquid rocket for deboost and parachute for soft landing LP22 Solid rocket for deboost and parachute for soft landing	LP112 Mechanical reliability LP113 Weight of electric drive LP211 Impulse accuracy LP212 Reliability, long storage LP221 Impulse accuracy
LR	Comm. (1 1 2)	Transmission data rate: 10^4 bits/sec. Range: 5,000 km Temporal requirements: 15 mins. every 2 hrs. for 10 days		LR11 UHF SHF transceiver	LR111 Antenna directivity
LS	Stab/Control (1 2 2)	Attitude control: ± 5° for deorbit		LS11 Hypergolic reaction jets and simple gyro reference	LS111 Reliability, long storage
LV	Vehicle (1 2 2 2)	Atmospheric entry Parachute soft landing Running gear, steerable Subsystem integration: field of view, communications		LV11 Atmospheric re-entry body parachute terminal descent, extendable and inflatable running gear, steerable	LV111 Uncertain characteristics of Venusian atmosphere LV112 Meteoric protection LV113 Landing shock LV114 Mechanical reliability of running gear LV115 Weight of running gear

SYSTEM DESCRIPTION

An 8,000 lb. unmanned spacecraft (including fuel) to fly to Venus with the Lander Rover, to deboost into Venus equatorial orbit, make IR radiometric and radar contour observation of Venus. When the Rover is deboosted to the surface, the Orbiter relays Rover signals to Earth.

DESIGNATOR VD01 S
CONCEPT VENUS ORBITER ROVER
SYSTEM Orbiter Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S 1 2 3 x; T 1 2 3)	Peak Power: 1K watts, 12 hours/day for 15 days in Venus orbit Continuous power: 500 watts, for 15 days in Venus orbit Continuous power: 50 watts enroute to Venus	SA11	Solar cells + NiCad battery	SA111 Specific power, solar cell (S 1 2 3 x) SA112 Specific cost, solar cell (1 2 3 x)
SD Data Proc. (1 2 4 x)	To process IR radiometric observations and radar range reflectivity measurement. Input data rate: 10^3 bits/sec Output communication rate: 2×10^3 bits/sec Temporary storage: 10^6 bits	SD11	Small digital data processor with variable speed tape recorder	SD111 Data compression (1 2 4 5 x) SD112 Memory density, digital processor (1 2 1 x) SD113 Reliability, digital processor (1 2 4 x) SD114 Reliability, tape recorder (1 2 4 x) SD115 R&D req'd, tape recorder (1 2 4 x)
SG Guid/Nav. (1 2 2 3 x)	M/C: Velocity accuracy ± 0.2 m/sec, Angle ± 5 degrees Orbit injection: Velocity ± 1 m/sec, Angle ± 1 degree	SG1 Midcourse SG2 Orbit Injection	SG11 DSIF command with onboard star tracker and inertial acceleration sensor SG21 Doppler radar range rate to determine nearest approach, switched to radar altimeter function to determine ΔV impulse	SG111 Reliability, inertial acceleration sensor (1 1 1 x) SG211 R&D for long range doppler radar (1 2 2 3 x) SG212 Reliability, doppler radar (1 2 2 3 x)
SI Task Instr. (1 1 1 1 x)	Capable of carrying instruments in the following instrument groups: Interplanetary Planet oriented IR Mapping Radio mapping Radio Propagation Experiment	SI11	Instrument package	SI111 Spaceborne packaging (1 1 1 1 x) SI112 Accuracy (1 1 1 1 x) SI113 Measurement techniques (1 1 1 1 x) SI114 Reliability, instr. pkg. (1 1 1 1 x) SI115 Sterilization (1 1 1 1 x)
SP Propulsion (1 2 2 x)	ΔV = 4.7 km/sec Payload = 6K lb.	SP11 SP12	Cryogenic liquid rocket Storable liquid rocket	SP111 Cryogenic storage (1 2 2 x) SP112 Reliability, long storage (1 2 2 x) SP121 Specific impulse (1 2 2 x) SP122 Reliability, long storage (1 2 2 x)
SR Comm. (1 2 3 x)	Transmission data rate 2×10^3 bits/sec to earth, 10^4 bits/sec from Lander/Rover; range up to 250×10^6 km to earth; 5,000 km to Venusian surface	SR11	RF-UHF/SHF transceiver through DSIF network to earth, Rover communications	SR111 Antenna directivity (1 1 2 x) SR112 Antenna pointing (1 2 3 x) SR113 Transmitter power (1 2 3 x) SR114 Reliability (1 2 3 x)
SS Stab/Control (1 2 3 x)	Attitude control ± 5° during enroute phase Pointing accuracy ± 0.2° in orbit Body rate 0.02°/sec for motion compensation	SS11	Hypergolic reaction jets, horizon sensors and star tracker	SS111 Reliability, reaction jet (1 2 3 x) SS112 Reliability, star tracker (1 2 3 x) SS113 Reliability [illegible] (1 2 4 x) SS114 Horizon [illegible] (1 2 2 5 x)
SV Vehicle	Arrange for field of view for cameras, sensors and antennas SOA			

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CONCEPT DESCRIPTION

CONCEPT VENUS INSTRUMENT LANDER

DESIGNATOR VD03

MISSION OBJECTIVES Investigation of the surface characteristics of Venus at one location over a period of time. The surface characteristics include such items as temperature, pressure, humidity, winds, seismic activity, physical and chemical composition of atmosphere and surface materials, biologic activity and acoustic phenomena.

GENERAL DESCRIPTION An unmanned mission, similar to the Near Voyager, landed on Venus conducting various experiments. The Lander is first orbitted and then braked to an aerodynamic atmospheric entry and parachute landing on Venus. Data is stored for programmed or interrogated transmission to earth during favorable portions of the planetary rotation and orbit cycles. Midcourse gross weight is about 3000 lbs., placing 800 lbs. on the surface. Length is 8 feet, diameter 10 feet. The mission date lies in the 1973 period.

LIST OF SYSTEMS

B *Booster (Atlas/Centaur/7K Stage)
G Ground Support Facility
L *Lander

REFERENCES

1. OSSA Voyager Mars

*Detailed description follows.

SYSTEM DESCRIPTION

An Atlas/Centaur with a high energy kick stage (7K lb thrust) to place 1500 to 3000 lb. into trajectory to Venus

DESIGNATOR VD03B

CONCEPT

SYSTEM

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
BA Aux. Power (S, T)	SOA			
BG Guid/Nav	SOA			
BP Propulsion (1 2 2 4 x)	Total Δ = 11.5 km/sec 3000 lb. payload for injection into Venus trajectory		BP11 Atlas/Centaur with 7K lb high energy upper stage	BP111 R&D [illegible] upper stage; BP112 Cryogenic storage; BP113 Corrosive fuel handling and storage; BP114 Restart [illegible]ability; BP115 Specific impulse
BS Stab/Control	SOA			
BV Vehicle	SOA			

SYSTEM DESCRIPTION

An 800 lb. instrumented payload soft landed on Venus. The lander is deboosted into circular parking orbit about Venus, then deboosts to atmospheric entry onto the landing site. Takes atmospheric and fixed-site surface measurements.

DESIGNATOR VD03 L
CONCEPT VENUS INSTRUMENT LANDER
SYSTEM Lander (Page 1 of 2)

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

LA Aux. Power

Peak power 500 watts for ten days during atmospheric entry and surface exploration. Continuous power 50 watts in flight.

LD Data Proc.

Input data rate 10^4 bits/sec.
Output communication rate 10^4 bits/sec.
Temporary storage 10^7 bits

LG Guid. /Nav.

M/C: Velocity accuracy ± 0.2 m/sec
Angle ± 5 degrees
Orbit injection: Velocity ± 1 m/sec
Angle ± 1 degree

LI Task Instr.

Capable of carrying instruments in the following instrument groups:
- Radar Mapping
- Atmospheric Entry
- Surface Weather and Space Oriented
- Surface and Subsurface
- Life Detection
- Surface Surveillance and Micro TV
- Radio Propagation Experiment

LP Propulsion

ΔV = 5 Km/sec to deboost to Venus orbit
ΔV = 250 m/sec to deboost for atmospheric re-entry
Payload 800 lbs.

LR Comm.

Transmission data rate 10^4 bits/sec.
Range: 75 x 10^6 km
Temporal requirements - continuous for 10 days

LS Stab/Control

Attitude control: ± 0.5° during thrusting

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Functional element	Configuration	Technology deficiency	S	T
LA Aux. Power	LA11 Solar cell for inflight power with fuel cell for landing instrumentation	LA111 Abrasion, solar cells	1	5
		LA112 Specific power, fuel cells	1	2
		LA113 Reliability, shutdown, fuel cell	1	2
LD Data Proc.	LD11 Small digital data processor and variable speed tape recorder	LD111 Reliability, digital processor	1	2
		LD112 Reliability, tape recorder	1	2
		LD113 Memory density, tape recorder	1	2
		LD114 R&D req'd., tape recorder	1	2
LG Guid. /Nav.	LG11 DSIF plus planet trackers, sun tracker, radar altimeter	LG111 R&D req'd., planet trackers	1	2
		LG112 R&D req'd., radar altimeter	1	2
		LG113 Reliability, planet trackers	1	2
		LG114 Reliability, radar altimeter	1	2
LI Task Instr.	LI11 Instrument package	LI111 High resolution	1	1
		LI112 Calibration standard	1	1
		LI113 Measurement techniques	1	1
		LI114 Spaceborne packaging	1	1
		LI115 Accuracy	1	1
		LI116 Sterilization	1	1
LP Propulsion	LP11 Storable liquid rocket for deboost and parachute for soft landing	LP111 Impulse accuracy	1	2
		LP112 Reliability, long storage	1	2
	LP12 Solid rocket for deboost and parachute for soft landing	LP121 Impulse accuracy	2	2
		LP122 Restart capability	2	2
LR Comm.	LR11 UHF/SHF transceiver	LR111 Antenna directivity	2	2
LS Stab/Control	LS1 Moment generators: LS11 Thermo-electric thrusters	LS111 R&D req'd., TE thrusters	1	1
		LS112 Non-linear performance	2	2
		LS113 Reliability	1	2
		LS121 Dead zone	2	2
	LS12 Hypergolic reaction jets	LS122 Attitude resolution	1	2
		LS123 Propellant limited	1	2
		LS124 Reliability	1	2
	LS2 Sensors: LS21 Horizon scanner, Attitude and rate gyros	LS211 Reliability, horizon scanners	1	2
		LS212 Reliability, rate gyro	1	2

SUBSYSTEM	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
LV Vehicle (1 2 2 2 ×)	Subsystem integration Field of view Communications Atmospheric entry		LV11 Atmospheric entry body with parachute terminal descent	LV111 [illegible] characteristics of Venus atmosphere LV112 Meteoroid protect LV113 [illegible] LV114 [illegible]

CONCEPT MANNED VENUS PROBE ORBITER

DESIGNATOR VO02

MISSION OBJECTIVES Manned observation of Venus from a 5000 km orbit (probably equatorial, but possibly polar), for a period of ten days. The orbiter inspects Venus and its atmosphere with a variety of instruments such as photography, IR, UV, radiometers, radar mapping, etc., and delivers one or more probes to the surface. This mission follows several unmanned missions: Venus Probe Orbiter (VO01), Venus Exploration Lander (VD01), and Venus Instrument Lander (VD03), and should exploit man's capability of making on-the-spot scientific investigation.

GENERAL DESCRIPTION A manned mission consisting of a three-man spacecraft and a command and re-entry vehicle assembled to an orbital booster in a 550 km earth orbit, using multiple Saturn V launches. Gross orbital weight varies between 270K lb and 1.1M lb, depending on the performance of the nuclear orbital booster. The 10-day stay in Venus orbit allows adequate time to make the desired radar maps of the equatorial region and to obtain detailed information about the atmosphere of Venus. One or two instrumented probes will be atmospherically braked to soft land on the Venus surface and telemeter back atmospheric density, temperature, pressure, and composition, and, if possible, a radar scan of the immediate area around the landing site. The mission duration is 200 to 250 days and the time period 1975 to 1980.

LIST OF SYSTEMS

B Booster (Saturn V)
G Ground Support Facility
J *Orbital Booster
M *Command and Re-Entry Module
P *Planet Probe
S *Spacecraft
X *Extra-Vehicular Activity Unit

REFERENCES

1. Summary Report, Future Programs Task Group, NASA 46-261 O USGPO

*Detailed description follows.

