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Study of Mission Modes and System Analysis for Lunar Exploration

MIMOSA

FINAL REPORT

PLANNERS' HANDBOOK

MIMOSA Planning Methodology – Vol. I

Except Appendixes K and L

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MIMOSA Planning Methodology - Vol. I

Except Appendixes K and L

Prepared Under Contract NAS 8-20262
for
GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

LOCKHEED MISSILES & SPACE COMPANY
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FOREWORD

This document is Volume I of MIMOSA Planning Methodology, which constitutes part of the final report on the Study of Mission Modes and Systems Analysis for Lunar Exploration (MIMOSA). This study was conducted by the LMSC MIMOSA team for the George C. Marshall Space Flight Center under contract NAS 8-20262. The entire final report covers work performed from 3 January 1966 to 3 February 1967 and comprises the following parts:

- MIMOSA Summary Digest
- MIMOSA Summary Technical Report
- MIMOSA Technical Report:
  Volume I – Lunar Exploration Equipment and Mode Definition
  Volume II – Candidate Lunar Exploration Programs
  Volume III – Recommended Lunar Exploration Plan
- MIMOSA Planning Methodology:
  Volume I – Planners' Handbook
  Volume II – Exploration Equipment Data Book
  Volume III – Scientific Programs

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- Lockheed Missiles & Space Company. Prime Contractor
- AiResearch Manufacturing Company. Environmental Control and Life Support System
- Bell Aerosystems Company. Lunar Flying Vehicles
- Bendix Corporation, Aerospace Systems Division. Lunar Roving Vehicles Definition and Contributions to Scientific Program Formulation
- General Electric Company, Missile & Space Division. Electrical Power Systems

The technical management of the study was conducted by a government team composed of several organizations and their selected representatives. The Technical Supervisor and Contracting Officers' Representative for the National Aeronautics and Space Administration was David Paul 3rd of the Advanced Systems Office, Marshall Space Flight Center (MSFC). Contributing organizations and their representatives were as follows:

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Dr. Harold Masursky of the Astrogeology Branch, U.S. Geological Survey, was consulted regarding geological experimentation, and Dr. William G. Tifft, Steward Observatory, University of Arizona, was consulted regarding optical astronomy. In addition, Dr. Alfred H. Webber of St. Louis University provided general advice on scientitic experimentation.

The study also drew on certain previous and concurrent studies for information. The most significant of these were as follows:

- Scientific Mission Support for Extended Lunar Exploration. North American Aviation, Inc., Contract NAS 8-20258 (William McKaig, Study Leader)
- Lunar Surface Mobility Systems Comparison and Evolution Study (MOBEV). Bendix Corporation, Aerospace Systems Division, Contract NAS 8-20334 (Carmelo J. Moscolino, Study Leader)
- Early Lunar Shelter Design and Comparison Study. AiResearch Manufacturing Company, Contract NAS 8-20261 (William L. Burriss, Study Leader)

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INTRODUCTION

The objectives of the MIMOSA study were twofold – to produce a methodology for generating lunar exploration programs and to generate a recommended lunar exploration plan, using the developed methodology.

The MIMOSA study was divided into the following three phases:

- Phase I – compilation and generation of data for the later phases (these data are contained in the Exploration Equipment Data Book.)
- Phase II – development of the planning methodology that includes a computer program for the mechanization of data handling, generation of a broad spectrum of candidate programs, and comparative analysis to answer certain planning questions
- Phase III – formulation of a recommended plan of lunar exploration, generation of three selected lunar exploration programs for implementing the plan, and intensive design effort for the equipment used in these three programs

Generation of the recommended lunar exploration plan is described in the MIMOSA Technical Report. The methodology is presented in these volumes under MIMOSA Planning Methodology.

This volume contains instructions to the planner for operating the MIMOSA Planning Methodology; it covers (1) lunar program analysis approach, (2) planning question determination, (3) scientific program formulation, (4) exploration equipment and equipment evolution definition, (5) mission formulation, (6) mode formulation, (7) mission-mode comparison, (8) exploration program generation, (9) program data summary, and (10) MIMOSA computer program input instructions.

Chapter 1
LUNAR PROGRAM ANALYSIS APPROACH

As part of the MIMOSA study contract, Lockheed Missiles & Space Company developed a systematic procedure for analyzing alternate approaches to lunar exploration. This procedure provides a tool for program planners to answer questions concerning scientific requirements, equipment options, operational concepts, and resource restraints. This chapter outlines the significant steps of the procedure and describes the organization of the remainder of this handbook.

1.1 GENERAL PLANNING PROCEDURE

Figure 1-1 indicates the MIMOSA procedure for lunar program analysis. As the figure shows, the procedure consists of the following eight major steps:

- Determine planning questions. Before proceeding with a lunar program analysis, a planner must know his objectives. These objectives are expressed in the form of specific questions to which well-substantiated answers are sought. The answers are obtained from a study of the characteristics of one or more candidate lunar programs. The preciseness with which the questions can be asked will determine how quickly alternate programs with the desired characteristics can be formulated.
- Formulate scientific programs. The goals and requirements of the scientific community are expressed in the form of one or more scientific programs. A scientific program consists primarily of a list of experiments to be conducted at certain locations, at specific frequencies,and with certain priorities for performing those experiments.
- Define exploration equipment and its evolution with time. The exploration equipment to perform the lunar program must be identified (with the specific planning question in mind) and described. Exploration equipment includes transportation equipment (launch vehicles and spacecraft), mission equipment

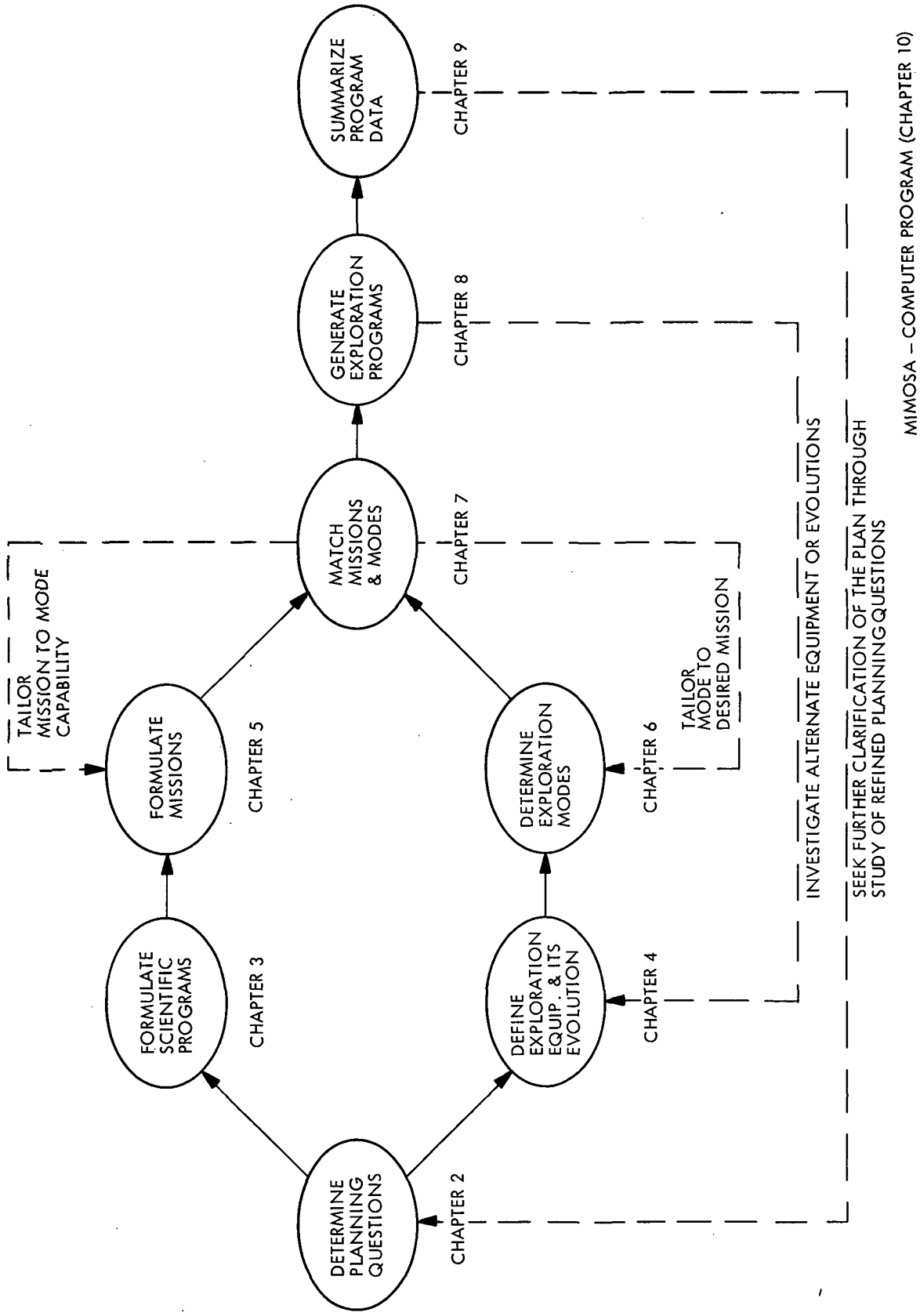


Fig. 1-1 General MIMOSA Approach to Lunar Program Analysis

(shelters, roving vehicles, flying vehicles, base support equipment, etc.), and major science equipment (telescopes, large drills, laboratories, etc.). The desired evolution from one equipment concept to another must exhibit a smooth development of capability. An evolution is established by considering the size and scope of the scientific program and by following certain planning assumptions (e.g., launch constraints, funding rates, timing of major events).

- Formulate missions. With the knowledge of the equipment evolution, planners can allocate the experiments in the scientific program into "missions" of generally increasing scope.
- Determine exploration modes. Planners can group the candidate equipment concepts that are to perform each mission into an exploration "mode." The equipment concepts in a mode must be compatible from both the design and operations points of view.
- Match missions and modes. Requirements of a mission are then compared with the mission-support capability of the mode. This mission-mode comparison can then be verified in detail by a specially developed computer program using the mission, mode, equipment, and experiment data stored in the computer memory. The computer points out any areas of incompatibility between mission requirements and mode capabilities calling for data revision. Additional iterations can be made depending on the accuracy of matching desired. It is this matching process that demonstrates the capability of an equipment evolution to perform a scientific program.
- Generate exploration programs. When all of the missions for a candidate exploration program have been matched satisfactorily with an exploration concept mode, the mission-mode combinations are scheduled and costed. The MIMOSA computer program again performs the tedious calculations. Each scheduled set of mission-mode combinations constitutes a lunar program. Any change in the combinations used, or in the schedule of the missions, results in another program.
- Summarize program data. Planners answer planning questions by studying the characteristics of alternate lunar programs that are generated. To do this, the large amount of detailed program data that such tools as the MIMOSA computer program provide must be summarized.