SYSTEM DESCRIPTION

DESIGNATOR [illegible]

CONCEPT MANN[illegible] ORBITER

SYSTEM [illegible]

Similar to Manned Mars Probe Orbiter. This is a massive system, assembled with the spacecraft in earth orbit. It provides four major thrusting increments: earth orbital launch, Venus orbital capture, V[illegible] orbit, and deboost to earth parabola, and also propulsion for midcourse corrections enroute. Nuclear pr[illegible] is required to minimize earth launch weight. The total gross weight of this system with the Spacecraft, Command and Re-Entry Module, and Venus probes is approximately 1.1M lbs., or 270K lbs. into earth orbit, depending on whether solid core nuclear or gaseous fission rockets are used. The orbital launch booster will be launched in sections, each approximately the maximum payload of a Saturn V vehicle.

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

JA Aux. Power (S / T)
- Continuous power: 1 KW during thrusting — SOA

JG Guid./Nav.
- Supplied by Command Module — SOA

JM Check/Maint. (1 2 3)
- Prelaunch checkout
- Performance monitor, report
- Switching of redundant units

JP Propulsion (2 2 4 2)

		Solid Core Nuclear I_{sp}=900	Gaseous Core Nuclear I_{sp}=3000	
1.	ΔV=3.9 km/sec	520K lb	205K lb	for escape from earth orbit
2.	ΔV=4.7 km/sec	241K lb	141K lb	for deboost into Venus orbit
3.	ΔV=4.0 km/sec	111K lb	101K lb	for escape from Venus orbit
4.	ΔV=3.3 km/sec	20K lb	20K lb	for deboost to earth parabola

JS Stab./Control
- Attitude: .25°
- Thrust Vector Control
- Roll Control

JV Vehicle (1 2 2 2)
- Shielding
- Docking
- Orbital Assembly

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

JM11 Automatic failure monitor and fault isolation
- JM111 Monitoring and switching (1 2 3)

JP11 Solid core nuclear fission rocket at I_{sp} = 900 sec, requiring 1.1M lb gross into earth orbit
- JP111 High temperature materials (2 2 4 2)
- JP112 Shielding (1 1 2 4)
- JP113 R&D required (2 2 4 2)
- JP114 Cryogenic storage (1 2 2)
- JP115 Cooldown and restart (2 2 4 2)

JP12 Gaseous core nuclear fission rocket at I_{sp} = 3000 sec, requiring 270K lb. gross into earth orbit.
- JP121 Thrust vectoring (2 2 4 4)
- JP122 Startup (2 2 4 8)
- JP123 Shielding (1 1 2 4)
- JP124 R&D required (2 2 4 6)
- JP125 Cryogenic storage (1 2 2)

Main propulsion — SOA

Hypergolic reaction jets — SOA

JV11 Open frame structure, package assembled in orbit
- JV111 Meteorite protection (1 2 2 2)
- JV112 Material degradation (1 2 2 2)
- JV113 Shielding for on/off operation (1 2 4 4)
- JV114 Dock shock (1 2 2)

SYSTEM DESCRIPTION

This system serves as an Earth re-entry capsule for the astronauts, and all necessary instrumentation, photographic film, taped data, etc., to return the results of the Venus expedition to Earth. In addition, it will serve as the vehicle for bringing the crew to the assembled space vehicle in orbit and as temporary quarters for the crew during the period of thrusting for Earth orbit launch, and deboost to earth parabola and atmospheric re-entry. The Command and Re-entry Module will include retro-propulsion for first control landing point during atmospheric re-entry. The re-entry portion will resemble the Apollo command module, though larger, and the entire system will weigh approximately 20,000 lbs., including the propulsion unit.

DESIGNATOR VO02 M

CONCEPT MANNED VENUS PROBE ORBITER

SYSTEM Command & Re-Entry Module (Page 1 of 2)

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

MA Aux. Power (S: x; T: 1 2 4)
- Cont. power: 3 kw; one week

MD Data Proc. (x; 1 2 4)
- RATES
  - Input data rate 10^3 bits/sec
  - Output comm. rate 10^3 bits/sec
  - Output display rate 10^3 bits/sec
- STORAGE
  - Recoverable None
  - Temporary 10^5 bits

ME Escape/Recy
- Safe return of astronauts during earth launch
- This is the primary function of this system.

MG Guid. /Nav. (x; 1 2 4)

Escape from orbit:	Velocity	± 1 m/sec
	Angle	± 0.1 degree
M/C	Vel. Accuracy	± 0.5 m/sec
	Angle	± 5 degrees
Approach	Position	± 50 km
Deboost:	Velocity	± 1 m/sec
	Angle	± 1 degree
Rendezvous & Docking:	Rel. Pos.	0.3 (m)
	Rel. Vel.	0.3 m/sec
	Acquisition Cond.	200 km

MH Life Support (x; 1 2 4 2)
- AIR: 1.8 lb. O_2/man/day
- WATER: 6.16 lb (drink), 9.84 lb (hygiene)/man/day
- FOOD: 3,000 cal/man/day
- T. P H: 75±5°F, 46%RH, 3.5-14.7 PSIA
- MED physiological monitoring
- RADIATION inst. 100 rem

MM Check/Maint (x; 1 2 3)
- Prelaunch checkout (ground/orbit)
- Performance monitor, report
- Switching of redundant units
- Malfunction diagnosis

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Subsystem	Functional Element	Configuration	Technology Deficiencies	S	T
MA		MA11 Fuel cell + NiCad battery	MA111 Shutdown reliability	x	1 2 4
			MA112 Specific power, fuel cell	x	1 2 4
			MA113 Service life, fuel cell	x	1 2 4
			MA114 High-load efficiency	x	1 2 4
MD		MD11 Central digital computer	MD111 Reliability, digital computer	x	1 2 4
			MD112 Memory density, digital computer	x	1 2 4
MG (SOA)	MG1 Escape from planet orbit	MG11 Star tracker and inertial system with laser ranging orbit determination	MG111 Reliability, star tracker	x	1 2 3
			MG112 Reliability, laser ranging	x	1 2 4
			MG113 R&D req'd, laser ranging	x	1 2 4 3
			MG114 Reliability, inertial system	x	1 2 4
	MG2 Midcourse	MG21 DSIF, star tracker and inertial system	MG211 Reliability, inertial system	x	1 2 4
	MG3 Planet approach	MG31 Planet horizon scanner with laser ranging	MG311 Horizon definition,	x	1 2 2 3
			MG312 Reliability, horizon scanner	x	1 2 4
			MG313 R&D req'd, laser ranging	x	1 2 4 3
			MG314 Reliability, laser ranging	x	1 2 4
	MG4 Deboost	MG41 Inertial system	MG411 Reliability, inertial system	x	1 2 4
	MG5 Rendezvous & docking	MG51 Radar, rendezvous	MG511 Reliability, radar	x	1 2 3
MH	MH1 Air	MH11 Nitrogen/oxygen	MH111 Leak detection & alarm	x	1 2 4
			MH112 CO_2 & CO monitor, alarm removal	x	1 2 4
	MH2 TPH	MH21 Automatic TPH	MH211 Waste heat rejection	x	1 2 4
			MH212 Fast action repressurization & leak alarm	x	1 2 4 3
	MH3 Medical/Psycho	MH31 Medical/psycho	MH311 Re-entry g physiology	x	1 1 1 1
			MH312 Reduction in natural immunities	x	1 2 4 4
MM	MM1 Inflight	MM11 Automatic failure monitor and fault isolation	MM111 Monitoring & switching	x	1 2 3
			MM112 Reliability of checkout & maintenance equipment	x	1 2 3
	MM2 Prelaunch (ground & orbit)	MM21 Automatic checkout	MM211 Reliability of C/M equip	x	1 2 3
			MM212 Simplification	x	1 2 3
			MM213 Monitoring & switching	x	1 2 3

SYSTEM DESCRIPTION

DESIGNATOR VO02M

CONCEPT MANNED VENUS PR[illegible] ORBITER

SYSTEM Command & [illegible]
(Page 2 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS		FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
MP Propulsion (S, T: 1 2 2 x)	ΔV 200 m/sec, payload 20,000 lb., for final control of re-entry point.			MP11 Storable liquid rocket	MP111 R[illegible] long storage (1 2 2 x); MP112 Cutoff precision (1 2 2 x); MP113 Specific impulse (1 2 2 x); MP114 Restart reliability (1 2 2 x)
MR Comm.	Trans. data rate 10^3 bits/sec digital plus voice Range 3,500 miles	SOA			
MS Stab/Control	Attitude control ±.25 degrees	SOA			
MT Sim/Train (1 2 2 4 x)	Prelaunch skill acquisition, retention of earth return skills.			MT11 Re-entry training	MT111 Skill retention (1 2 2 4 x)
MV Vehicle (2 2 4 4 x)	Atmospheric entry from earth orbit Shielding Thermal environment EVA portals, access to spacecraft Docking			MV11 Atmospheric entry body	MV111 High velocity re-entry (2 2 4 4 x)
MY Display	Inflight displays of operation (mission & subsystem management), rendezvous and docking. Subsystem Status (equip. status monitoring and maintenance).	SOA			

SYSTEM DESCRIPTION

Several small probes (500 to 1000 lbs.) will be launched to sound out the atmosphere and surface conditions of Venus. Measurements of atmosphere (density, temperature, composition) will be made during fall. The probe will soft land by parachute and measure surface data (temperature, pressure, minerals, bearing strength, etc.). Data to be telemetered to orbiting spacecraft. Probe will make horizontal radar maps and transmit to the orbiter on each pass.

DESIGNATOR VO02 P
CONCEPT MANNED VENUS PROBE ORBITER
SYSTEM Planet Probe

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
PA Aux. Power (S 1 2 3 x)	Peak Power: 100 watts, 15 min., every 2 hours for 10 days. Continuous Power: 50 watts, 10 days		PA11 Silver-zinc battery	PA111 Specific energy, AgZn (1 1 1 x 5) PA112 Specific cost, AgZn (1 2 x 3) PA113 Temperature (1 2 x 3)
PD Data Proc. (1 2 4 x)	RATES Input data rate: 10^4 bits/sec Output comm. rate: 10^4 bits/sec STORAGE Recoverable: None Temporary: 10^7 bits		PD11 Small digital data processor and variable speed tape recorder	PD111 Reliability, digital processor (1 2 x 4) PD112 Reliability, tape recorder (1 2 x 4) PD113 Memory density, tape recorder (1 2 x 4)
PI Task Instr. (1 1 1 1 x)	Capable of Carrying Instruments in the Following Instrument Groups Atmospheric Entry Surface Weather and Space Oriented Surface and Subsurface Life Detection Surface Surveillance & Micro TV Radio Propagation Experiment Microwave Radar Panoramic Mapping		PI11 Instrument package	PI111 Spaceborne packaging (1 1 1 1 x) PI112 Accuracy (1 1 1 1 x) PI113 Reliability, instr. pkg. (1 1 1 1 x)
PP Propulsion (1 2 2 x)	ΔV 250 m/sec for deorbit Payload 500 - 1000 lbs.		PP11 Hypergolic storable liquid rockets for deboost and parachute for soft landing	PP111 Impulse accuracy (1 2 2 x) PP112 Reliability, long storage (1 2 2 x)
			PP12 Solid rocket for deboost and parachute for soft landing	PP121 Impulse accuracy (2 2 3 x)
PR Comm. (1 1 2 x)	Trans data rate: 10^4 bits/sec Range: 5,000 km Temporal requirements: 15 mins. every two hours for 10 days		PR11 UHF/SHF transceiver	PR111 Antenna directivity (1 1 2 x)
PS Stab./Cont. (1 2 2 x)	Attitude Control ±5° for deorbit		PS11 Hypergolic reaction jets and simple gyro ref.	PS111 Reliability, long storage (1 2 2 x)
PV Vehicle (1 2 2 2 x)	Subsystem Integration Field of View Communications Atmospheric Entry		PV11 Atmospheric entry body with parachute terminal descent	PV111 Uncertain characteristics of Venusian atmosphere (1 1 2 4 x) PV112 Meteoric protection (1 2 2 x) PV113 Landing shock (1 2 2 x)

SYSTEM DESCRIPTION

The spacecraft provides living quarters for 6 men for the duration of the mission (200 to 250 days) except for periods of thrusting. A shirtsleeve environment is required. Observational sensors will be mounted on the spacecraft as well as communications antennas. Communications equipment, data processing, display and other mission oriented equipment will be carried in the spacecraft. An artificial gravity environment may be attained during enroute phases by spinning the entire assembly. Provision for mounting, launching and monitoring several atmospheric and surface probes will be made. A radiation "storm cellar" environment suitable for a few days will be required. The spacecraft will weigh in the vicinity of 75,000 lbs. Guidance and navigation contained in Command & Re-Entry Module.

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

SA Aux. Power (S: x; T: 1 2 4 5)
- Continuous power: 25 KW, 250 days.

SD Data Proc. (x; 1 2 4)
- Input data rate: 10^5 bits/sec, 8 min. twice daily
- Output communication rate: 10^4 to 10^5 bits/sec
- Recoverable storage: tape and film
- Temporary storage: 10^6 bits

SE Escape/Recy
- Safe return of astronauts.

SH Life Support (1 2 4 2)
- SEE PAGE 2.

SI Task Instr. (x; 1 1 1 1 1)
- Capable of carrying instruments in the following instrument groups
  - Manned Systems
  - Interplanetary
  - Planet Oriented
  - Radar Mapping
  - Radio Propagation Experiment

SM Check/Maint (x; 1 2 3)
- Prelaunch checkout in orbit
- Performance monitor, report
- Switching of redundant units
- Malfunction diagnosis
- Orbital assembly checkout

SR Comm. (x; 1 2 3)
- Transmission data rate: Max. 10^4 to 10^5 bits/sec
- Range: Maximum ~ 75 x 10^6 km

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Functional element	Configuration	Technology deficiencies	S	T
SA11 Solar dynamic		SA111 High temperature materials	x	1 2 4 10
		SA112 Waste heat rejection	x	1 2 4
		SA113 Wearout	x	1 2 4 8
SA12 Nuclear fission reactor dynamic (SNAP-8)		SA121 High temperature materials	x	1 1 1 1 5
		SA122 R&D required, nuclear reactor	x	1 2 2 6
		SA123 Wearout	x	1 2 2 6
		SA124 Shielding	x	1 1 2 4
		SA125 Waste heat rejection	x	1 2 4
SD11 Digital computer, tape recorder, video encoder		SD111 Memory density, tape recorder	x	1 2 4
		SD112 Reliability, digital computer	x	1 2 4
		SD113 Reliability, tape recorder	x	1 2 4
		SD114 Data compression	x	1 2 4 5
		SD115 Radiation alteration of memory	x	1 2 2 3
	Use normal command module for re-entry from earth orbit, no provision for abort during interplanetary flight & during Venus orbit.			
SI11 Instrument package		SI111 Spaceborne packaging	x	1 1 1 1
		SI112 Accuracy	x	1 1 1 1
		SI113 R&D, high resolution image	x	1 1 1 1
		SI114 Reliability, instr. package	x	1 1 1 1
SM2 Orbital assembly and prelaunch from orbit.	SM21 Automatic checkout	SM211 Reliability of c&m equipment	x	1 2 3
		SM212 Simplification	x	1 2 3
SM3 Inflight	SM31 Automatic failure monitor and fault isolation	SM311 Monitoring & switching	x	1 2 3
		SM312 Fault isolation	x	1 2 3
		SM313 Spares weight and interchangeability	x	1 2 3
		SM314 Zero-g work, tools	x	1 2 3
		SM315 Technical data access	x	1 2 3
SR11 UHF/SHF Transceiver		SR111 Power requirement	x	1 2 3
		SR112 Transmitter efficiency	x	1 2 3
		SR113 Antenna directivity	x	1 1 2
		SR114 Low signal/noise ratio	x	1 1 1 3

SYSTEM DESCRIPTION

DESIGNATOR
CONCEPT
SYSTEM

VO02S
MANNED VENUS FLYBY
Spacecraft
(Page [illegible])

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

Life Support

1	2	4	2
		x	

AIR. 1.8 lb. O_2/man/day
WATER· 6.16 lb. (drink), 9.84 lb. (hygiene)/man/day
FOOD· 3,000 cal/man/day
TPH· 75±5°F, 46% RH, 3.5 - 14.7 PSIA
MEDICAL· Medical, dental care, physiological monitoring
RADIATION inst. 100 rem, cumulative 350 rem 1 year

Stab/Cont

1	2	3		
		x		

Attitude control: ±0.25° during thrusting
±5° during coast

Venus local vertical· ±0.2°

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

					1	2	3	4	5	6
SH1	Air	SH11	Nitrogen/oxygen	SH111	[illegible]			x		
				SH112	CO_2 & CO monitor, alarm, removal			x		
				SH113	Contaminant detection			x		
				SH114	Odor & contaminant removal			x		
SH2	Water	SH21	Recycled water	SH211	Psychological				x	
				SH212	Ion removal & pH control			x		
				SH213	Trace contaminants				x	
SH3	Food	SH31	Stored food	SH311	Monotony			x		
				SH312	Waste disposal			x		
				SH313	Preservation & storage			x		
				SH314	Nutrient bulk ratio			x		
				SH315	Preparation and/or reconstitution, crumbs, outgassing			x		
				SH316	Biological gas & odor production			x		
SH4	TPH	SH41	Automatic TPH	SH411	Fast action repressurization				x	
				SH412	Non-toxic fire extinguisher				x	
				SH413	Contaminant factors			x		
				SH414	Atmospheric circulation & cycling			x		
SH5	Medical/psycho	SH51	Medical/psycho	SH511	Zero-g physiology				x	
				SH512	Morale				x	
				SH513	Sanitation			x		
				SH514	Diagnosis & treatment, health			x		
				SH515	Surgical implant of biomedical sensors				x	
				SH516	Reduction in natural immunities				x	
SS1	Moment generators	SS11	Thermo-electric thrusters	SS111	R&D required, thermo-electric thruster				x	
				SS112	Non-linear performance				x	
				SS113	Reliability, TE thrusters				x	
		SS12	Hypergolic reaction jets	SS121	Dead zone			x		
				SS122	Attitude resolution			x		
				SS123	Propellant required			x		
				SS124	Reliability			x		
SS2	Sensors	SS21	Horizon scanner, attitude and rate gyros	SS211	Reliability, horizon scanner			x		
				SS212	Reliability, rate gyros			x		

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

ST Sim. /Train

S			x	
T	1	1	1	1

Prelaunch skill requisition and inflight skill retention for vehicle operation and scientific work.

SV Vehicle

			x	
1	2	2	2	

Subsystem integration
- Magnetism
- Field of view
- Communications
- Boom extension
- Shielding
- Thermal environment
- EVA portals
- Docking
- Orbital assembly

SY Display

Inflight displays of operation (mission and subsystem management)
Subsystem status (equipment status, monitoring and maintenance)
Task (scientific instrumentation and analysis)

SOA

FUNCTIONAL ELEMENTS / CONFIGURATIONS

- ST11 Inflight skill retention
- SV1 Docking and assembly
  - SV11 Closed spacecraft structure
- SV2 Inflight
  - SV21 Living Quarters

TECHNOLOGY DEFICIENCIES

		S	T				
ST.1	[illegible]					x	
ST112	Redundancy					x	
SV111	Large vehicle assembly operations				2	4	
SV112	Docking			1	2	2	
SV211	Meteoric protection			1	2	2	x 2
SV212	Material degradation			1	2	2	x 3
SV213	Portal reaction thrust			1	2	2	x
SV214	Optical window degradation			1	2	2	x 3
SV215	Waste disposal			1	1	x 3	

SYSTEM DESCRIPTION

DESIGNATOR VO02 X
CONCEPT MANNED VENUS PROBE ORBITER
SYSTEM Extra-Vehicular Activity Unit

Same as MO04 X. This is a non-pressurized one-man space tug used for major assembly jobs in earth orbit. The operator will wear a conventional EVA space suit. It should be usable for 10 hours, rechargeable from spacecraft. Must have adequate propulsion for sel. nd equipment. Must be able to control attitude in orbit. Must be capable of performing any necessary work in assembling the various systems. Communications for voice to 500 miles.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
XA Aux. Power (S T)	Continuous power 200 W, 10 hours	SOA		
XH Life Support	Tankage for oxygen, water, food, waste.	SOA		
XP Propulsion (1 2 2)	Total ΔV 2.0 m/sec, 250,000 lb. payload, to maneuver units for docking. Acceleration impulse limited to 0.5 m/sec ΔV. Throttleable.		XP11 Cryogenic liquid rockets XP12 Hypergolic storable liquid rockets	XP111 Specific impulse (1 2 2) XP112 Cryogenic storage (1 2 2) XP113 Restart reliability (1 2 2) XP114 Throttleability (1 2 2) XP121 Specific impulse (1 2 2) XP122 Restart reliability (1 2 2) XP123 Throttleability (1 2 2)
XR Comm. (1 1 2)	4 channel voice 200 km 10 hrs. 1 channel voice 2000 km 10 min. 1 channel biomed. digital data link 200 km 10 hrs.	XR1 Voice, local XR2 Voice, long range, biomed data link	SOA XR21 VHF/UHF transceiver	XR211 Antenna directivity (1 1 2) XR212 Power (1 1 2) XR213 Coding (1 1 2 3)
XS Stab/Control	0.25°/sec 3-axis angular rate sensor, display only, manual control of attitude jets.	SOA		
XT Sim/Train. (1 1 1 1)	Prelaunch skill acquisition for vehicle maneuvering and docking operation and docking crew coordination.		XT11 Assembly training	XT111 Realism of zero-g work (1 1 1 1) XT112 Crew mix (1 1 1 1)
XV Vehicle (1 2 2)	Unpressurized open one-man vehicle with propulsion and life support tankage to support one worker in space suit. Grapplers and shock absorbers for maneuvering and docking operations.		XV11 Open one-man space vehicle	XV111 Docking shock (1 2 2) XV112 Grappling of large masses (1 2 2 1)
XY Display	Display of attitude rate, propulsion and life support supply status, biomedical monitor display.	SOA		

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CONCEPT DESCRIPTION

CONCEPT JUPITER FLYBY

DESIGNATOR JF01

MISSION OBJECTIVES Flyby investigation of Jupiter and its moons, with particular emphasis upon Ganymede and Callisto. Atmospheric characteristics and properties, energy balance, magnetic fields and electromagnetic radiation emanating from Jupiter will be evaluated.

GENERAL DESCRIPTION An unmanned mission in which a 1500 lb. spacecraft makes a 650 day trip (or more) to Jupiter for the purpose of telemetering photographic observations and various other scientific measurements while in the vicinity of Jupiter and its moons. Launch windows for such a mission occur in about 1972 and 1984.

LIST OF SYSTEMS

B *Booster (Atlas/Centaur/7 K)
G Ground Support Facility
S *Spacecraft

REFERENCES

1. OSSA- Concept - same name

*Detailed description follows.

SYSTEM DESCRIPTION

An Atlas/Centaur with a high energy kick stage (7K lb thrust) to place 1500 lb payload trajectory to Jupiter

DESIGNATOR JF01B

CONCEPT JUPITER FLYBY

SYSTEM Booster

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS / FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

BA Aux. Power — S T — SOA

BG Guid/Nav. — SOA

BP Propulsion — 1 2 2 4 — Total Δ V = 14 km/sec, 1500 lb. payload for injection into Jupiter trajectory

- BP11 — Atlas/Centaur with 7K lb. high energy upper stage
  - BP111 R&D required on upper stage — 1 2 2 4 (x)
  - BP112 Cryogenic storage — 1 2 2 (x)
  - BP113 Corrosive fuel handling and storage — 1 2 2 (x)
  - BP114 Restart reliability — 1 2 2 4 (x)
  - BP115 Specific impulse

BS Stab/Control — 1 — SOA

BV Vehicle — SOA

S T

SYSTEM DESCRIPTION

A large Mariner type spacecraft, 1500 lbs. injected into a close flyby of Jupiter and either Ganymede or Callisto by the Launch booster. During the Jupiter pass it will take measurements of the magnetic field, radiation belts, spectroscopic and radiometric measurements of the atmosphere, and radar mapping of the Jovian surface, radar sounding of the atmosphere; and surface photography, spectroscopic and radiometric measurements of the atmosphere of Ganymede or Callisto.