1.2 PLANNER'S HANDBOOK ORGANIZATION

The general MIMOSA approach forms the basis for organization of the subsequent sections of the Planner's Handbook. Figure 1-1 indicates this organization.

Chapters 2, 3, and 4 discuss the preliminary steps necessary for planning exploration programs. Chapter 2 provides guidance to planners for formulating questions and determining an approach for answering these questions. Chapter 3 deals with the formulation of scientific programs from an analysis of general scientific requirements. Chapter 4 discusses the definition of exploration equipment and equipment evolutions.

Chapters 5, 6, 7, and 8 present steps for formulating candidate exploration programs. Chapter 5 discusses mission generation. Chapter 6 describes the technique for mode formulation. The procedure for comparing mission requirements and mode capabilities using the MIMOSA computer program is presented in Chapter 7. Chapter 8 outlines the method for generating exploration programs from selected mission-mode combinations.

Chapter 9 suggests a format for summarizing the data generated in the formulation of a lunar program.

Finally, Chapter 10 presents a complete set of instructions for using the MIMOSA computer program.

Chapter 2
PLANNING-QUESTION DETERMINATION

Successful use of the MIMOSA lunar program analysis procedure depends on proper formulation of planning questions. The type of question and the conciseness with which it is phrased are both important. Some types of questions require more labor than others to achieve a useful answer, and a vaguely worded question often results in wasted effort.

Planning questions can be grouped into four categories depending on whether they are related to science, equipment, operations, or resource allocation. Each of the four categories is discussed briefly in this chapter.

2.1 SCIENCE QUESTIONS

Typical science questions involve the effects on program costs or equipment evolutions of any changes in size and scope of scientific effort. The level of scientific activity, the emphasis on particular science areas, and the degree of experiment mechanization are typical topics of interest.

To answer such questions, planners derive alternative scientific programs that exhibit variations of the characteristic under study. One or more equipment evolutions are then matched to the missions obtained from these alternative scientic programs. The resulting sets of mission-mode combinations are then costed as separate candidate lunar programs. The answer to the question comes from the study of these candidate lunar programs.

2.2 EQUIPMENT QUESTIONS

Typical equipment questions concern the effects of introducing alternative equipment concepts for lunar exploration. Topics of interest include comparison of equipment

performance and efficiency, the advantages and disadvantages of a particular concept, and the effect of delaying equipment development.

Equipment questions are usually answered by the generation of several candidate lunar programs. These programs are then compared for cost and scientific achievement. Chapter 8 discusses techniques for efficiently generating such programs.

2.3 OPERATIONAL QUESTIONS

Typical operational questions involve the advisability of performing various lunar operations or the evaluation of alternative operation procedures. Sample topics from which questions could be formulated include different traversing techniques (flying or roving, long traverses or short traverses, caching or resupply), alternative techniques for hardware and crew delivery, and possible methods to reduce nonscientific time. In each case, the answers are found by deriving a sufficient number of lunar programs to exhibit the characteristics and potentialities of the various proposed operations.

The present MIMOSA planning technique was not derived to evaluate alternative approaches to details in the plan of a particular mission. For example, a question as to whether a particular experiment should be performed on the second or third day of a specific mission is beyond the scope of the MIMOSA analysis procedure. Only the influence of operations on overall program parameters (such as cost, schedule, or total scientific achievement) can be evaluated.

2.4 RESOURCE-ALLOCATION QUESTION

The allocation of resources to a lunar program is of fundamental importance in program planning. Typical questions involve total funding limits, rate of hardware procurement, launch rates, and schedule changes.

For the most part, questions on resource restraint variations are handled by separate cost calculation runs using the MIMOSA computer program. As shown in Chapter 10 of this handbook, extensive variations in input cost and schedule data for the computer are possible.

Chapter 3
SCIENTIFIC-PROGRAM FORMULATION

A scientific program is an ordered set of experiments and loci of investigation that are selected to satisfy specific scientific goals. Planners may select an existing scientific program* or formulate one of their own. The only stipulation is that program requirements be specified in the standard MIMOSA format. To formulate a new program, planners may utilize the logic developed within the MIMOSA methodology; the following steps are required to formulate a program:

- Identify basic goals.
- Identify major science disciplines to pursue the basic goals.
- Construct a matrix of scientific investigations relevent to each basic goal and scientific discipline.
- Select scientific experiments appropriate to each investigation.
- Specify major scientific equipment.
- Delineate the lunar surface exploration pattern.
- Distribute experiments in accordance with the exploration pattern.
- Complete a scientific-program specification.

A brief discussion of each of the foregoing steps is presented in this chapter.

3.1 IDENTIFICATION OF SCIENTIFIC GOALS

The first step in formulating a scientific program is to identify the goals to be achieved. Planners may have their own specific objectives, or they may rely on the desires of the scientific community.

*Seven typical scientific programs representing widely different levels of scientific activity are provided as part of the MIMOSA tool. They are documented in MIMOSA Planning Methodology, Vol. III.

Basic goals for lunar exploration can be expressed in the form of a set of 15 questions promulgated by the Space Science Board of the National Academy of Sciences during their Summer 1965 Conference at Woods Hole, Massachusetts. These questions are confined to the Moon as an object of inquiry. In the MIMOSA contraced study, ten additional questions were formulated. These questions extend the scope of inquiry to include use of the Moon as a base for pursuit of extralunar goals such as planetary astronomy, stellar astronomy, and space physics. They are drawn primarily from the Space Science Board proceedings related to aspects of the national space program other than lunar exploration. Table 3-1 is a complete list of the 25 questions.

3.2 IDENTIFICATION OF MAJOR DISCIPLINES

The second step in formulating scientific programs is to identify the science disciplines involved in pursuit of the basic goals. Working groups at the NASA Conference on Lunar Exploration and Science at Falmouth, Massachusetts, following the 1965 Woods Hole Conference, established eight major scientific disciplines concerned with exploring the Moon. Later, two additional disciplines, providing for engineering assessment of the lunar environment and for exploitation of the Moon for purposes of applied science, were recognized. The ten suggested major disciplines are as follows:

- Lunar Atmosphere Studies
- Geodesy/Cartography
- Geology
- Geochemistry
- Geophysics
- Particles and Fields
- Bioscience
- Astronomy
- Mission Support
- Applied Science

Table 3-1

BASIC SCIENTIFIC QUESTIONS

Question No.*	Question
1	Is the internal structure of the Moon radially symmetrical like the Earth, and if so, is it differentiated? Specifically, does it have a core, and does it have a crust?
2	What is the geometric shape of the Moon? How does the shape depart from fluid equilibrium? Is there a fundamental difference in morphology and history between the sub-Earth and averted faces of the Moon?
3	What is the present internal energy regime of the Moon? Specifically, what is the present heat flow at the lunar surface, and what are the sources of this heat? Is the Moon seismically active, and is there active volcanism? Does the Moon have an internally produced magnetic field?
4	What is the average composition of the rocks at the surface of the Moon, and how does the composition vary from place to place? Are volcanic rocks present on the surface of the Moon?
5	What are the principal processes responsible for the present relief of the lunar surface?
6	What is the present tectonic pattern on the Moon and distribution of tectonic activity?
7	What are the dominant processes of erosion, transport, and deposition of material on the lunar surface?
8	What volatile substances are present on or near the surface of the Moon or in a transitory lunar atmosphere?
9	Is there evidence for organic or proto-organic materials on or near the lunar surface? Are living organisms present beneath the surface?
10	What is the age of the Moon? What is the range of the age of stratigraphic units on the lunar surface, and what is the age of the oldest exposed material? Is a primordial surface exposed?
11	What is the history of dynamical interaction between the Earth and the Moon?
12	What is the thermal history of the Moon? What has been the distribution of tectonic and possible volcanic activity in time?
13	What has been the flux of solid objects stricking the lunar surface in the past, and how has it varied with time?
14	What has been the flux of cosmic radiation and high-energy solar radiation over the history of the Moon?
15	What past magnetic fields may be recorded in the rocks at the Moon's surface?
16	What are the long-term effects of reduced gravity on various life forms, including man?
17	What lunar resources are available for exploitation?
18	What lunar environmental factors are most significant to the design of proposed lunar exploration equipment?
19	Are the basic postulates of general relativity valid?
20	What is the total inventory of stars and interstellar matter in a representative volume of our galaxy?
21	What processes account for the phenomena observed in the Sun, e.g., sunspots, flares, plages, faculae, and prominences?
22	What are the structures, composition, and energy regimes of planetary atmospheres other than that of Earth?
23	What are the structures and compositions of comets?
24	What are the precise locations of discrete x-ray sources, and what is the distribution of faint x-ray sources?
25	What is the distribution of very-long wavelength radio stars?

*Questions 1 to 15, inclusive, are taken directly from proceedings of the 1965 Woods Hole conference and are concerned with the Moon per se. The remaining questions were stated or implied at the Woods Hole and Falmouth Conferences and are motivated by the potentialities of the Moon as a base for pursuit of astronomical and other extralunar scientific goals.

3.3 SCIENTIFIC-INVESTIGATION MATRIX

The third step in formulating scientific programs is to derive a scientific investigation matrix of goals versus disciplines. The 25 questions (Table 3-1) and the 10 major disciplines represent the coordinates of such a two-dimensional matrix. Each combination of a basic scientific question with a major discipline represents an element of the matrix.

Within each matrix element, a group of investigations is then identified that is relevant to the basic question and the major discipline forming the element. The total array of investigations identified in all of the matrix elements is the scientific-investigation matrix. The scientific-investigation matrix provides a generalized outline of the contents of a broad spectrum of candidate scientific programs. Table 3-2 is an example of a portion of a scientific-investigation matrix. Not all of the major disciplines contribute to every basic question. For example, with reference to question 1, there are no entries in Table 3-2 under Lunar Atmosphere, Bioscience, Mission Support, or Applied Science.