DESIGNATOR JF01 S
CONCEPT JUPITER FLYBY
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (1 2 2 6)	Peak Power: 500 W during 5-day encounter Continuous Power: 150 W during 500-600 day cruise	SA11	Isotope/thermoelectric	SA111 R&D req'd TE conversion (1 2 3 10) SA112 Isotope resources (1 2 3 12) SA113 Specific energy (1 2 3) SA114 Radiation damage, semiconductors (1 2 3 10)
SD Data Proc. (1 2 4)	Input data rate: 10^5 bits/sec. during encounter Output communication rate: 10 bits/sec. during cruise, 100 bits/sec. during encounter and 100 days after Temporary storage 2×10^8 bits	SD11	Small digital processor and variable speed tape recorder	SD111 Reliability, dig processor (1 2 4) SD112 Reliability, tape recorder (1 2 4) SD113 Memory density tape recorder (1 2 4) SD114 Data compression (1 2 4 5) SD115 Radiation alteration of memory (1 2 2 3) SD116 R&D req'd., tape recorder (1 2 4)
SG Guid/Nav. (1 2 4)	Approach Position ± 1000 km at target plane M/C: Velocity accuracy ± 0.5 m/sec. Angle ± 3 degrees	SG11	Sun and star tracker for attitude reference, planet tracker for approach guidance relayed to DSIF for guidance command. DSIF for midcourse correction. Timed pulse for thrust.	SG111 Uncertainty in Jupiter ephemeris (1 1 1 5) SG112 Reliability, planet tracker (1 2 5)
SI Task Instr. (1 1 1 1)	Capable of carrying instruments in the following instrument groups. Interplanetary Planet Oriented Photo Mapping Surface Surveillance Radio Propagation Experiment Lightweight radar atmospheric sounder	SI11	Long range radar altimeter to measure perigee altitude and atmospheric sounding instrument package	SI111 Choice of frequency (1 1 1 1) SI112 Correlation of return with atmospheric characteristics (1 1 1 1) SI113 R&D required radar altimeter (1 2 3 2) SI114 Reliability, radar altimeter (1 2 3) SI115 Accuracy (1 1 1 1) SI116 Calibration standards (1 1 1 1) SI117 R&D required, high resolution image (1 1 1 1) SI118 Spaceborne packaging (1 1 1 1) SI119 Reliability, instr. pkg. (1 1 1 1)
SP Propulsion (1 2 2)	ΔV = 200 m/sec for midcourse and approach correction Payload = 1500 lbs.	SP11 SP12	Storable hypergolic liquid r Solid rocket	SP111 Restart reliability (1 2 2) SP112 Impulse control (1 2 2) SP121 Restartability (2 2 3 2) SP122 Impulse control (2 2 3)
SR Comm. (1 2 2)	Transmission data rate: 15 bits/sec during cruise, 100 bits/sec. following encounter for 100 days. Communication distance 5.5 to 7.5 AU	SR11	SHF transceiver	SR111 Reliability, communications equipment (1 2 3) SR112 Antenna directivity (1 1 2)
SS Stab/Control (1 2 3)	Attitude control ± 5° continuous during flight Pointing accuracy ± 0.25°, 5 hours } during encounter Body rate .01°/sec. for 5 hours } Attitude for communication pointing	SS11	Cold gas jets and solar sails, sun and star tracker, attitude reference	SS111 Reliability, cold gas jets (1 2 3)
SV Vehicle (1 2 2 2)	Large Mariner type with protection from meteoric damage in Asteroid belt	SV11	Large Mariner type	SV111 Meteoric protection (1 2 2 2)

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CONCEPT DESCRIPTION

CONCEPT SATURN FLYBY

DESIGNATOR NF01

MISSION OBJECTIVES Investigation through photographic, IR, UV and radiometric techniques of Saturn, its rings, and its moons--in particular, Titan. The system also estimates ring density, thickness, temperature and composition, as well as investigating magnetic and radiometric properties of outer, planetary space and evaluating electric rocket performance in deep space.

GENERAL DESCRIPTION An unmanned mission consisting of a 5000+ lb. electrically propelled spacecraft carrying 200 to 500 lbs. of instrument payload and a 200-foot antenna for telemetry. It also carries a nuclear power supply. A high speed control thrust, short transit time orbit relieves reliability problems which occur because of the length of time required for the Hohmann minimum energy transfer. The flyby should be made in such a direction as to avoid Saturn's rings, i.e., to pass approximately through the polar axis of Saturn with the axis tilted away from the arriving spacecraft. This condition will obtain for normal approaches in Saturn spring or fall, and hence will occur for about five years out of each fifteen, with a launch opportunity during each year. The mission date lies in the 1973-76 period.

LIST OF SYSTEMS		REFERENCES
B	*Booster (Saturn I-B/High Energy Upper Stage)	
G	Ground Support Facility	
S	*Spacecraft	

*Detailed description follows.

SYSTEM DESCRIPTION

A Saturn IB type with high energy (40K lb / 7K lb) upper stages to place 5K lbs into trajectory to Saturn (15 km/sec). Parking orbit and restart capability.

DESIGNATOR [illegible]
CONCEPT SATURN FLYBY
SYSTEM Booster

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
BA Aux. Power (S T)	SOA			
BG Guid/Nav.	SOA			
BP Propulsion (1 2 2 4 x)	Total Δ V = 15 km/sec, 5K lb. payload for injection into Saturn trajectory	BP11 Saturn IB with 40K lb and 7K lb. high energy upper stages H_2O_2 or FLOX	BP111 R&D required on upper stage (1 2 2 4 x) BP112 Cryogenic storage (1 2 2 x) BP113 Corrosive fuel handling and storage (1 2 2 x) BP114 Restart reliability (1 2 2 4 x) BP115 Specific impulse	
BS Stab/Control	SOA			
BV Vehicle	SOA			

SYSTEM DESCRIPTION

DESIGNATOR NF01 S
CONCEPT SATURN FLYBY
SYSTEM Spacecraft

A large Mariner type spacecraft, 5000+ lbs., injected into a close flyby of Saturn and Titan by the Launch Booster. During the Saturn pass it will take measurements of the magnetic field, radiation belts, spectroscopic and radiometric measurements of the atmosphere, and radar mapping of the Saturn surface, radar sounding of the atmosphere; and surface photography, spectroscopic and radiometric measurements of the atmosphere of Titan.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S: x; T: 1 2 3 5)	Peak Power: 500 W during 5 day encounter Continuous: 150 W during 500-600 day cruise		SA11 Isotope/thermoelectric	SA111 R&D req'd., TE conversion (S: x; T: 1 2 3 10) SA112 Isotope resources (x; 1 2 3 12) SA113 Specific energy (x; 1 2 3) SA114 Radiation damage, semiconductors (x; 1 2 3 10)
SD Data Proc. (x; 1 2 4)	Input data rate 10^5 bits/sec during encounter Output comm. rate, 10 bits/sec during cruise, 100 bits/sec during encounter and 100 days after. Temporary storage: 2×10^8 bits		SD11 Small digital data processor and variable speed tape recorder	SD111 Reliability, dig. processor (x; 1 2 4) SD112 Reliability, tape recorder (x; 1 2 4) SD113 Memory density tape recorder (x; 1 2 4) SD114 Radiation alteration of memory (x; 1 2 2 3) SD115 Data compression (x; 1 2 4 5) SD116 R&D req'd., tape recorder (x; 1 2 4)
SG Guid./Nav. (x; 1 2 4)	Approach Position ±1000 km at target plane M/C: Velocity accuracy ± 0.5 m/sec Angle ±3 degrees	SG11 Sun and star tracker for attitude reference, planet tracker for approach guidance relayed to DSIF for guidance command. DSIF for midcourse correction. Timed pulse for thrust.		SG111 Uncertainty in Saturn ephemeris (x; 1 1 1 5) SG112 Reliability, planet tracker (x; 1 2 5)
SI Task Instr. (x; 1 1 1 1)	Capable of carrying instruments in the following instrument groups: Interplanetary Planet Oriented Photo Mapping Surface Surveillance Radio Propagation Experiment Lightweight radar atmospheric sounder.	SI11 Long range radar altimeter to measure perigee altitude and atmospheric characteristics Instrument package		SI111 Choice of frequency (x; 1 1 1 1) SI112 Correlation of return with atmospheric characteristics (x; 1 1 1 1) SI113 R&D required (x; 1 2 3 2) SI114 Reliability (x; 1 2 3) SI115 Accuracy (x; 1 1 1 1) SI116 Calibration standards (x; 1 1 1 1) SI117 R&D required, high resolution image (x; 1 1 1 1) SI118 Spaceborne packaging (x; 1 1 1 1) SI119 Reliability, instr. pkg. (x; 1 1 1 1)
SP Propulsion (x; 2 2 2 3)	10^{-4} g continuous thrust, reversed before midpoint		SP11 Electric propulsion	SP111 High voltage power source (x; 2 2 2 3) SP112 Charge neutralization (x; 2 2 2 3) SP113 Thrust/weight ratio (x; 2 2 2 3) SP114 R&D required, electric propulsion (x; 2 2 2 3)
SR Comm. (x; 1 1 3)	Trans. data rate - 10 bits/sec during cruise, 25 bits/sec following encounter for 400 days. Range: 1.5×10^9 km		SR11 SHF transceivers	SR111 Reliability, communications equipment (x; 1 2 3) SR112 Antenna directivity (x; 1 1 2)
SS Stab./Control (x; 1 2 3)	Attitude Control ±1° continuous during flight Pointing Accuracy ±1/4° for five day encounter Body Rate 0.01°/sec for five day encounter		SS11 Cold gas jets and solar sails. Sun and star tracker altitude reference.	SS111 Reliability, cold gas jets (x; 1 2 3) SS112 Reliability, sun and star tracker (x; 1 2 3)
SV Vehicle (x; 1 2 2 2)	Large Mariner type with protection from Meteoric damage in asteroid belt		SV11 Large Mariner type	SV111 Meteoric protection (x; 1 2 2 2)

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CONCEPT DESCRIPTION

CONCEPT MERCURY FLYBY

DESIGNATOR YF01

MISSION OBJECTIVES Investigation of Mercury. Items such as magnetic fields, atmosphere, charged particle presence, evidence of micrometeorites, surface features and surface temperatures are examined. This precedes the Manned Mercury Flyby (YF02)

GENERAL DESCRIPTION An unmanned mission composed of a 400 to 600 pound vehicle equipped with a TV camera and other sensors. It spends 95 to 135 days in transit and approximately five hours in the vicinity of Mercury. The mission date lies in the 1968-1970 period.

LIST OF SYSTEMS

B *Booster (TAT/Agena D/7 K)
G Ground Support Facility
S *Spacecraft

REFERENCES

SYSTEM DESCRIPTION

A thrust-augmented Thor-Agena D type with high energy (7K lb.) upper stage to place a 600 lb. spacecraft into trajectory to Mercury (13 km/sec). Parking orbit and re-start capability.

DESIGNATOR [illegible]
CONCEPT MERCURY - [illegible]
SYSTEM Booster

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
BA Aux. Power (S, T)	SOA			
BG Guid. / Nav	SOA			
BP Propulsion (1 2 2 4)	Total Δ V = 13 km/sec, 600 lb. payload injection into Mercury trajectory	BP11	Thrust augmented Thor-Agena D with 7K lb. high energy upper stage	BP111 R&D required on upper stage (1 2 2 4); BP112 Cryogenic storage (1 2 2); BP113 Corrosive fuel handling and storage (1 2 2); BP114 Restart reliability (1 2 2); BP115 Specific impulse (1 2 2 4)
BS Stabil/Control	SOA			
BV Vehicle	SOA			

SYSTEM DESCRIPTION

A Mariner type spacecraft, 600 lbs., injected into a close flyby of Mercury by the Launch Booster. During the Mercury pass it will make photographs, take measurements to determine the extent of any magnetic field and charged particle fields, spectroscopic measurements of the atmosphere, and altitude measurement periapsis. The data is telemetered to earth.

DESIGNATOR YF01 S
CONCEPT MERCURY FLYBY
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S: x; T: 1 2 2 2)	Peak power 200 W for 5 hours during flyby Continuous power 2[illegible] W during 135-day transit	SA11	Solar cell array with AgCd batteries	SA111 High temperature operation (S: x; T: 1 2 2 2) SA112 Abrasion, solar cells (x; 1 1 2 5) SA113 Specific energy, AgCd battery (x; 1 2 3)
SD Data Proc. (x; 1 2 3 2)	Input data rate 15 bits/sec during cruise; 10^5 bits/sec during 5 hour encounter Output communication rate: 200 bits/sec. following encounter for 30 days Temporary storage: 10^8 bits	SD11	Small digital data processor and variable speed tape recorder	SD111 High temperature operation (x; 1 2 2 2) SD112 Reliability, dig processor (x; 1 2 4) SD113 Reliability, tape recorder (x; 1 2 4) SD114 Radiation alteration of memory (x; 1 2 2 3) SD115 Data compression (x; 1 1 4 5) SD116 R&D req'd., tape recorder (x; 1 2 4)
SG Guid/Nav. (x; 1 2 4)	Approach Position ± 1000 km at target plane M/C : Velocity accuracy ± 0.5 m/sec. Angle ± 3 degrees	SG11	Sun and star tracker for attitude reference, planet tracker for approach guidance relayed to DSIF for guidance command. DSIF for midcourse correction. Timed pulse for thrust.	SG111 Uncertainty in Mercury ephemeris (x; 1 1 1 6) SG112 Uncertainty in Mercury mass (x; 1 1 1 5) SG113 Reliability, planet tracker (x; 1 2 5)
SI Task Instr. (x; 1 1 1 1)	Capable of carrying instruments in the following instrument groups: Interplanetary Planet Oriented Photo Mapping Surface Surveillance Radio Propagation Experiment	SI11	Long range radar altimeter to measure perigee altitude, instrument package	SI111 R&D required, radar altimeter (x; 1 2 3 2) SI112 Reliability, radar altimeter (x; 1 2 3) SI113 Accuracy (x; 1 1 1 1) SI114 Calibration standards (x; 1 1 1 1) SI115 Spaceborne packaging (x; 1 1 1 1) SI116 Reliability, instr. pkg. (x; 1 1 1 1)
SP Propulsion (x; 1 2 2)	ΔV = 200 m/sec for midcourse and approach correction Payload = 600 lbs.	SP11 SP12	Storable hypergolic liquid rocket Solid rocket	SP111 Restart reliability (x; 1 2 2) SP112 Impulse accuracy (x; 1 2 2) SP121 Restart capability (x; 2 2 3 2) SP122 Impulse control (x; 2 2 3)
SR Comm. (x; 1 1 2)	Transmission data rate: 15 bits/sec. during cruise; 200 bits/sec. following encounter for 30 days; Range 200 x 10^6 km maximum	SR11	SHF transceivers	SR111 Reliability, communications equipment (x; 1 2 3) SR112 Antenna directivity (x; 1 1 2)
SS Stab/Control (x; 1 2 3)	Attitude control ± 5° continuous during flight Pointing accuracy ± 0.25°, 5 hours } during encounter Body rate .01°/sec. for 5 hours	SS11	Cold gas jets and solar sails. Sun and star tracker attitude reference	SS111 Reliability, cold gas jets (x; 1 2 3)
SV Vehicle	Mariner type	SOA		

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CONCEPT DESCRIPTION

CONCEPT MANNED MERCURY FLYBY

DESIGNATOR YF02

MISSION OBJECTIVES Manned investigation of Mercury. The mission permits close examination of Mercury's surface, magnetosphere and gravity field; close observation of the sun; surface mapping and temperature measurements of Mercury; verification of an alternate theory to relativity for the residual advance of perihelion (about 4 arc sec per century are unaccounted for by relativity); and examination of solar wind streamlines as shaded by Mercury and solar neutron absorption by Mercury. This concept follows the Mercury Flyby (YF01).

GENERAL DESCRIPTION A manned mission, assembled in a 550 km earth orbit, earth-launched by multiple Saturn V boosters. Gross orbital weight varies between 235K lb. and 600K lb., depending on the performance of the nuclear orbital booster. It carries three men on a 220 to 260 day trip to Mercury and return. Observations, photographs, and spectrographic measurements are made at two to five planet radii from Mercury during the flyby pass. A soft landing probe (small Surveyor type) is landed on the surface to make close-up observations and surface composition analysis. Considerable radiation protection is required at .3 to .4 AU from the sun.

LIST OF SYSTEMS

B Booster (Saturn V)
G Ground Support Facility
J *Orbital Booster
M *Command and Re-Entry Module
P Planet Probe (Surveyor SOA)
S *Spacecraft
X *Extra-Vehicular Activity Unit

*Detailed description follows

REFERENCES

1. "Study of Interplanetary Missions to Mercury through Saturn, etc.", K.A. Ehricke, GD/A, 63-0916, 30 Sept 1963

SYSTEM DESCRIPTION

Similar to Manned Mars Fly by MF02 J. This is a massive system, assembled with the spacecraft in earth orbit. It provides two major thrusting increments: earth orbital launch and braking to earth parabola, and also propulsion for midcourse and approach corrections enroute. Nuclear propulsion is required to minimize earth launch weight. The total gross weight of this system with the Spacecraft, Command and Re-Entry Module, and Mercury probes, is approximately 600K lbs., or 235K lbs. into earth orbit, depending on whether solid core nuclear or gaseous fission rockets are used. The orbital launch booster will be launched in sections, each approximately the maximum payload of a Saturn V vehicle.

DESIGNATOR YF 2 J — YF02J —

CONCEPT MANNED MERCURY FLY BY

SYSTEM Orbital Booster

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
JA Aux. Power (S, T)	Continuous Power 1 KW during thrusting Chemical dynamic system.	SOA		
JG Guid./Nav.	Supplied by Command Module			
JM Check/Maint. (1 2 3 x)	Prelaunch checkout Performance monitor, report Switching of redundant units		JM11 Automatic failure monitor and fault isolation	JM111 Monitoring & switching (1 2 3 x)
JP Propulsion (2 2 4 2 x)	1. ΔV = 8 km/sec 2. ΔV = 0.32 km/sec 3. ΔV = 5 km/sec Solid Core Nuclear I_{sp}=900: 138K lb; 15K lb Gaseous Core Nuclear I_{sp}=3000: 123K lb; 15K lb for escape from earth orbit; for M/C & approach corrections; for deboost into earth parabola		JP11 Solid core nuclear fission rocket at I_{sp} = 900 sec., requiring 600K lb. gross into earth orbit JP12 Gaseous core nuclear fission rocket at I_{sp} = 3000 sec., requiring 235K lb. gross into earth orbit	JP111 High temperature materials (2 2 4 2 x) JP112 Shielding (1 1 2 4 x) JP113 R&D required (2 2 4 2 x) JP114 Cryogenic storage (1 2 2 x) JP115 Cooldown and restart (2 2 4 2 x) JP121 Thrust vectoring (2 2 4 4 x) JP122 Startup (2 2 6 8 x) JP123 Shielding (1 1 2 4 x) JP124 R&D required (2 2 4 6 x) JP125 Cryogenic storage (1 2 2 x)
JS Stab./Cont.	Attitude .25° Thrust Vector Control Roll Control		Main propulsion SOA Hypergolic reaction jets SOA	
JV Vehicle (1 2 2 2 x)	Shielding Docking Orbital Assembly		JV11 Open frame structure. Tankage assembled in orbit.	JV111 Meteoric protection (1 2 2 2 x) JV112 Material degradation (1 2 2 2 x) JV113 Shielding for on/off operation (1 2 4 4 x) JV114 Dock shock (1 2 2 x)

SYSTEM DESCRIPTION

This system serves as an earth re-entry capsule for the astronauts, and all necessary instrumentation, photographic film, taped data, etc., to return the results of the Mercury expedition to earth. In addition, it will serve as the vehicle for bringing the crew to the assembled space vehicle in orbit and as temporary quarters for the crew during periods of thrusting for earth orbit launch, and deboost to earth parabola and atmospheric re-entry. The Command and Re-Entry Module will include retro-propulsion for final control of the landing point during atmospheric re-entry. The re-entry portion will resemble the Apollo command module, and the entire system will weigh approximately 12,000 lbs. including the propulsion unit.

DESIGNATOR YF02 M

CONCEPT MANNED MERCURY FLYBY

SYSTEM Command and Re-Entry Module (Page 1 of 2)

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS / FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

MA Aux. Power (S: 1 2 4; T: x)

- Continuous power: 2 kw, one week.

MD Data Proc. (1 2 4; x)

- RATES
  - Input data rate 10^3 bits/sec
  - Output comm. rate 10^3 bits/sec
  - Output display rate 10^3 bits/sec
- STORAGE
  - Recoverable None
  - Temporary 10^5 bits

ME Escape/Recy

- Safe return of astronauts during earth launch
- This is the primary function of this system

SOA

MG Guid./Nav. (1 2 4; x)

Subsystem	Requirement	Value
Escape from orbit:	Velocity	±1 m/sec
	Angle	±0.1 degree
Midcourse	Vel. Accuracy	±0.5 m/sec
	Angle	±5 degrees
Approach:	Position	±50 km
Deboost:	Velocity	±1 m/sec
	Angle	±1 degree
Rendezvous & Docking:	Rel. Pos.	0.3 (m)
	Rel. Velocity	0.3 m/sec
Acquisition	Condition	200 km

MH Life Support (1 2 4 2; x)

- AIR: 1.8 lb. O_2/man/day
- WATER: 6.16 lb (drink), 9.84 lb (hygiene)/man/day
- FOOD: 3,000 cal/man/day
- T, P, H: 75±5°F, 46% RH, 3.5-14, PSIA
- MED: physiological monitoring
- RADIATION: inst. 100 rem

MM Check/Maint (1 2 3; x)

- Prelaunch checkout (ground/orbit)
- Performance monitor, report
- Switching of redundant units
- Malfunction diagnosis

Functional Elements	Configurations	Technology Deficiencies
MA11	Fuel cell + NiCad battery	MA111 Shutdown reliability (S: 1 2 4; T: x)
		MA112 Specific power, fuel cell (1 2 4; x)
		MA113 Service life, fuel cell (1 2 4; x)
		MA114 High-load efficiency (1 2 4; x)
MD11	Central digital computer	MD111 Reliability, digital computer (1 2 4; x)
		MD112 Memory density, digital computer (1 2 4; x)
MG1 Escape from planet orbit	MG11 Star tracker and inertial system with laser ranging orbit determination	MG111 Reliability, star tracker (1 2 3; x)
		MG112 Reliability, laser ranging (1 2 4; x)
		MG113 R&D req'd., laser ranging (1 2 4 3; x)
		MG114 Reliability, inertial system (1 2 4; x)
MG2 Midcourse	MG21 DSIF, star tracker and inertial system	MG211 Reliability, inertial system (1 2 4; x)
MG3 Planet approach	MG31 Planet horizon scanner with laser ranging	MG311 Horizon definition, Mercury (1 2 2 3; x)
		MG312 Reliability, horizon scanner (1 2 4; x)
		MG313 R&D req'd., laser ranging (1 2 4 3; x)
		MG314 Reliability, laser ranging (1 2 4; x)
MG4 Deboost	MG41 Inertial system	MG411 Reliability, inertial system (1 2 4; x)
MG5 Rendezvous & docking	MG51 Radar, rendezvous	MG511 Reliability, radar (1 2 3; x)
MH1 Air	MH11 Nitrogen/oxygen	MH111 Leak detection & alarm (1 2 4; x)
		MH112 CO_2 & CO monitor, alarm, removal (1 2 4; x)
MH2 TPH	MH21 Automatic TPH	MH211 Waste heat rejection (1 2 4; x)
		MH212 Fast action repressurization and leak alarm (1 2 4 3; x)
MH3 Medical/psycho	MH31 Medical/psycho	MH311 Re-entry g physiology (1 1 1 1; x)
		MH312 Reduction in natural immunities (1 2 4 4; x)
MM1 Inflight	MM11 Automatic failure monitor and fault isolation	MM111 Monitoring & switching (1 2 3; x)
		MM112 Reliability of checkout & maintenance equipment (1 2 3; x)
MM2 Prelaunch (ground & orbit)	MM21 Automatic checkout	MM211 Reliability of C/M equip. (1 2 3; x)
		MM212 Simplification (1 2 3; x)
		MM213 Monitoring & switching (1 2 3; x)

SYSTEM DESCRIPTION

DESIGNATOR [illegible]
CONCEPT MANNED MERCURY [illegible]
SYSTEM Command and Re-Entry Module (Page 2 of 2)

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
MP Propulsion (S, T: 1 2 2 x)	Δ V 200 m/sec, payload, 12,000 lbs., for final re-entry control		MP11 Storable liquid rocket	MP111 Reliability long storage (S, T: 1 2 2 x); MP112 Cutoff precision (1 2 2 x); MP113 Specific impulse (1 2 2 x); MP114 Restart reliability (1 2 2 x)
MR Comm.	Trans. data rate: 10^3 bits/sec digital, plus voice	SOA		
MS Stab/Cont	Attitude control: ±.25 degree	SOA		
MT Sim/Train (1 2 2 4 x)	Prelaunch skill acquisition, retention of earth return skills.		MT11 Re-entry training	MT111 Skill retention (1 2 2 4 x)
MV Vehicle (2 2 4 4 x)	Atmospheric entry from earth orbit Shielding Thermal environment EVA portals, access to spacecraft Docking		MV11 Atmospheric entry body	MV111 High velocity re-entry (2 2 4 4 x)
MY Display	Inflight displays of operation (mission & subsystem management), rendezvous and docking. Subsystem status (equip. status monitoring and maintenance).	SOA		

SYSTEM DESCRIPTION

DESIGNATOR YF02 S
CONCEPT MANNED MERCURY FLYBY
SYSTEM Spacecraft

The spacecraft provides living quarters for three men for the duration of the mission (500 to 600 days) except for periods of thrusting. A shirtsleeve environment is required. Observational sensors will be mounted on the spacecraft as well as communications antennas. Communications equipment, data processing, display and other mission oriented equipment will be carried in the spacecraft. An artificial gravity environment may be attained during enroute phases by spinning the entire assembly. Provision for mounting, launching and monitoring several atmospheric and surface probes will be made. A radiation "storm cellar" environment suitable for a few days will be required. The spacecraft will weigh in the vicinity of 50,000 lbs. Guidance and navigation contained in the Command and Re-Entry Module.