3.4 SELECTION OF SCIENTIFIC EXPERIMENTS

The fourth step in scientific program formulation is to select one or more experiments to accomplish each investigation in the scientific-investigation matrix. For the purposes of the MIMOSA analysis procedure, the principal source of experiment definitions is the catalog of lunar scientific experiments compiled by North American Aviation, Inc.* The NAA catalog comprises about 350 distinct experiments classified in accordance with the 10 major scientific disciplines listed in paragraph 3.2. Classification of the experiments in this manner speeds selection of experiments appropriate to the investigations in the scientific-investigation matrix.

Experiment selection is not a completely automatic operation. Scientific-program planners must apply selective judgement in choosing the appropriate experiments

*North American Aviation, Inc., "Scientific Mission Support for Extended Lunar Exploration," NAA SID Report 66-957, NASA Contract NAS-8-20258 (in preparation).

Table 3-2

ELEMENTS OF AN INVESTIGATION MATRIX FOR A TYPICAL SPACE SCIENCE BOARD QUESTION

Discipline	Question 1 Is the internal structure of the Moon radially symmetrical like the Earth, and if so, is it differentiated? Does it have a core and a Crust?
Lunar Atmosphere	
Geodesy/ Cartography	(a) Establish a selenocentric coordinate system. (b) Establish a topographic map of the lunar surface. (c) Determine a reference figure. (d) Determine the gross elastic parameters of the Moon. (e) Determine the mass and moment of inertia. (f) Determine degree of isostatic compensation. (g) Determine symmetry of density distribution.
Geology	(a) Determine stratigraphic sequence of surface deposits and structure of exposed rocks. (b) Establish stratigraphic succession in lunar craters and rilles. (c) Determine petrologic variations in oldest rocks exposed on highlands and in maria basement rocks. (d) Determine composition of volcanic ejecta and plutonic xenoliths.
Geochemistry	(a) Determine the state of compositional, structural, and age differentiation of the lunar crust. (b) Evaluate with respect to genetic environment outcropping or shallowly buried xenoliths formed at depths beyond reach of the drill. (c) Determine and evaluate regional patterns of radiometric rock ages. (d) Obtain data on composition of exposed basement rocks.
Geophysics	(a) Determine the near surface structure (0-5 km) of selected geologic terrains by surface traverses. (b) Determine the structure of selected geologic terrain at intermediate depths (5-100 km). (c) Determine deep structure (100 km to the center of the Moon). (d) Determine the vertical deflection of gravity over the lunar surface. (e) Determine rock properties by in situ measurements in drill holes and from drill hole cores.
Particles and Fields	(a) Obtain structure and variations in lunar magnetic field and solar wind to determine whether the lunar magnetic field is intrinsic or due to solar wind accretion.
Bioscience	
Astronomy	(a) Determine lunar body motions with respect to inertial space.
Mission support	
Applied Science	

implied by their investigation matrix. For example, experiments concerning oceanology and meteorology appear in the NAA catalog. These experiments find no place in a matrix defined by the 25 Space Science Board questions. Moreover, a study of the NAA catalog reveals numerous redundant experiments. Hence, the quality of the experiment-selection process depends on the degree of understanding of the basic principles and objectives of the investigations to be performed. Table 3-3 presents examples of experiments pertinent to a few of the scientific-investigation matrix elements in Table 3-2.

3.5 SPECIFICATION OF MAJOR SCIENTIFIC EQUIPMENT

The next step is to identify those items of scientific equipment that are sufficiently large to require special launch packaging considerations. These items are called major scientific equipment. Table 3-4 lists the major scientific equipment presently contained in the MIMOSA Equipment Data Book. Each new item of major scientific equipment must be assigned a MIMOSA data sheet number and treated in the same manner as other exploration equipment.

3.6 LUNAR-SURFACE EXPLORATION PATTERNS

Objects of scientific interest are distributed widely over the lunar surface. There are two approaches to the exploration of this wide distribution on lunar surface. The locale approach is to visit isolated points on the lunar surface with limited (e.g., 10- to 200-km radius) surface-traverse capability in the neighborhood of each landing site. The path approach connects points of interest on the lunar surface by extensive (e.g., up to 1,500 km) paths along which exploration traverses are performed. Exploration patterns are a combination of these two approaches. Figure 3-1 shows a typical surface exploration pattern for a MIMOSA scientific program.

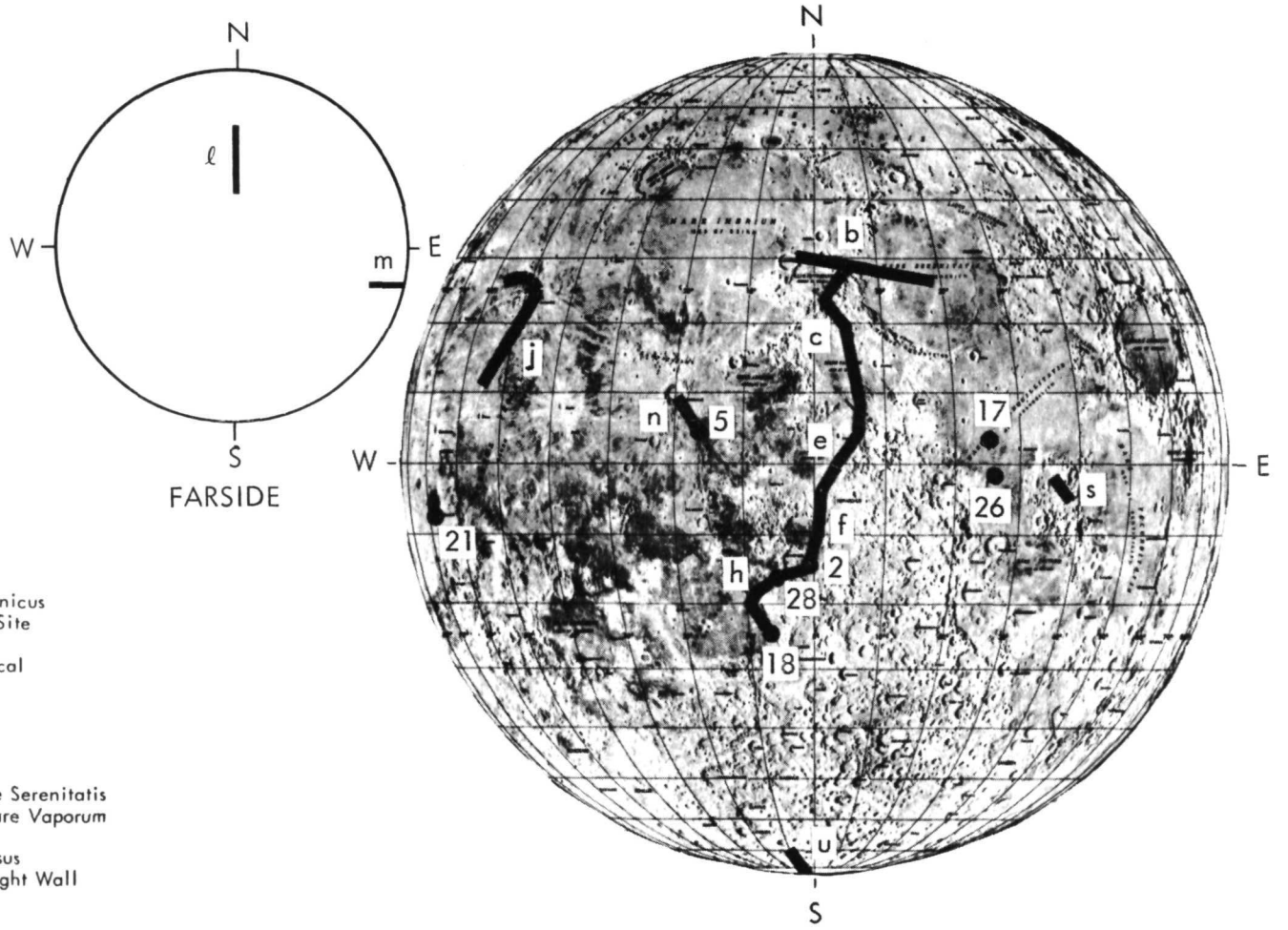
The pattern that best meets exploration requirements should be derived. Later mission-mode matching will result in some modifications to the pattern. Locations of scientific activity, path lengths, and experiments required at all specific locations are then specified.

Table 3-3

SELECTED EXPERIMENTS

Discipline	Question 1
	Is the internal structure of the Moon radically symmetrical like the Earth, and if so, is it differentiated? Does it have a core and a crust?
Geodesy/ Cartography	(a) Establish a selenodetic coordinate system: 12020606* – Selenodetic mapping with lunar orbiter 90050201 – Earth/Moon laser corner reflectors (b) Establish a topographic map of the lunar surface: 11010101 – Selenodetic astronomy on the lunar surface 12010202 – Selenodetic surveying on the lunar surface 40060565 – High-resolution radar 80120501 – Sterophotogrammetry (c) Determine a lunar reference figure etc.
Geology	(a) Determine the stratigraphic sequence of surface deposits: 21040101 – Geologic mapping with unmanned orbiters 21040102 – Photogeologic mapping with manned orbiters 21010203 – Fine structure mapping etc.

*Each experiment in the NAA catalog is identified by an eight-digit number.



Legend:

Locales

- 2 Alphonsus
- 5 Dark Halo Craters Southeast of Copernicus
- 17 Ranger VIII Landing Site
- 18 Straight Wall
- 21 Grimaldi, Astronomical Location
- 26 Moltke B
- 23 Mare Nubium

Paths

- b Mare Imbrium – Mare Serenitatis
- c Palus Putredinis – Mare Vaporum
- e Sinus Medii
- f Ptolemaeus – Alphonsus
- h Mare Nubium – Straight Wall
- j Marius Hills
- ℓ Central Farside
- m Mare Orientale
- n Copernicus
- s Capella M
- u South Pole

Fig. 3-1 Lunar Surface Exploration Pattern

Table 3-4

MAJOR SCIENTIFIC EQUIPMENT

Data Sheet No.	Equipment	Mass (kg)
3213-01	300-meter core drill	9,243
3242-02	1-meter optical telescope	1,300
3242-03	1.3-meter optical telescope	5,025
3242-04	2-meter optical telescope	13,950
3242-05	Solar Observatory	35,410
3243-01	Stellar observatory	23,750
3231-01	X-ray telescope	1,620
3224-01	Mills Cross radio telescope	12,528
3223-01	Radio telescope dishes	22,250
3132-02	Geochemical laboratory	1,130

3.7 DISTRIBUTION OF SCIENTIFIC EXPERIMENTS

The next step in scientific-program formulation is to distribute the scientific experiments making up the investigation matrix over the selected exploration pattern. To speed this effort and to greatly reduce the labor required later for mission definition, many of the scientific experiments can be assembled into groups called experiment packages. Each package is characterized by a commonality of experiment requirements.