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

SA Aux. Power (S: x; T: 1 2 4 5)
- Continuous power: 15 KW, 600 days

SD Data Proc. (x; 1 2 4)
- Input data rate: 10^5 bits/sec, 8 min. twice daily
- Output communication rate: 10^4 to 10^5 bits/sec
- Recoverable storage: tape and film
- Temporary storage: 10^9 bits

SH Life Support (x; 1 2 4 2)
- SEE PAGE 2

SI Task Instr. (x; 1 1 1 1)
- Capable of carrying instruments in the following instrument groups:
  - Manned Systems
  - Interplanetary
  - Planet Oriented
  - TV Mapping
  - Radar Mapping
  - Radio Propagation Experiment

SM Check/Maint (x; 1 2 3)
- Prelaunch checkout in orbit.
- Performance monitor, report
- Switching of redundant units
- Malfunction diagnosis
- Orbital assembly checkout

SR Comm. (x; 1 2 3)
- Transmission data rate: Max. 10^4 to 10^5 bits/sec
- Range: Maximum ~ 2.5×10^8 km

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

SA11 Solar dynamic
- SA111 High temperature materials (S: x; T: 1 2 4 10)
- SA112 Waste heat rejection (x; 1 2 4)
- SA113 Wearout (x; 1 2 4 8)

SA12 Nuclear fission reactor dynamic (SNAP-8)
- SA121 High temperature materials (x; 1 1 1 5)
- SA122 R&D required, nuclear reactor (x; 1 2 2 6)
- SA123 Wearout (x; 1 2 2 6)
- SA124 Shielding (x; 1 1 2 4)
- SA125 Waste heat rejection (x; 1 2 4)

SD11 Digital computer, tape recorder, video encoder
- SD111 Memory density, tape recorder (x; 1 2 4)
- SD112 Reliability, digital computer (x; 1 2 4)
- SD113 Reliability, tape recorder (x; 1 2 4)
- SD114 Data compression (x; 1 2 4 5)
- SD115 Radiation alteration of memory (x; 1 2 2 3)

SI11 Instrument package
- SI111 Spaceborne packaging (x; 1 1 1 1)
- SI112 Accuracy (x; 1 1 1 1)
- SI113 R&D, high resolution image (x; 1 1 1 1)
- SI114 Reliability, instr. package (x; 1 1 1 1)

SM2 Orbital assembly and prelaunch from orbit.
- **SM21 Automatic checkout**
  - SM211 Reliability of c&m equipment (x; 1 2 3)
  - SM212 Simplification (x; 1 2 3)

SM3 Inflight
- **SM31 Automatic failure monitor and fault isolation**
  - SM311 Monitoring & switching (x; 1 2 3)
  - SM312 Fault isolation (x; 1 2 3)
  - SM313 Spares weight and interchangeability (x; 1 2 3)
  - SM314 Zero-g work, tools (x; 1 2 3)
  - SM315 Technical data access (x; 1 2 3)

SR UHF/SHF Transceiver
- SR111 Power requirement (x; 1 2 3)
- SR112 Transmitter efficiency (x; 1 2 3)
- SR113 Antenna directivity (x; 1 1 2)
- SR114 Low signal/noise ratio (x; 1 1 1 3)

SYSTEM DESCRIPTION

DESIGNATOR YF02S
CONCEPT MANNED MPS
SYSTEM Spacecraft

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

SH Life Support (1 2 4 2)

AIR: 1.8 lb. O_2/man/day
WATER: 6.16 lb. (drink), 9.84 lb. (hygiene)/man/day
FOOD: 3,000 cal/man/day
TPH: 75±5°F, 46% RH, 3.5 - 14.7 PSIA
MEDICAL: medical, dental care, physiological monitoring
RADIATION: inst. 100 rem, cumulative 350 rem 1 year

SS Stab. /Control (1 2 3)

Attitude control: ±0.25° during thrusting
±5° during coast
Local vertical: ±0.2° 1 σ

FUNCTIONAL ELEMENTS / CONFIGURATIONS / TECHNOLOGY DEFICIENCIES

Functional Element	Configuration	Technology Deficiency	ST
SH1 Air	SH11 Nitrogen/oxygen	SH111 Leak detection & alarm	1 3 x 4
		SH112 CO_2 & CO monitor, alarm, removal	1 2 x 4
		SH113 Contaminant detection	1 2 x 4
		SH114 Odor & contaminant removal	1 2 x 4
SH2 Water	SH21 Recycled water	SH211 Psychological	1 1 1 x 1
		SH212 Ion removal & pH control	1 2 x 4
		SH213 Trace contaminants	1 2 3 x 3
SH3 Food	SH31 Stored food	SH311 Monotony	1 1 x 3
		SH312 Waste disposal	1 1 x 3
		SH313 Preservation & storage	1 1 x 3
		SH314 Nutrient/bulk ratio	1 1 x 3
		SH315 Preparation and/or reconstitution, crumbs, outgassing	1 1 x 3
		SH316 Biological gas & odor production	1 1 x 3
SH4 TPH	SH41 Automatic TPH	SH411 Fast action repressurization	1 2 4 x 2
		SH412 Non-toxic fire extinguisher	1 2 4 x 2
		SH413 Comfort factors	1 2 x 4
		SH414 Atmospheric circulation & cycling	1 2 x 4
SH5 Medical/psycho	SH51 Medical/psycho	SH511 Zero-g physiology	1 1 1 1 x 1
		SH512 Morale	1 1 1 1 x 1
		SH513 Sanitation	1 2 x 4
		SH514 Diagnosis & treatment, health	1 2 x 4
		SH515 Surgical implant of biomedical sensors	1 2 4 x 4
		SH516 Reduction in natural immunities	1 2 x 4
SS1 Moment generators	SS11 Thermo-electric thrusters	SS111 R&D required, thermo-electric thrusters	2 2 2 x 2
		SS112 Non-linear performance	1 2 3 x 3
		SS113 Reliability, TE thrusters	2 2 2 x 3
	SS12 Hypergolic reaction jets	SS121 Dead zone	1 2 x 3
		SS122 Attitude resolution	1 2 x 3
		SS123 Propellant limited	1 2 x 3
		SS124 Reliability	1 2 x 3
SS2 Sensors	SS21 Horizon scanner, attitude and rate gyros	SS211 Reliability, horizon scanners	1 2 x 4
		SS212 Reliability, rate gyros	1 2 x 3

SYSTEM DESCRIPTION

DESIGNATOR YF02 S
CONCEPT MANNED MERCURY FLYBY
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
ST Sim/Training	Prelaunch skill requisition and inflight skill retention for vehicle operation and scientific work		ST11 Inflight skill retention	ST111 Crew mix; ST112 Redundancy
SV Vehicle	Subsystem integration; Magnetism; Field of view; Communications; Boom extension; Shielding; Thermal environment; EVA portals; Docking; Orbital assembly	SV1 Docking & assembly; SV2 Inflight	SV11 Closed spacecraft structure; SV21 Living quarters	SV111 Large vehicle assembly operations; SV112 Docking shock; SV211 Meteoric protection; SV212 Material degradation; SV213 Portal reaction thrust; SV214 Optical window degradation; SV215 Waste disposal
SY Display	Inflight displays of operation (mission and subsystem management); Subsystem status (equipment status, monitoring and maintenance); Task (scientific instrumentation and analysis) SOA			

SYSTEM DESCRIPTION

DESIGNATOR [illegible]

CONCEPT MANNED M[illegible]

SYSTEM Extra[illegible]

This is a non-pressurized one-man space tug used for major assembly jobs [illegible] from space [illegible]. Must have adequate propulsion for self and equipment. Must be able to control attitude in orbit. Must be capable of performing any necessary work in assembling the various systems. Communications for voice to 500 miles.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
XA Aux. Power (S/T)	Continuous power 200 W, 10 hours.	SOA		
XH Life Support	Tankage for oxygen, water, food, waste.	SOA		
XP Propulsion (1 2 2 x)	Total ΔV 2.0 m/sec, 250,000 lb. payload, to maneuver units for docking. Acceleration impulse limited to 0.5 m/sec ΔV. Throttleable.		XP11 Cryogenic liquid rockets XP12 Hypergolic storable liquid rockets	XP111 Specific impulse (1 2 2 x) XP112 Cryogenic storage (1 2 2 x) XP113 Restart reliability (1 2 2 x) XP114 Throttleability (1 2 2 x) XP121 Specific impulse (1 2 2 x) XP122 Restart reliability (1 2 2 x) XP123 Throttleability (1 2 2 x)
XR Comm. (1 1 2 x)	4 channel voice 200 km 10 hrs. 1 channel voice 2000 km 10 min. 1 channel biomed. digital data link 200 km 10 hrs.	XR1 Voice, local — SOA XR2 Voice, long range, biomed data link	XR21 VHF/UHF transceiver	XR211 Antenna directivity (1 1 2 x) XR212 Power (1 1 2 x) XR213 Coding (1 1 2 3 x)
XS Stab/Control	0.25°/sec 3-axis angular rate sensor, display only, manual control of attitude jets.	SOA		
XT Sim/Train (1 1 1 1 x)	Prelaunch skill acquisition for vehicle maneuvering and docking operation and docking crew coordination.		XT11 Assembly training	XT111 Realism of zero-g work (1 1 1 1 x) XT112 Crew mix (1 1 1 1 x)
XV Vehicle (1 2 2 1 x)	Unpressurized open one-man vehicle with propulsion and life support tankage to support one worker in space suit. Grapplers and shock absorbers for maneuvering and docking operations.		XV11 Open one-man space vehicle	XV111 Docking shock (1 2 2 x) XV112 Grappling of large masses (1 2 2 1 x)
XY Display	Display of attitude rate, propulsion and life support supply status, biomedical monitor display	SOA		

CONCEPT DESCRIPTION

CONCEPT ASTEROID PROBE

DESIGNATOR CF01

MISSION OBJECTIVES Flyby investigation of the asteroids. This should reveal much about their origin and history. If they are the remains of a destroyed planet, it may be possible to study the interior of a planet. Measurement of surface erosion should lead to estimates of comparative age of the fragmented surface. Preliminary investigation of using asteroids for raw materials or manned bases since some pass close to the earth's orbit is also an objective. It is desired to pass within 200 km of the asteroid for observation.

GENERAL DESCRIPTION An unmanned mission with launch opportunities occurring in the 1970's and Eros as the probable first mission target. Eros is available in 1974, 1977 and 1979. Increased thrust will make Vesta available in 1974 and 1980 as well as Ceres in 1976. The spacecraft resembles the Mariner and weighs 400 to 600 lbs. Ideal velocity range from 12.8 to 13.3 km/sec. and mission duration ranges from 200 to 475 days.

LIST OF SYSTEMS

B Booster (Atlas/Centaur)
G Ground Support Facility
S *Spacecraft

*Detailed description follows.