The variety of possible experiment packages reflects the variety of situations that govern the distribution of experiments. Some experiment packages are designed for assignment to areas of suspected volcanic activity. Other packages may be composed of experiments requiring a standard number of repetitions along traverses. Still another package may comprise a group of experiments associated with logging a drill hole. There are a few experiments with chronological requirements, such as particle and field measurements to be correlated with the 11-yr cycle of solar activity. These may also be grouped into packages.

When the experiments and experiment packages with special requirements have been distributed to the appropriate locales and paths, there remains a number of experiments that can be performed with equal validity almost anywhere on the Moon. These experiments serve as "fillers" to round out the scope and the scientific "balance" of missions and to use mission support capability inherent in the selected equipment mode that might otherwise be wasted.

3.8 SCIENTIFIC PROGRAM SPECIFICATION

The final step is to prepare a scientific-program specification in standard MIMOSA format that comprises all of the material defining the scientific program in the form required by mission planners for mission-mode matching. The scientific-program specification consists of the following:

- One or more lunar maps representing the lunar-surface exploration pattern
- A list of locales and paths in the preferred order of accomplishment
- A list of required major scientific equipment
- A tabulation of experiments and experiment packages with instructions as to their distribution relative to the lunar-surface exploration pattern, and a specification of the required number of experiment replications in each instance of use
- Any explanatory notes concerning special requirements of experiments, such as deployment of explosives, use of photosurvey orbiters, and alternative distributions of experiments.

A typical page from a scientific-program specification is given in Table 3-5 as an illustration of the kind of material submitted by the scientific-program planner to the scientific-mission planner.

When one scientific program has been specified fully, other scientific programs can usually be generated merely by varying the magnitude of the following key factors:

- The number of lunar locales to be visited and the extent of surface paths to be traversed

Table 3-5

"FILLER" EXPERIMENTS FOR LOCALES*

Experiment ID No.	Name	Locales Required	Replic. per Locale	Approx. Manhours per Locale	Mass (kg)	Comments
68040102	Evidence of Existing Life	2	1	10.0	57	One locale of each type
80010302	Engineering Properties of Lunar Surface	5	1	21.0	2	
80010303	Engineering Properties of Lunar Subsurface	5	1	10.0	6	
80010305	Lunar Soil Shielding	5	1	23.0	10	
80010321	Electrical Parameters, Surface and Subsurface	2	1	24.0	35	One Type I and one Type II
80010322	Lunar Strata E-M Properties	3	1	15.0	3	
80020101	Surface Dust Environment	3	1	4.0	2	One Type I and one Type II
80020302	Lunar RF Noise	2	1	11.0	70	
80020501	Lunar Atmospheric Contamination – Rocket	2	1	1.0	5	First locale and before sixth locale
80110101	Gas Requirements for Drill	1	1	0.1	1	Before drilling
80110401	Geological Chemical Sampling	3	2	8.0	20	One setup
80120301	Explosive Energy Coupling	2	1	16.0	10	Before crust-upper mantle surveys
80130101	Biocontamination of Lunar Soil	2	1	2.0	15	
80300201	Genetic Effects – Animals	1	1	53.0	100	Mass override required
80320301	RF Ground-Wave Propagation	3	1	57.0	8	
80320401	RF Subsurface Propagation	2	1	45.0	10	
80340101	Dust Removal Technique	2	1	2.0	10	
80360201	Dangerous Terrain Warning	4	2	3.0	20	Two Type I and two Type II
80370102	Visual Techniques – Land Navigation	2	1	6.0	1	
90050201	Laser-Beam Corner Reflectors	3	1	0.5	30	Place at locales 18, 5, and 3
99999909	Early ESS	4	1	22.0	150	
99999917	Particle Experiment II	1	1	5.0	29	1971-73 or 1977-79
99999920	Particle Experiment V	1	1	5.0	134	1971-73 or 1977-79

*These experiments are to be done at the Program C locales as early as possible. They can be done at either type locale except as noted.

- The number and size of major scientific equipment
- The number of experiments to be performed for each investigation in the scientific-investigation matrix
- The number of replications of each experiment at each locale and along each path

Chapter 4
EXPLORATION EQUIPMENT AND EQUIPMENT-EVOLUTION DEFINITION

This chapter defines lunar exploration equipment, describes the equipment data required for MIMOSA exploration program analysis, and discusses how equipment concepts are linked together in an orderly evolution.

4.1 EQUIPMENT DESCRIPTION

Exploration equipment includes all major pieces of hardware used to conduct a lunar program. Major categories of exploration equipment are transportation systems (both launch vehicles and flight systems) and mission equipment (lunar orbiters, surface equipment, and scientific equipment).

Table 4-1 lists the various types of exploration equipment that are presently defined in the MIMOSA Exploration Equipment Data Book (MIMOSA Planning Methodology – Vol. II). Each type of equipment is subdivided into groups that embody those concepts with similar performance or design characteristics. The group identification number plays a key role in the MIMOSA computer program. Many of the group identification numbers trigger special computer calculation subroutines.

4.1.1 Transportation Systems

For purposes of MIMOSA, launch vehicles and spacecraft are called "flight systems." Generally, over one-half the equipment on any launch consists of flight systems. It has been found useful to consider all flight systems on a launch as a single entity. This entity is called a "transportation system."

Transportation systems play a vital role in the MIMOSA analysis. They are the means by which the individual launches of a mode can be identified and the performance capability of the launches can be described. As Table 4-1 indicates,

Table 4-1

EXPLORATION EQUIPMENT

Equipment Type	Data Book Group ID No.
Transportation Systems	
Personnel Transport	1111 to 1124
Logistic Transport	1132 to 1148
Orbiter Transport	1151 to 1152
Probe Transport	1161
Test Launch Transport	1171 to 1172
Launch Vehicles	1211 to 1271
Spacecraft	1311 to 1454
Mission Equipment	
Lunar Probes (Unmanned)	2111 to 2132
Lunar Orbiters	2211 to 2222
Personnel Shelters	2321 to 2327
Lunar Roving Vehicles (LRV)	2411 to 2423
Roving Vehicle Trailers	2431 to 2433
Lunar Flying Vehicles (LFV)	2512 to 2522
Lunar Surface Support	2711 to 2722
Major Scientific Equipment	3111 to 3243

the MIMOSA Data Book includes five types of transportation systems: personnel, logistics, orbiter, probe, and test.

4.1.2 Mission Equipment

The major items of mission support hardware used on or near the lunar surface are called "mission equipment." Mission equipment includes probes, orbiters, surface personnel shelters, roving vehicles (LRV), trailers for roving vehicles, flying-vehicles (LFV), resupply systems for expendables and for LFV propellant, fuel-regeneration systems, nuclear power supplies, and "major" scientific equipment. A piece of scientific equipment is called "major" if it exerts a pronounced influence on mission-support capability of a mode or if it requires peculiar packaging considerations.

Data on mission equipment are used directly by the MIMOSA computer program in comparing mode capabilities with mission requirements. As a result, there are special data input requirements for nearly every type of mission equipment. These are summarized in the following paragraphs.

4.2 COMPUTER INPUT PREPARATION FOR EXPLORATION EQUIPMENT

The detailed MIMOSA analysis, which utilizes a special computer program, requires specific information about each type of equipment. This information falls into the general categories of mission-support performance and resource planning (schedules and costs). All systems must have a suitable name and identification number for input to the computer. The remaining information for each type of equipment varies. This is because each type requires different parameters to describe its performance. Table 4-2 lists 33 items of required data. They are as follows:

4.2.1 Transportation Systems

(1) Payload delivery capability. Total delivered payload to the lunar surface (or orbit) in kilograms. This is not input directly to the computer, but is

Table 4-2

EXPLORATION EQUIPMENT COMPUTER INPUTS

System	Required Information	
	Performance	Resource Planning (All Systems)
Transportation System	(1) Payload delivery capability (kg) (2) Return to Earth payload (kg)	(26) Nonrecurring system cost ($M) (27) Nonrecurring facilities cost ($M) (28) Recurring hardware procurement cost ($M) (29) Recurring operations support cost ($M) (30) Procurement cost reduction with quantity (percent of first cost) (31) Research and development flight test schedule (6-mo increments) (32) Subsystem SOTA advances: – Nonrecurring costs ($M) – Required delivery date before system development (6-mo increments) (33) Spares procurement rate
All Mission Equipment	(3) Crew levels (No. of men) (4) Operations expendables (kg/day)[a] (5) Experiment power expendable rate (kg/kw-hr) (6) Spacesuit expendable rate (kg/mhr)[b] (7) Unusable expendables (kg)[a] (8) Activate and deactivate time – Shirtsleeve (mhr)[a] – Spacesuit (mhr)[a] (9) Non-scientific operations – Shirtsleeve (mhr/day)[a] – Spacesuit (mhr/day)[a]	
Shelter Only	(10) Maximum staytime (days)[a]	
LRV/Trailer Only	(11) Mobility expendable rate (kg/km)[a] (12) Expendables per stop (kg)[a] (13) Time per stop – Shirtsleeve (mhr)[a] – Spacesuit (mhr)[a] (14) Nom. single-excursion time (days)[a] (15) Nom. single-excursion range (km)[a] (16) Average speed (km/hr)[a] (17) Max. payload-carrying capability (kg)[a] (18) Driving in shirtsleeves or spacesuit[a]	
LFV Only	(19) Time and expendables per stop[a] (20) Max. excursion time (hrs)[a] (21) Range vs. number of stops (km) (22) Specific impulse (m/s) (23) Flying vehicle inert mass (kg)[a] (24) Flying in shirtsleeves or spacesuit[a]	
Major Scientific Equipment Only	(25) Identification of related experiment	

(a) At each crew level in item (3).
(b) In excess of shirtsleeve expendable usage.

used to calculate the maximum mass permitted for scientific equipment by a mode (paragraph 6.1).

(2) Return to Earth payload. Maximum payload, in excess of the flight crew, that can be returned to Earth. This is not input directly, but is used to calculate the total sample return capability of each mode (paragraph 6.1).

4.2.2 All Mission Equipment

(3) Crew levels. Various crew levels (i.e., number of men) for which the system is intended to be compatible. For LRV Trailers, the crew levels associated with the companion LRV are used.

(4) Operations expendables. Total expendables in kilograms/day used at each of the crew levels in foregoing item (3) to maintain and operate the system without driving or providing power for scientific experiments. It includes power supply expendables, life support and environmental control expendables, water, and atmospheric losses. All expendables are counted (whether dumped overboard or not) except those that are required for spacesuit operation.

(5) Experiment power expendable rate. Expendable rate, in kilogram/kilowatt-hour used to provide power for experiments supported by the system.

(6) Spacesuit expendable rate. Additional expendables in kilograms/manhour, required for spacesuit operations over and above the normal shirtsleeve requirements for oxygen usage rate, water for cooling, replacement batteries, and rate of usage of lithium hydroxide cartridges. If the normal operation of the system is in spacesuit, the total spacesuit expendable rate is used.

(7) Unusable expendables. Total expendables in kilograms that are supplied with the system but are not available for use. Included are boiloff (both before and during the mission), ullage, refueling losses, and reserves.

(8) Activate and deactivate time. Total manhours for both activation and deactivation of the system for each crew level in foregoing item (3).

The manhours for both spacesuit and shirtsleeve operations are specified. Deployment times, which cover offloading and preliminary work before the system is ready for setting up and activation, are not included. Deployment times are specified at the mode level (see paragraph 6.1).

(9) Nonscientific operations. Total manhours per day for system maintenance, repairs, stationkeeping, airlock operations, and time required by the crew for resting, eating, and personal hygiene. The time is specified for both spacesuit and shirtsleeve requirements.

4.2.3 Shelter Only

(10) Maximum staytime. Maximum number of days that a shelter can support each crew level specified in item (3) while depleting its load of expendables as described in items (4), (5), (6), and (7).

4.2.4 LRV/Trailer Only

(11) Mobility expendable rate. Expendables in kilograms/kilometer that are required to power the mobility subsystem of an LRV or LRV plus trailer. Expendables for startup or for powering other subsystems, such as environmental control or astrionics, are not included. These expendables are included in item (4).

(12) Expendables per stop. Total expendables in kilograms/cycle that are used by a roving vehicle for activation and deactivation at each local stop. Expendables for the crew, and for normal operations occurring during this period, are not included. These are covered by item (4).

(13) Time per stop. Spacesuit and shirtsleeve manhours required for the activation and deactivation of a roving vehicle at each local stop for the crew levels given in item (3).

(14) Nominal single-excursion time. Nominal time, in days, that a roving vehicle with a given load of expendables on board can support for each crew level specified in item (3).

(15) Nominal single-excursion range. Nominal range in kilometers that a roving vehicle, with a rated load of expendables on board, can travel (one way) at its most efficient expendables consumption rate. Separate values must be given for each crew level specified in item (3). Normally, the nominal range is given in conjunction with nominal excursion time.

(16) Average speed. Average roving vehicle speed in kilometers/hour. The input value is used by the computer to determine driving time.

(17) Maximum payload-carrying ability. Total cargo and minor scientific equipment in kilograms that can be carried by the vehicle. The crew and its equipment are not included.

(18) Driving in shirtsleeve or spacesuit. Specification as to whether normal operations during travel on the vehicle require spacesuit or not.

4.2.5 LFV Only

(19) Time and expendables per stop. Same as items (12) and (13) as applied to flying vehicles.

(20) Maximum single excursion time. Duration in hours that a given crew level can operate a flying vehicle without expendables resupply from another system. The expendables do not include propellant.

(21) Range vs. number of stops. Tradeoff of kilometer range vs. number of stops (i.e., landings and takeoffs) for a single traverse by LFV.

(22) Specific impulse. LFV propellant capability in terms of specific impulse in meters/second.

(23) Flying vehicle inert mass. Mass of an LFV concept in kilograms derived from the sum of the total nonexpendables in the concept design plus the unusable LFV propellant. This does not include the crew members, their spacesuits and backpacks, usable LFV propellant, and all other expendables.

(24) Flying in shirtsleeves or spacesuit. Specification as to whether all operations on the LFV require spacesuits or not.

4.2.6 Major Scientific Equipment Only

(25) Identification of related experiment. List of all the experiments that are performed either partly or wholly by a given item of major scientific equipment. Eight-digit North American Aviation study experiment identifiers* are used.

4.2.7 All Systems

(26) Nonrecurring system cost. Nonrecurring funding in millions of dollars versus 6-mo intervals required for system R&D. The delivery date of the first flight-qualified system to the payload integrator is considered as the end of the R&D phase.

(27) Nonrecurring facilities cost. Nonrecurring funding in millions of dollars versus 6-mo intervals for facilities construction during the system R&D phase.

(28) Recurring hardware procurement cost. Required funding in millions of dollars versus 6-mo intervals for recurring hardware procurement costs of the first production unit. The required time interval runs from manufacturing go-ahead to delivery of the first unit to a payload integrator.

(29) Recurring operations support cost. Required funding in millions of dollars versus 6-mo intervals for recurring operations support of the first production unit. Each 6-mo interval is measured from the delivery date of the first unit to a payload integrator.

(30) Procurement cost reduction with quantity. Factors for determining system cost reduction associated with the "learning curve." The curve is generated by grouping the expected total number of articles to be procured into no more than ten groups and assigning to each group a decreasing percentage of first-article cost.

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*North American Aviation, Inc., "Scientific Mission Support for Extended Lunar Exploration," NAA SID Report 66-957, NASA Contract NAS-8-20258 (in preparation)

(31) Research and development flight test schedule. The number of R&D test flights versus 6-mo intervals measured from the delivery data of the first flight-qualified system to the payload integrator. The launch vehicle used for each test flight is also identified.

(32) Subsystem state-of-the-art (SOTA) advances. Subsystem nonrecurring R&D costs, as well as cost of subsystem facilities, by 6-mo time intervals from start of funding to delivery date of the first flight-qualified subsystem to the system integrator. These costs are figures exactly as in items (26) and (27) except at a subsystem level.

(33) Spares procurement rate. Rate at which costs for equipment spares or backups are accumulated expressed as the number of mission articles procured before a backup is procured. One backup is automatically costed when an equipment item is used the first time.

4.3 EQUIPMENT-EVOLUTION REQUIREMENTS

Equipment evolution, as defined in the MIMOSA study, means growth of mission-support capability from some low-performance capability level (such as Apollo) to some higher level (such as 6- to 12-man permanent bases). An equipment evolution should meet six requirements other than growth from small to large performance. These are as follows:

- Endpoint Capability. An equipment evolution must have some final attainment. This point is usually the first selected feature of an equipment evolution. It is expressed in terms of some level of transportation system uprating or some level of crew support. Having decided upon an endpoint capability, it is then possible to analyze alternate paths to that capability.
- Compatibility. At any point in equipment evolution, systems should be compatible with regard to crew support level, staytime, landed mass capability, sample return capability, dormant lunar storage time, and Earth support requirement. It makes little sense, for example, to transport low-performance surface mission equipment with high-performance transportation equipment.

- Irreversibility. An equipment evolution should not regress. Once a level of attainment is achieved, it must not be discarded to make room for less capable systems. To do so would raise doubts as to the necessity of the higher capability systems.
- Maximum Usage of Developed Systems. All systems in an equipment evolution should have maximum utility and growth potential.
- Flexibility. An equipment evolution, which does not take into account the possible effects of feedback from early missions or changes in national goals is extremely vulnerable. Each step in the evolution must not preclude changes in scope and level of effort or the exploitation of possible state-of-the-art advances.
- Integration With Existing Plans. Equipment evolutions should evolve smoothly from current planning. Evolutions formulated on an abrupt change of existing plans or operations may not be accepted readily.

4.4 SAMPLE EQUIPMENT EVOLUTIONS

Figure 4-1 shows sample equipment evolutions. It illustrates four different ways to evolve from Apollo to a large mission support endpoint capability. It steps first from Apollo to S/AA. The S/AA involves two-man, 2-wk missions with limited mobility and no Saturn V uprating. The second step is to a modest (approximately 125%) uprating of Saturn V to the level where three-man crews can be delivered and supported on the lunar surface for up to 180 days. The third step (the endpoint capability) involves substantial uprating of Saturn V to deliver and return six men with direct launches and to support those men for periods up to 2 yr.

Equipment Evolution 2 goes directly to the endpoint capability from S/AA. Evolution 3 bypasses both intermediate steps of Evolution 1 and jumps directly from Apollo to the endpoint capability. Evolution 4 bypasses the first step of Evolution 1 and goes directly from Apollo to the 125% Saturn V.