REFERENCES

1. OSSA Asteroid Flyby
2. "Comets & Close Approach Asteroid Mission," Symp. on Post-Apollo Space Exploration, May 1965, paper VIII-4.
3. "Capturing the Asteroid," D. M. Cole, Astronautics and Aerospace Engr., March 1963.
4. NASA CR-57101

SYSTEM DESCRIPTION

Resembles Mariner in function and structure. 400 - 600 lb. total weight
Instrumentation includes TV's [illegible] inspection, magnetometer, micro-wave radiometer, radar experiment for ranging and large particle detection, micrometeorite detectors

DESIGNATOR [illegible]
CONCEPT ASTEROID [illegible]
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (1 2 3 2 x)	Peak Power 200 W, 10 days Continuous Power 50 W, 400 days		SA11 Isotope/thermoelectric	SA111 Specific energy (S T 1 2 3 x) SA112 Waste heat rejection (1 2 4 x) SA113 Shielding (1 1 2 x) SA114 Radiation damage semiconductors (1 2 3 10 x) SA115 Isotope resources (1 2 3 12 x)
			SA12 Solar cells + NiCad batteries	SA121 Specific area, solar cells (1 1 2 5 x) SA122 Specific power solar cells (1 2 3 x) SA123 Reliability NiCad battery (1 1 2 3 x) SA124 High-load efficiency, NiCad (1 1 2 4 x) SA125 Abrasion solar cells (1 1 2 5 x)
SD Data Proc.	Input data rate 10^4 bits/sec during encounter Output communication rate: 10 bits/sec cruise 100 bits/sec following encounter Temporary storage: 10^8 bits		SD11 Small digital data processor and variable speed tape recorder	SD111 Reliability, tape recorder (1 2 4 x) SD112 Weight, tape recorder (1 2 4 x) SD113 R&D req'd, tape recorder (1 2 4 x)
SG Guid./Nav. (1 2 3 x)	M/C: Velocity accuracy ± 0.5 m/sec Angle ± 5 degrees Approach: Position ± 100 km	SG1 Midcourse SG2 Approach	SG11 Modified Mariner + DSIF SG21 Approach TV/earth command	SG111 Ephemeris, asteroid (1 1 1 7 x) SG211 R&D req'd., approach TV (1 2 3 2 x)
SI Task Instr. (1 1 1 1 x)	Capable of carrying instruments in the following instrument groups: Interplanetary Planet Oriented TV Mapping Radar Mapping Radio Propagation Experiment		SI11 Instrument package	SI111 Accuracy (1 1 1 1 x) SI112 Spaceborne packaging (1 1 1 1 x) SI113 R&D required, high resolution image (1 1 1 1 x) SI114 Reliability, instr. pkg. (1 1 1 1 x)
SM Check/Maint.	Prelaunch checkout Performance monitor, report Switching of redundant units	SOA		
SP Propulsion	Δ V 150 m/sec Payload 600 lb.	SOA		
SR Comm. (1 2 3 x)	Transmission data rate 200 bits/sec Range 0.3 AU		SR11 SHF transceiver	SR111 Reliability, transceiver (1 2 3 x)
SS Stab/Control (1 2 3 x)	Attitude control ± 5° cont. Pointing accuracy ± 0.25°, 10 hours Body rate 0.01°/sec, 10 hours		SS11 Cold gas jets, solar sails	SS111 Reliability, cold gas jets (1 2 3 x)
SV Vehicle	Mariner type	SOA		

CONCEPT DESCRIPTION

CONCEPT COMET PROBE

DESIGNATOR CF03

MISSION OBJECTIVES Flyby determination of the nature and origin of comets. Measurement of the charged and neutral particle fields, magnetic field and chemical composition of the coma and solar-comet plasma interactions, as well as close range observation of the physical features of the nucleus and its spectral emissions is made. Information may be gained on the origin of the solar system and the galaxy since comets may come from condensation of the solar nebula at the time of planet formation or from material trapped by the sun during passage through interstellar clouds.

GENERAL DESCRIPTION An unmanned mission in which the precise configuration varies with the comet target because of the differences in injection velocities. Close approach comets require an injection velocity of approximately 11.6kw/sec which allows use of a Modified Mariner Mars spacecraft. The booster for the 1969-70 Pons-Winnicke Mission is an Atlas/Agena while for the 1973 and 1974 missions, it is an Atlas/Centaur. The payload requirement is 400 to 600 lbs., with a flight duration of 170 to 2.0 days. Preacquisition analysis of comet trajectory is desirable to simplify guidance requirements, but larger midcourse velocity corrections are necessary because of the uncertainty in the comet trajectory at launch. Communications distance is approximately .3 AU.

LIST OF SYSTEMS

B Booster (Atlas/Agena or Centaur)
G Ground Support Facility
S *Spacecraft

REFERENCES

1. Comet and Close Approach Asteroid Mission, Moore & Reece, Philco, SPACE VIII-4, p. 13
2. OSSA Comet Intercept

*Detailed description follows.

SYSTEM DESCRIPTION

Mariner Mars with larger midcourse velocity correction capability. A minimum of other Mariner modifications are necessary. Comet tracking capability with provision for TV system output since comet has very low brightness. Instruments already available or easily adapted are magnetometers, dust collectors, visual, UV and IR and cosmic ray spectrometers, plasma probe, charged particle detectors, hydrogen L α indicator.

DESIGNATOR CF03S 210-

CONCEPT COMET PROBE

SYSTEM Spacecraft

SUBSYSTEMS / SUBSYSTEM REQUIREMENTS

SA Aux. Power

Peak Power 150 watts, 1 hr.
Cont. Power 5 watts, 130 days
Non-magnetic power conditioning.

SD Data Proc.

RATES
Input data rate - 400-600 bits/sec
Output comm. rate - 30-80 bits/sec
STORAGE
Temporary - 6 x 10^7 bits

SG Guid./Nav.

Approach Position ± 100 km
MC Vel. Accuracy ± 0.5 m/sec
Angle ± 5 degrees

SI Task Instr.

Capable of carrying instruments in the following Instrument Groups:
Interplanetary
Planet Oriented
TV Mapping
Radar Mapping
Radio Propagation Experiment

SM Check/Maint

Prelaunch checkout
Performance monitor, report
Switching of redundant units
SOA

SP Propulsion

ΔV 120 m/sec
Payload 400 - 600 lbs.
SOA

SR Comm.

Trans. data rate - 80 bits/sec. max.
Range: 0.3 AU
SOA

SS Stab/Control

Attitude control ± 5°, 130 days
Pointing accuracy ±0.25°, 1 hour
Spin up to 1 RPM for experiment
SOA

SV Vehicle

Subsystem integration
Magnetism
Field of view
SOA

FUNCTIONAL ELEMENTS / CONFIGURATIONS

SA11 — N/P silicon solar cells plus NiCad battery

SD11 — Small digital processor; Variable speed tape recorder

SG1 Midcourse — SG11 Modified Mariner DSIF

SG2 Approach — SG21 Approach TV/earth commands

SI11 — Instrument package

TECHNOLOGY DEFICIENCIES

		$	T
SA111	Specific power, solar cells	x	1 2 3
SA112	Specific cost, solar cells	x	1 2 3
SD111	Reliability, tape recorder	x	1 2 4
SD112	Weight, tape recorder	x	1 2 4
SD113	R&D req'd., tape recorder	x	1 2 4
SG111	Ephemeris, comet	x	1 1 1 9
SG211	R&D req'd., approach TV	x	1 2 3 2
SI111	Accuracy	x	1 1 1 1
SI112	Spaceborne packaging	x	1 1 1 1
SI113	R&D required, high resolution image	x	1 1 1 1
SI114	Reliability, instr. pkg	x	1 1 1 1

CONCEPT DESCRIPTION

CONCEPT OUT-OF-THE-ECLIPTIC PROBE

DESIGNATOR SF01

MISSION OBJECTIVES Measurement of solar and cosmic phenomena and particles outside the ecliptic plane. Included are examination of magnetic fields, density and distribution of charged particles of solar and galactic origin, concentration and energies of dust and micrometeorites, and properties of the solar wind.

GENERAL DESCRIPTION An unmanned mission similar to Advanced PIONEER, weighing about 600 pounds, and containing 200 pounds of instrumentations, is injected into an elliptical orbit with aphelion 1 AU, perihelion 0.4 AU and inclination to the ecliptic of 30°. The spacecraft is injected by a Saturn IB booster and high energy 40K/7K upper stages to achieve the necessary 21km/sec ΔV. A variable data rate for communications is required as the communication range may vary up to 2 AU. The mission duration is one to two years and the mission date about 1975.

LIST OF SYSTEMS

B *Booster
G Ground Support Facility
S *Spacecraft

* Detailed description follows.

REFERENCES

1. ARS Journal, July 1962, "Out of Ecliptic Trajectories", R. R. Burly

TRAJECTORY DESCRIPTION

SYSTEM DESCRIPTION

A Saturn IB type booster with 40K and 7K high energy upper stages to boost the spacecraft 30° out of the ecliptic and to a 0.4 AU perihelion.

DESIGNATOR SF01E SF01E

CONCEPT OUT-OF THE ECLIPTIC PROBE

SYSTEM Booster

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
BA Aux. Power		SOA		
BG Guid. / Nav.		SOA		
BP Propulsion (1 2 2 4)	Total Δ V = 21 Km/sec for 600 lb. payload into injection to 0.4 AU perihelion and 30° plane change.	BP11	Saturn IB with high energy (40K and 7K thrust) upper stages	BP111 R&D required on upper stage (1 2 2 4); BP112 Cryogenic storage (1 2 2); BP113 Corrosive fuel handling and storage (1 2 2); BP114 Restart reliability (1 2 2); BP115 Specific impulse (1 2 2 4)
BS Stab/Control		SOA		
BV Vehicle		SOA		

SYSTEM DESCRIPTION

A 600-lb. vehicle containing about 200 lbs. of PIONEER-type instruments. Orientation is maintained for thermal control, solar cell and antenna pointing.

DESIGNATOR SF01 S
CONCEPT OUT-OF-THE-ECLIPTIC PROBE
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S: x; T: 1 2 2 4)	Peak power: 250 W during data transmission to earth Continuous power: 25W during flight for 2 years	SA11	Solar cell array with AgCd batteries	SA111 High temperature operation (S: x; T: 1 2 2 2) SA112 Abrasion, solar cells (x; 1 1 2 5) SA113 Specific energy, AgCd batt. (x; 1 2 3)
SD Data Proc. (x; 1 2 4 2)	Input data rate: 200 bits/sec in flight Output communication rate: variable 100 bits/sec to 1000 bits/sec Temporary storage: 10^8 bits	SD11	Small digital data processor and variable speed tape recorder	SD111 High temperature operation (x; 1 2 2 2) SD112 Reliability, dig. processor (x; 1 2 4) SD113 Reliability, tape recorder (x; 1 2 4) SD114 Radiation alteration of memory (x; 1 2 2 3) SD115 Data compression (x; 1 2 4 5) SD116 R&D req'd., tape recorder (x; 1 2 4)
SI Task Instr. (x; 1 1 1 1 1)	Capable of carrying instruments in the following instrument groups: Interplanetary Radio propagation experiment	SI11	Instrument package	SI111 Accuracy (x; 1 1 1 1) SI112 Spaceborne packaging (x; 1 1 1 1) SI113 Reliability (x; 1 1 1 1)
SR Comm. (x; 1 2 3)	Transmission data rate: variable on command from 100 bits/sec to 1000 bits/sec. depending on range. Maximum range 2 AU	SR11	SHF transceiver with 4' dish antenna with programmed antenna pointing, adjustable on command	SR111 Reliability, communications equipment (x; 1 2 3) SR112 Antenna directivity (x; 1 1 2) SR113 Antenna pointing (x; 1 2 3)
SS Stab/Control	Attitude control: ± 5° during flight	SOA		
SV Vehicle	Advanced PIONEER-type	SOA		

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CONCEPT DESCRIPTION

CONCEPT INTERPLANETARY PHYSICS PROBE

DESIGNATOR SF03

MISSION OBJECTIVES Acquisition of environmental data (micrometeorites, radiation, ionized particles, magnetic field and its relation to solar particle flux) on interplanetary space, asteroid observation, investigation of the interaction between solar plasma and a weakly magnetized solid body, and observing cosmic rays at various solar altitudes. This concept is similar to and may be combined with the Asteroid Probe (CF01).

GENERAL DESCRIPTION An unmanned mission in a highly elliptic heliocentric orbit with aphelion at 3 AU (in the asteroid belt) and perihelion about 0.4 AU (near Mercury's orbit). It consists of a spacecraft similar to IMP but larger, allowing for a bigger solar power supply unit and redundant instrumentation and weighing 600 pounds including 200 pounds of experiments, exclusive of propulsion. The trajectory is a two-impulse transfer, first to the 3 AU aphelion, where a retro impulse causes the orbit to lower to the 0.4 AU perihelion. This represents an extension of IMP techniques to deeper space. Lifetime of the mission is about two years and the mission date lies in the 1972-1976 period.

LIST OF SYSTEMS

B Booster (Saturn IB/Centaur)
G Ground Support Facility
S *Spacecraft

*Detailed description follows.

REFERENCES

1. OSSA Interplanetary Explorers

SYSTEM DESCRIPTION

DESIGNATOR [illegible] SF03S -216-
CONCEPT INTERPLANETARY [illegible] PROBE
SYSTEM Spacecraft

A spacecraft similar to IMP plus propulsion totalling 5000 lb. gross, to probe interplanetary space from [illegible] (6.4 AU) to the asteroid belt (3 AU). Spacecraft is boosted to transfer to 3 AU aphelion (6 Km/sec) [illegible] Booster. Propulsion unit provides 3.7 Km/sec impulse at aphelion to yield a 0.4 AU perihelion, for the 600 lb. payload of the spacecraft. Capable of asteroid flyby.

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (S/T 1 2 3 x)	Peak power 200 W for 5 hours during flyby of asteroid Continuous power 25W during 4 year flight	SA11	Solar cell array with AgCd batteries	SA111 High temperature operation (S/T 1 2 2 x) SA112 Abrasion, solar cells (1 1 2 3 x) SA113 Specific power, AgCd (1 2 3 x)
SD Data Proc (1 2 3 2 x)	Input data rate 200 bits/sec in interplanetary flight, 10^5 bits/sec during asteroid flyby Output communication rate variable 100 - 1000 bits/sec Temporary storage: 10^8 bits.	SD11	Small digital data processor and variable speed tape recorder	SD111 High temperature operation (1 2 2 5 x) SD112 Reliability, dig. processor (1 2 4 x) SD113 Reliability, tape recorder (1 2 4 x) SD114 Radiation alteration of memory (1 2 2 3 x) SD115 Data compression (1 2 4 5 x) SD116 R&D req'd., tape recorder (1 2 4 x)
SG Guid/Nav. (1 2 4 x)	Approach position ± 100 km at target plane M/C: Velocity accuracy ± 0.5 m/sec Angle ± 3 degrees	SG11	Sun and star tracker for attitude reference, planet tracker for approach guidance relayed to DSIF for guidance command. DSIF for midcourse correction. Timed pulse for thrust.	SG111 Uncertainty in ephemeris, asteroids (1 1 1 7 x) SG112 Uncertainty in asteroid mass (1 1 1 7 x) SG113 Reliability, planet trackers (1 2 5 x)
SI Task Instr. (1 1 1 1 x)	Capable of carrying instruments in the following instrument groups: Interplanetary Planet Oriented Photo Mapping Surface Surveillance Radio Propagation Experiment	SI11	Instrument package	SI111 Accuracy (1 1 1 1 x) SI112 Spaceborne packaging (1 1 1 1 x) SI113 Reliability (1 1 1 1 x)
SP Propulsion (1 2 2 x)	Δ V = 3.7 Km/sec. for 600 lb. payload at 3 AU aphelion	SP11 SP12	Storable hypergolic liquid rocket Solid rocket	SP111 Long storage reliability (1 2 2 x) SP112 Specific impulse (1 2 2 x) SP121 Long storage reliability (2 2 3 x) SP122 Specific impulse (2 2 3 x)
SR Comm. (1 1 3 x)	Transmission data rate 15 bits/sec during cruise; 200 bits/sec following encounter for 30 days; maximum range 4 AU	SR11	SHF transceiver	SR111 Reliability, communications equipment (1 2 3 x) SR112 Antenna directivity (1 1 2 x)
SS Stab/Control (1 2 3 x)	Attitude control ± 5° continuous during flight Pointing accuracy ± 0.25°, 5 hours } during encounter Body rate .01°/sec for 5 hours	SS11	Cold gas jets and solar sails. Sun and star tracker attitude reference	SS111 Reliability, cold gas jets (1 2 3 x)
SV Vehicle	MARINER type	SOA		

CONCEPT DESCRIPTION

CONCEPT NEAR SOLAR PROBE

DESIGNATOR SO03

MISSION OBJECTIVES Performance of in situ measurements of the solar environment at distances of 0.1 AU from the sun. Typical measurements of interest include particles, magnetic fields, plasma cloud observations during solar flares, solar ULF, ultra-violet and x-ray radiation, and the solar "wind".

GENERAL DESCRIPTION An unmanned mission placing a 600 pound spacecraft at 0.1 AU from the sun. Approximately 50 to 100 lb. of instrumentations will be carried with the bulk of the spacecraft weight devoted to shielding and thermal control requirements. The propulsive requirements for this mission are massive with a characteristic velocity of 21.3 km/sec., for which Saturn IB with the 40K/7K high energy upper stages are required. The useful lifetime of the spacecraft is about six months and the mission date lies in the 1975-1980 period.

LIST OF SYSTEMS

B *Booster
G Ground Support Facility
S *Spacecraft

* Detailed description follows.

REFERENCES

1. OSSA Solar Probe
2. Space/Aeronautics, Jan. 1965, Nov. 1964
3. Honeywell CPE 3D-B-35, Sept. 1963, "Solar Probe Report"

SYSTEM DESCRIPTION

A Saturn IB type booster with 40K and 7K high energy upper stages to boost the spacecraft to a 0.1 AU perihelion solar orbit.

DESIGNATOR SO03B
CONCEPT NEAR SOLAR PROBE
SYSTEM Booster

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
BA Aux. Power	SOA			
BG Guid/Nav.	SOA			
BP Propulsion (1 2 2 4 x)	Total Δ V = 21 Km/sec for 600 lb. payload into injection to 0.1 AU perihelion	11	Saturn IB with high energy (40K and 7K thrust) upper stages	BF111 R&D required on upper stage (1 2 2 4 x); BP112 Cryogenic storage (1 2 2 x); BP113 Corrosive fuel handling and storage (1 2 2 x); BP114 Restart reliability (1 2 2 x); BP115 Specific impulse (1 2 2 4 x)
BS Stab/Control	SOA			
BV Vehicle	SOA			

S T

SYSTEM DESCRIPTION

A 600 lb. vehicle containing about 60 lbs. of Pioneer-type instrumentation. Orientation is maintained for thermal control, solar cell and antenna pointing. Designed to withstand solar thermal and particle radiation at 0.1 AU.

DESIGNATOR SO03 S
CONCEPT NEAR SOLAR PROBE
SYSTEM Spacecraft

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (1 2 3 x 3)	Peak power 200 W for 5 hours during flyby Continuous power 25W during 8 mos. transit.	SA11 Solar cells and solar thermoelectric	SA111 Junction radiation damage, TE (S T 1 2 3 x 10) SA112 High temperature materials, TE (1 2 3 x 10) SA113 Waste heat rejection, TE (1 2 x 4) SA114 Efficiency, TE (1 2 x 4) SA115 Radiation damage, semiconductors (solar cells) (1 2 x 3)	
SD Data Proc. (1 2 4 x 3)	Input data rate 10^5 bits/sec during solar flyby, 50 bits/sec during flight Output communication rate 200 bits/sec following encounter Temporary storage 10^8 bits	SD11 Small digital data processor and variable speed tape recorder	SD111 High temperature operation (1 2 2 x 2) SD112 Reliability, dig processor (1 2 x 4) SD113 Reliability, tape recorder (1 2 x 4) SD114 Radiation alteration of memory (1 2 2 x 3) SD115 Data compression (1 2 4 x 5) SD116 R&D req'd., tape recorder (1 2 x 4)	
SI Task Instr (1 1 1 x 1)	Capable of carrying instruments in the following instrument groups: Interplanetary Sun Oriented Radio propagation experiment Surface surveillance	SI11 Instrumentation	SI111 Thermal and radiation protection (1 1 1 x 1) SI112 Accuracy (1 1 1 x 1) SI113 Spaceborne packaging (1 1 1 x 1)	
SR Comm. (1 2 2 x 2)	Transmission data rate: 15 bits/sec during cruise, 200 bits/sec following encounter for 30 days, range 165 x 10^6 km maximum	SR11 SHF transceiver with 4' dish antenna with programmed antenna pointing, adjustable on command	SR111 Reliability, long life (1 2 3 x) SR112 Thermal and radiation protection (1 2 2 x 2) SR113 Antenna directivity (1 1 2 x)	
SV Vehicle (1 2 3 x 3)	Advanced PIONEER-type with thermal and radiation protection for 0.1 AU flyby	SV11 Pioneer type spacecraft [illegible] ports [illegible] surface & high temperature materials	SV111 High temperature materials (1 2 3 x 3)	

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CONCEPT DESCRIPTION

CONCEPT GALACTIC PROBE

DESIGNATOR UF01

MISSION OBJECTIVES Measurement of the solar system environment and investigation of the outer limits of the solar magnetosphere at distances from 5 to 25 AU fromthe sun. Observation of the outer planets, if possible, is also desired. Transit time to 5 AU is desired less than one year after earth launch.

GENERAL DESCRIPTION An unmanned mission, similar to Advanced PIONEER, carrying large antennas and weighing about 2000 pounds. Long range communication, thermal control, isotopic power supply, and electric propulsion are mission requirements. The spacecraft carries sensors for magnetic field, solar, and comet particle detection. The spacecraft is to be boosted to earth escape velocity by an Atlas/Centaur class booster, whereupon a low, continuous thrust ($\sim 10^{-3}$ g) electric engine will propel the spacecraft on its way. Data will be transmitted as long as possible, and the mission duration is several years. The mission date lies in the 1974-1977 period.

LIST OF SYSTEMS

B Booster (Atlas/Centaur)
G Ground Support Facility
S *Spacecraft

*Detailed description follows.

REFERENCES

1. OSSA Galactic Probe

SYSTEM DESCRIPTION

DESIGNATOR
CONCEPT
SYSTEM

SUBSYSTEMS	SUBSYSTEM REQUIREMENTS	FUNCTIONAL ELEMENTS	CONFIGURATIONS	TECHNOLOGY DEFICIENCIES
SA Aux. Power (1 2 3 6 x)	Peak power 1 KW for 15 min. per day for data transmission. Continuous power 1 KW during flight for [illegible] engine and enroute measurements (time share auxiliary [illegible] propulsion requirements and communications requirements)	SA11	[illegible]	SA [illegible]
				SA11 [illegible]
				SA11 [illegible]
				SA11 [illegible]
				SA11 [illegible]
				SA116 Isotope resources
SD Data Proc. (1 2 4 2 x)	Input data rate 200 bits/sec. during cruise. Output communication rate variable 10 bits/sec. to 1000 bits/sec. Temporary storage 10^7 bits	SD11	Small digital data processor and variable speed tape recorder	SD111 High [illegible]
				SD112 [illegible]
				SD113 Reliability, tape recorder
				SD114 Radiation alteration of memory
				SD115 Data compression
				SD116 R&D req'd., tape recorder
SI Task Instr (1 1 1 1 x)	Capable of carrying instruments in the following instrument groups: Interplanetary; Radio propagation experiment	SI11	Standard interplanetary instrument package	SI111 Reliability, instr. pkg
				SI112 Accuracy
				SI113 Spaceborne packaging
SP Propulsion (2 2 2 3 x)	10^{-3} g continuous thrust for 3 - 5 years	SP11	Electric propulsion	SP111 High voltage power source
				SP112 Charge neutralization
				SP113 Thrust/weight ratio
				SP114 R&D required, electric propulsion
SR Comm. (1 2 3 x)	Transmission data rate variable on command from 10 bits/sec. to 1000 bits/sec. depending on range. Maximum range 25 AU	SR11	SHF transceiver with 4' dish antenna with programmed antenna pointing, adjustable on command	SR111 Reliability, communications equipment
				SR112 Antenna directivity
				SR113 Antenna pointing
SS Stab/Control	Attitude control: ± 5° during flight	OA		
SV Vehicle	Advanced Pioneer type	SOA		