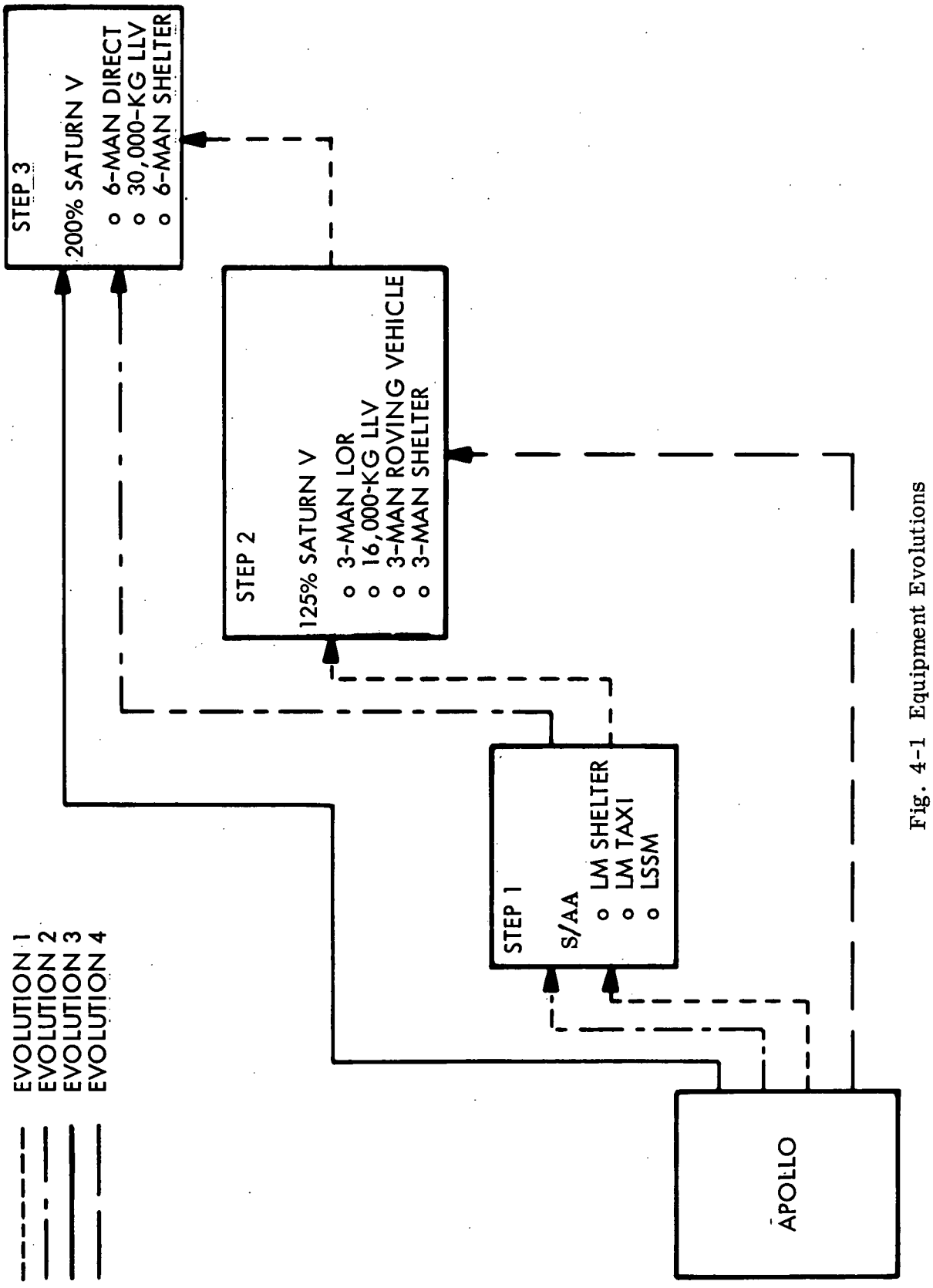

Fig. 4-1 Equipment Evolutions

Chapter 5
MISSION FORMULATION

A mission is defined as a set of experiments performed at a definable location on or about the Moon and accomplished in a finite length of time. A mission constitutes a portion of a total scientific program. The mission may require manned effort on the lunar surface or in lunar orbit, or it may require no manned effort at all; all activity may be clustered at one point, or it may be spread over extensive traverses. This chapter presents the process of mission sizing and traverse formulation, describes a sample mission, and discusses the computer input for missions.

5.1 MISSION SIZING

The crux of mission planning is sizing the mission. Some missions are immediately delineated by virtue of their isolated location. Others are defined uniquely because of some specific required activity such as optical or radio astronomy. Whatever its major characteristics, a mission must eventually be accomplished by some grouping of mission equipment. Mission planners must have intimate knowledge of the mission equipment, and must make educated guesses as to how much scientific mass and manhours can be assigned to any specific step in equipment evolution in a given location at a given time.

To size missions, the following instructions should be observed. The entire scientific program is laid out (preferably on a map) to show exactly where each experiment is to be performed and how much scientific equipment mass is associated with each experiment. This layout is scanned to find for likely personnel and logistics landing sites. The most obvious sites are points where experiments are concentrated or where large individual mass or labor is required. These sites are then used as "centroids" of experiment arrays. The mass and manhours of experiments are summed within the

arrays and are compared with the capabilities of the mission equipment in the desired equipment evolution. If a vast disparity exists (i.e., a large overrun or underrun in one or more parameters) the number of mission experiments are trimmed or added to, whichever is appropriate. Numerous trades can be made at this point since many experiments can be performed at several sites and may be moved from one mission to another. "Filler" experiments (paragraph 3.7) can be added or removed.

5.2 TRAVERSE FORMULATION

A traverse is a scientific excursion on or over the lunar surface for the purpose of obtaining measurements, observing scientific phenomena, or accomplishing other mission-related activities. The traversing equipment has a scientific-manhour capability as well as a cargo-carrying capability. These parameters, combined with the excursion length, generally govern the number and types of traverses.

For traverse formulation, a vehicle must be identified. To define the traverse, the scientific map of the mission must be examined. Starting at the most distant experiment location on one side of the personnel landing site for the mission and working toward the landing site, the minor scientific mass of all the experiments must be summed. This process stops when the sum reaches 80 percent of the cargo-caryying capability of the traversing vehicle or when the landing site is reached. This defines a tentative traverse. If the sum of cargo-mass requirement reaches the vehicle limit before the landing site or a significant supply point is reached, then the remaining experiments should be performed on another traverse. If the sum of the cargo-mass requirement does not achieve the vehicle limit before the landing site or supply point is reached, then the possibility arises for enlarging the scope of the traverse by incorporating other traverse of the mission.

The range of a traverse is the distance traveled from a starting point (usually the landing site or supply point) to an ending point, (usually the same landing site or another supply point). With this range determined, the traverse staytime may be estimated from the range-staytime tradeoff curves found in the MIMOSA Equipment Data Book

for the traversing vehicle. This staytime must be multiplied by the vehicle crew level to obtain the gross manhour availability of the equipment. Then this availability is multiplied by some factor (20 percent has proved useful with the current estimates of man's capabilities in a spacesuit and reflects a realistic estimate of nonscientific time see Table 7-1 in Chapter 7) to estimate the scientific manhour capability of the traversing vehicle. The scientific manhour capability is then compared with the sum of the experiment scientific manhours. If the scientific manhour requirement is less than the vehicle capability, then the tentative traverse may be submitted to the computer. If the scientific manhour requirement exceeds the vehicle capability, then the list of experiments must be adjusted either by cutting the number of experiments or by cuting replications of experiments.

5.3 SAMPLE MISSION

Figure 5-1 shows a typical mission used during the MIMOSA study.* It is mission 28 of 32 required to accomplish a large scientific program. This scientific program requires traversing 20 paths on the Moon. The path shown in the inset of Fig. 5-1 involves explosives emplacement, hole drilling, general surveying, and mapping.

Actually, each particular branch of this path could have been a mission. For the branch labeled traverse R-01, the total scientific manhours required by the experiments is 601 (394 +207), and the total minor scientific equipment mass is 13,265 kg. During the early 1980's, the allowable step in the equipment evolution being analyzed has a capability of about 1,600 scientific manhours per mission and 46,650-kg reserves for minor scientific equipment. Thus, incorporation of more branches (traverse R-02 and traverse R-03) produces a better balance between mission requirements and equipment capability.

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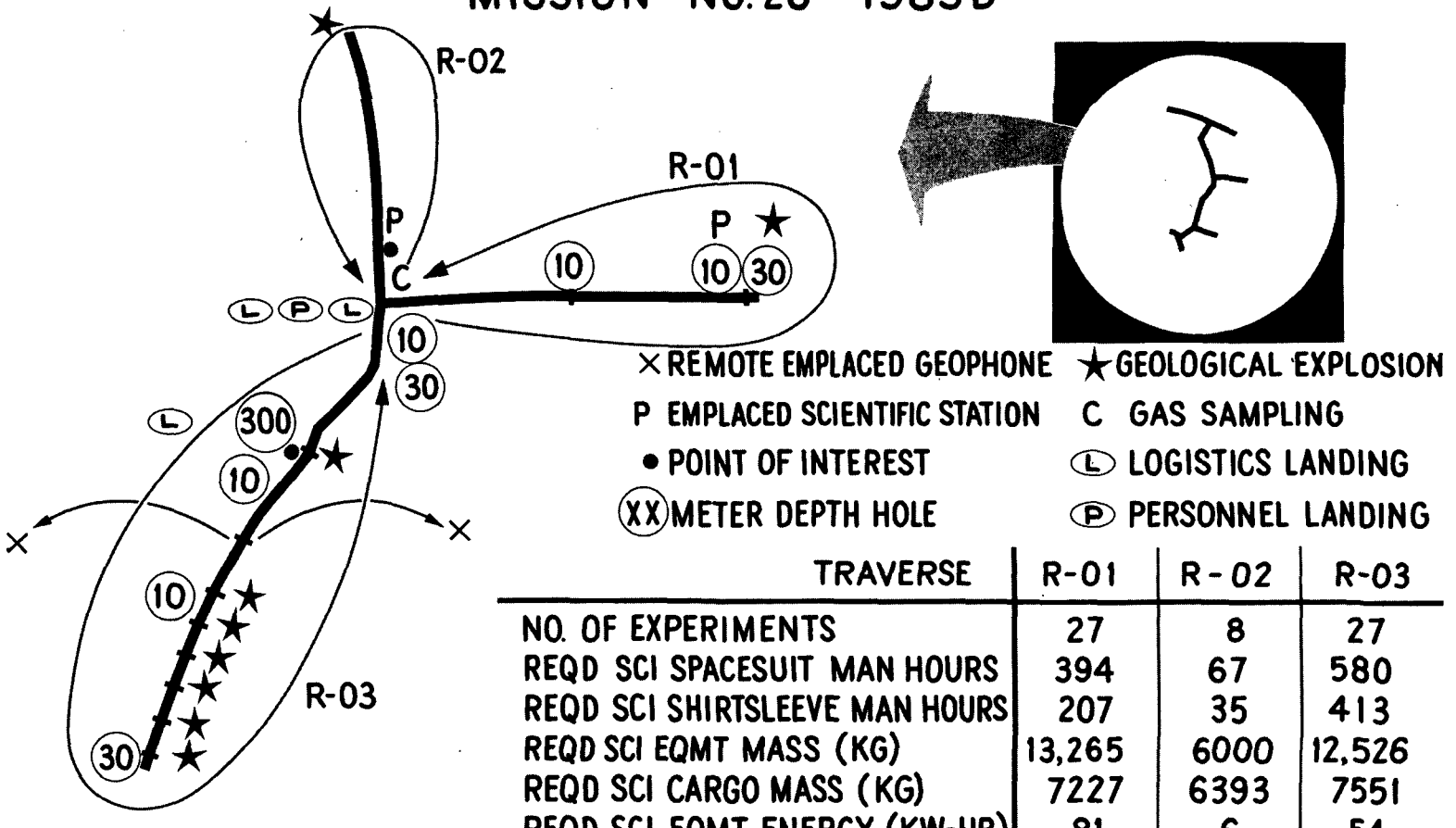
*Apart from the number of experiments to be performed, the mission data given in tabular form on the figure are derived from the computer output. The degree of accuracy indicated is not required for the initial planning exercise.



TRAVERSE	R-01	R-02	R-03
NO. OF EXPERIMENTS	27	8	27
REQD SCI SPACESUIT MAN HOURS	394	67	580
REQD SCI SHIRTSLEEVE MAN HOURS	207	35	413
REQD SCI EQMT MASS (KG)	13,265	6000	12,526
REQD SCI CARGO MASS (KG)	7227	6393	7551
REQD SCI EQMT ENERGY (KW-HR)	81	6	54
TRAVERSE LENGTH (KM)	900	350	1150

Fig. 5-1 Example Mission

The vehicle expected to perform the traverses in the sample mission could carry an estimated 7,660 kg of cargo. If that value had been exceeded on any of the traverses, then some traverse rearrangement would be needed. If, for example, the cargo for traverse R-03 had been greater than 7,660 kg, perhaps a traverse could be added (R-04) that would go from the central point down to the 300-m drill site and back. Traverse R-03 cargo could then be reduced by whatever cargo was carried on R-04.

5.4 COMPUTER INPUT PREPARATION

After a mission has been defined to the planners' satisfaction, its pertinent characteristics data are input to the computer. Paragraph 10.5.1 of this handbook presents the detailed instruction for the following inputs.

Whether the mission is to be matched to a mode or not, all experiment and equipment data should be input to the computer for cost purposes. For example, two flying vehicles were used to implant remote geophones in traverse R-03 of the example mission. The capability of the unmanned flying vehicle was completely defined by the MIMOSA Data Book. In simple cases like these, there is no need for computer verification. In this mission, the probe experiments were grouped with R-03, and the flying vehicles were added to the cargo of the roving vehicle.

Data on a mission are input to the computer by preparing four types of cards. The first card type (No. 3-01) assigns a unique number to the mission and names the physical location on or about the Moon where the mission is to be performed. It is assigns a nominal mission start date and establishes any minimum time intervale that must elapse between that start date and the end of any earlier mission.

The second type of card (3-02) identifies each base experiment to be performed on the mission. Each card of this type specifies the number of times an experiment must be setup (Phase 1), operated (Phase 2), analyzed (Phase 3), and taken down (Phase 4). Input by experiment phase accommodates the many alternate ways in which different experiments can be performed. If the experiment uses major scientific equipment or

shares equipment with other experiments on the mission, or if there is a desire to modify the given minor scientific experiment mass, then an opportunity is provided on this same card to override the experiment mass value used to calculate the launch mass for the mission. In a like fashion, the nonrecurring and recurring costs of the experiment may be overridden with new numbers if different scientific equipment is being used or if there is conflict with the experiment input cost data.

The next card type (3-03) identifies each traverse, the traverse range, the number of major stops and, if a flying traverse, the total velocity increment expended. Mission planners establish each of these items. They may wish to increase the straight line range by a suitable percentage (e.g. 10 percent) to account for any rough terrain. They determine the total velocity increment for a flying traverse by summing the range requirements for each separate flight of the traverse and obtaining the resulting velocity increment from the flying vehicle MIMOSA data sheet.

The last card type (3-04) identifies each experiment performed on a traverse. Replications of the experiment are given in the same manner (i.e., four phases: setup, operate, analysis, and take down) as with the 3-02 card. This card just as with the 3-02 card, provides an opportunity to override launch mass, nonrecurring cost, and recurring cost of the experiment. In addition, the value used by the computer to calculate the traversing vehicle cargo mass requirement can be overridden. The provision is used frequently as a means of achieving a realistic cargo total. Often it takes two or more traverses to transport the mass for one experiment to some specific location. This subdivision of cargo mass can be input to the computer by showing cargo overrides for that experiment on all the subject traverses. The cargo override can be used to account for the mass of a surface-to-surface probe that is used to emplace an experiment at a remote location. If an experiment is performed while on a traverse but the experiment mass is not actually delivered by the traversing vehicle, then the cargo mass for the experiment can be overridden to zero.

The computer takes all of this input data, stores it, and prints out what it has stored. Figure 5-2 shows two of 14 printed pages for the example mission 28. The figure

```
                                MISSION A7  0128

MISSION IDENTIFIER                          A7  0128PATH   I3,5,4,5    1
NOMINAL START DATE                          1978A
RELATED MISSION NUMBER                      27
MIN. NO. 6 MO. PERIODS BETWEEN THE MISSIONS 0.
```

Fig. 5-2 Example Computer Printout – Missions

MISSION A7 0128

TRAVERSE IDENTIFIER	R-01
TRAVERSE RANGE (KM)	900.00
NUMBER OF STOPS	10.00
LFV VELOCITY INCREMENT (METERS/SEC)	-.00

EXPERIMENT IDENTIFIER 9.9.99.99.12	PHASE	1	2	3	4
	CODE	A	A	A	A
	FREQUENCY	1.00	3.00	3.00	1.00
		PAYLOAD MASS (KG)	NON-REC COST (MILLIONS)	REC COST (MILLIONS)	CARGO MASS (KG)
	CODE				B
	OVERRIDE	-.00	-.00	-.00	.00
EXPERIMENT IDENTIFIER 9.0.05.02.01	PHASE	1	2	3	4
	CODE	A	A	A	A
	FREQUENCY	1.00	1.00	1.00	1.00
		PAYLOAD MASS (KG)	NON-REC COST (MILLIONS)	REC COST (MILLIONS)	CARGO MASS (KG)
	CODE				
	OVERRIDE	-.00	-.00	-.00	-.00
EXPERIMENT IDENTIFIER 9.9.99.99.36	PHASE	1	2	3	4
	CODE	A	A	A	A
	FREQUENCY	1.00	1.00	1.00	1.00
		PAYLOAD MASS (KG)	NON-REC COST (MILLIONS)	REC COST (MILLIONS)	CARGO MASS (KG)
	CODE				B
	OVERRIDE	-.00	-.00	-.00	.00
EXPERIMENT IDENTIFIER 2.1.01.04.12	PHASE	1	2	3	4
	CODE	A	A	A	A
	FREQUENCY	1.00	1.00	1.00	1.00
		PAYLOAD MASS (KG)	NON-REC COST (MILLIONS)	REC COST (MILLIONS)	CARGO MASS (KG)
	CODE				B
	OVERRIDE	-.00	-.00	-.00	.00
EXPERIMENT IDENTIFIER 2.1.02.03.07	PHASE	1	2	3	4
	CODE	A	A	A	A
	FREQUENCY	1.00	1.00	1.00	1.00
		PAYLOAD MASS (KG)	NON-REC COST (MILLIONS)	REC COST (MILLIONS)	CARGO MASS (KG)
	CODE	B	B	B	B
	OVERRIDE	.00	.00	.00	.00

Fig. 5-2 (Cont.)

shows the first page of printout for the mission plus one of five pages of printout on traverse R-01. The first page is nearly blank because base experiments, which would be printed here, are not required on this mission.

Chapter 6
MODE FORMULATION

A mode is a physically compatible group of equipment and associated operations that can perform a mission. The concept of a mode permits identification of a complex set of equipment and operations with one identification number; this is useful for computer manipulation. The description of a mode takes into account those special operations and costs that cannot be accounted for by individual equipment items alone. The principal drawback to the mode concept is that, if two modes are identical except for one item of data, they still must be given different mode numbers and be treated as completely different entities.

This chapter describes the requirements for mode formulation, presents a sample mode, lists the required computer input for modes, and discusses the application of several types of special modes. These special types are "working" modes, "zero launch" modes, and "emergency" modes.

6.1 MODE REQUIREMENTS

A mode provides mission-support capability through (1) appropriate mission equipment, (2) sample return capability, (3) manhours for scientific operations, and (4) mass margin. Mass margin is the difference between mass delivery capability of the transportation system and mass of the mission equipment (which includes major science equipment) making up the mode.

To formulate a mode, the following steps are necessary:

(1) Assemble the transportation equipment, mission-support equipment (such as shelters and rovers), and major items of scientific equipment (such as laboratories and telescopes) that are required to perform a mission (leaving it up to the computer to provide verification of performance).

(2) Identify the launch that will carry each piece of equipment.

(3) Ensure that each launch is feasible (i.e., that mass delivery capability, payload envelope, or earth-support capability limits are not exceeded).

(4) Calculate the mass margin and Earth-return mass capability of the mode. This is done by summing the mass margins and mass return capabilities of each launch in the mode.

(5) Identify the mass and manhours for all special operations associated with the mode. These operations include deployment, refueling, resupply, and crew-rotation time (including on site training and orientation).

(6) Identify mode-level nonrecurring and recurring costs for payload integration, mission control, tracking, data acquisition, and data analysis. (In the MIMOSA contract study, launch and crew recovery costs were assigned to the individual transportation systems and were not considered at the mode level.)

6.2 SAMPLE MODE

Figure 6-1 shows a typical MIMOSA mode data sheet. The mode shown (503-30114-01) was matched against the sample mission displayed in Fig. 5-1. There are four launches in the mode, three that carry mission equipment and one that delivers three personnel to the lunar surface. Each launch has been loaded with specific systems and with sufficient structure to support those systems during flight and to assist in their deployment at the landing site. All launches show a mass margin available for minor scientific equipment and mission-extension expendables.

6.3 COMPUTER INPUT PREPARATION

A mode is input to the computer by extracting certain information from the mode data sheet and other information from program ground rules, and then preparing nine types of data cards. Table 6-1 itemizes each input and shows where it is obtained. Paragraph 10.5.2 of this handbook presents the detailed instructions for filling out each type of card.

MIMOSA DATA SHEET	No. 503-30114	-01	Page 1 of 1
MOBILE BASE - THREE MAN			Date Jan 67 / Rev.

GENERAL:

Personnel Delivery Concept	Direct
Logistics Delivery Concept	Direct
Surface Crew Level	3
Total Crew Level	3
Maximum Staytime (Days)	90
Sample Return Capability (Kg)	50
Concurrent Shelters (Yes or No)	No
Number of Payload Launches	4

OPERATIONS:

Time for Base Deployment (Days)	6
Shirtsleeve Manhours for Special Ops.	2
Spacesuit Manhours for Special Ops.	3

PAYLOAD LAUNCH IDENTIFICATION: Mass Margin for Launch

#1	14,588	#5	
#2	16,132	#6	
#3	15,520	#7	
#4	1,400	#8	

SYSTEMS DESCRIPTION:

Launch #	System	Data Book #	Men Supported	Delivery Prior To Launch (6 Mos.)	Expendables For Special Ops. (Kg)
1	Transport	1147-01	-	-	-
	300-m drill	3213-02	0	2	0
	Probe	2132-02	0	2	0
	Probe	2132-02	0	2	0
2	Transport	1147-01	-	-	-
	Trailer	2433-04	3	2	0
	LFV	2521-02	3	2	0
3	Transport	1147-01	-	-	-
	LRV	2423-01	3	2	2
4	Transport	1124-01	3	-	-

RECURRING COST:

Time for Recurring Activities (6 Mos.)	1	2	3	4	5	6	7	8	9	10	Total
Operations	8.0	12.8	16.6	13.1	11.2	6.5					68.2
Launches				▼	▼	▼					

503-30114-1

Fig. 6-1 Sample Mode Data Sheet

Table 6-1

MODE COMPUTER INPUT

Card Type	Input Item	Where Obtained	Also Used For	
			"Working" Mode	Emergency Mode
1	• Mode identification number	Data sheet	√	√
	• Active-mode crew level	Data sheet	√	
	• Total-mode crew level	Data sheet	√	√
	• Mode staytime	Data sheet	√	
	• Sample return capability	Data sheet		
	• Minimum decimal fraction of available mode manhours that must be used during any given mission	Program analysis ground rules		
	• Launch lead time for minor scientific equipment	Data sheet		
	• Flag for concurrent shelters	Data sheet	√	
	• Number of payload launches in the mode	Data sheet	√	
2	• Total time for base deployment	Data sheet	√	
	• Shirtsleeve and spacesuit man-hours for special operations	Data sheet	√	
	• Lifetime and replacement mass of spacesuits and backpacks	Program analysis ground rules	√	
3	Nonrecurring R&D costs	Data sheet		√
4	Nonrecurring cost of facilities	Data sheet		√
5	Recurring hardware procurement	Data sheet		√
6	Recurring operations support	Data sheet		√
7	• Launch identifier	Data sheet	√	√
	• Related launch identifier	Data sheet		
	• Timing between related launches	Data sheet		
	• Launch mass margin	Data sheet		
8	• Launch identifier	Data sheet	√	√
	• System on that launch	Data sheet	*	√
	• Number of men supported by this system	Data sheet	√	√
	• Launch lead time of this system (6-mo increments)	Data sheet		√
	• Expendables required for special operations for this system	Data sheet	√	
9	• Identifier of crew rescue emergency mode	Program analysis ground rules		
	• Identifier of logistics emergency mode	Program analysis		

*Transportation systems not required.

The first card type assigns an identification number to the mode and inputs certain general data. Two types of crew level are specified. The "active-mode crew level" is the number of men actually performing the mission experiments at any given time. If one or more additional men are in some other location (such as lunar orbit) throughout the mission, these men plus the "active" crew form the total mode crew level.

Mode staytime is generally determined from the nominal maximum staytime of the principal crew system (such as shelter or rover) supporting the "active crew level."

The second card type inputs operations data including total time for deployment, manhours for any special operations, and spacesuit and backpack replacement requirements. The total time for base deployment is the number of days required to complete deployment whether the crew spends full time at that job or not. The computer bases its calculations on the assumption that the full active crew level is at the base during this time.

The third, fourth, fifth, and sixth card types input costs for nonrecurring R&D, nonrecurring facilities construction, recurring procurement, and recurring operations, respectively. The MIMOSA contract study calculated only recurring operations costs at the mode level: hence, the standard mode data sheet format allows for only this cost.

The seventh card type identifies the various launches of the mode. Each launch requires a separate card. The card inputs any schedule dependency between that launch and any previous launch. It also inputs the launch mass margin.

The eighth card type identifies the equipment on each launch. A separate card is required for each transportation system (paragraph 4.1.1) or piece of mission equipment (paragraph 4.1.2).

The ninth card type is used only if an emergency mode is being considered as backup to the regular mode. Emergency modes are discussed in paragraph 6.6.

The computer takes all input data, stores it in predetermined locations on magnetic tape, and prints out what it has stored. Figure 6-2 shows a typical printout of mode 503-30114-01 as an example.

6.4 "WORKING" MODES

The mission-mode match routine of the computer program requires only part of the total mode input. For example, the computer works only with mission support equipment; it ignores transportation systems. In the match routine, the computer also disregards cost and schedule data. Therefore, it is often desirable, particularly in the early stages of mission-mode matching, to worry only about those items essential to proper performance of the computer. This can be done by using "working modes." Table 6-1 identifies those items that must be input for working modes. Note that for card type 8, transportation systems may be omitted.

6.5 "ZERO-LAUNCH" MODES

Occasions arise when it is desirable to use a set of equipment in a mode for mission-mode matching, while ignoring several items of that equipment set in later cost calculations. For example, a mission may be accomplished by a mode in which some items of equipment are being re-used from a previous mission. Under these conditions it is desirable to match the equipment to the mission, but not calculate the cost of that equipment again. The computer has been programmed to handle such cases provided the equipments are grouped into a "zero-launch" mode.

Construct a zero-launch mode for computer input in much the same manner as a regular mode except for three things:

(1) Begin the mode identifier with the number 9.
(2) Group all systems that are not to be costed into one "launch" that is called launch 0 (zero).
(3) Arrange the input cards so that launch 0 is the last one in the sequence of launches.

MODE IDENTIFIER	503-30114-01		
ACTIVE MODE CREW LEVEL	3.		
TOTAL MODE CREW LEVEL	3.		
MODE STAYTIME (DAYS)	90.0000		
SAMPLE RETURN CAPABILITY (KG)	50.0000		
MIN. DECIMAL FRACTION	.75		
LAUNCH LEAD TIME-MINOR SCIEN. EQUIP.	3.	(NOTE 1)	
CONCURRENT SHELTERS FLAG	0.	(NOTE 2)	
NUMBER OF PAYLOADS	4.	(NOTE 3)	
TOTAL TIME FOR BASE DEPLOYMENT (DAYS)	6.0000		
DEPLOYMENT MAN-HOURS (SHIRTSLEEVE)	2.0000		
DEPLOYMENT MAN-HOURS (SPACESUIT)	3.0000		
MAN-HOURS OF SUIT LIFETIME	240.0000		
MAN-HOURS OF BACKPACK LIFETIME	100.0000		
MASS OF SUIT REPLACEMENT (KG)	33.0000		
MASS OF BACKPACK REPLACEMENT (KG)	10.0000		

COST CURVES

NON - RECURRING					
ZERO POINT (NOTE 4) -0.					
VALUES (MILLIONS)	-.0000	-.0000	-.0000	-.0000	-.0000
	.0000	.0000	.0000	.0000	.0000
	.0000	.0000	.0000	.0000	.0000
COST OF FACILITIES					
ZERO POINT (NOTE 4) -0.					
VALUES (MILLIONS)	-.0000	-.0000	-.0000	-.0000	-.0000
	.0000	.0000	.0000	.0000	.0000
	.0000	.0000	.0000	.0000	.0000
RECURRING PROCUREMENT					
ZERO POINT (NOTE 4) -0.					
VALUES (MILLIONS)	-.0000	-.0000	-.0000	-.0000	-.0000
	.0000	.0000	.0000	.0000	.0000
	.0000	.0000	.0000	.0000	.0000
RECURRING OPERATIONS					
ZERO POINT (NOTE 4) 4.					
VALUES (MILLIONS)	8.0000	13.8000	17.6000	14.1000	12.2000
	2.5000	-.0000	-.0000	-.0000	-.0000
	.0000	.0000	.0000	.0000	.0000

EXPLANATION OF NOTES

(1) NUMBER OF 6-MO. PERIODS PRIOR TO THE FIRST LAUNCH OF THE MODE THAT ALL MINOR SCIENTIFIC EQUIPMENT MUST BE DELIVERED FOR PAYLOAD INTEGRATION. INPUT IS 1 FOR 0-6 MO., 2 FOR 7-12 MO., ETC.

(2) 0 INDICATES NO CONCURRENT SHELTERS, 1 INDICATES TWO OR MORE CONCURRENT PERSONNEL SHELTERS.

(3) MAXIMUM ALLOWED IS 8.

(4) NUMBER OF FULL OR PARTIAL 6-MO. TIME PERIODS THAT OCCUR FROM START OF FUNDING UP TO AND INCLUDING THE 6-MO. TIME PERIOD OF A SPECIFIC DEADLINE DATE.

Fig. 6-2 Example Computer Printout — Modes

PAYLOADS

PAYLOAD LAUNCH NUMBER	RELATED LAUNCH NUMBER	TIME BETWEEN RELATED LAUNCHES MIN. NO. 6 MONTH PERIODS	TIME BETWEEN RELATED LAUNCHES MAX. NO. 6 MONTH PERIODS	MASS MARGIN AVAILABLE (KG)
1.	-0.	-0.	-0.	14388.0
2.	-0.	-0.	-0.	16132.0
3.	-0.	-0.	-0.	15520.0
4.	-0.	-0.	-0.	1400.0

SYSTEMS ON PAYLOAD 1

SYSTEM IDENTIFIER	NUMBER OF MEN SUPPORTED	LAUNCH LEAD TIME (FULL OR PARTIAL 6-MO. PERIODS BEFORE LAUNCH DATE)	EXPENDABLES SPECIAL OPERATIONS (KG)
321302	0.	2.	.0
213202	0.	2.	.0
213202	0.	2.	.0
114701	-0.	-0.	-.0

SYSTEMS ON PAYLOAD 2

SYSTEM IDENTIFIER	NUMBER OF MEN SUPPORTED	LAUNCH LEAD TIME (FULL OR PARTIAL 6-MO. PERIODS BEFORE LAUNCH DATE)	EXPENDABLES SPECIAL OPERATIONS (KG)
243304	3.	2.	.0
252102	3.	2.	.0
114701	-0.	-0.	-.0

SYSTEMS ON PAYLOAD 3

SYSTEM IDENTIFIER	NUMBER OF MEN SUPPORTED	LAUNCH LEAD TIME (FULL OR PARTIAL 6-MO. PERIODS BEFORE LAUNCH DATE)	EXPENDABLES SPECIAL OPERATIONS (KG)
242303	3.	3.	2.0
114701	-0.	-0.	-.0

SYSTEMS ON PAYLOAD 4

SYSTEM IDENTIFIER	NUMBER OF MEN SUPPORTED	LAUNCH LEAD TIME (FULL OR PARTIAL 6-MO. PERIODS BEFORE LAUNCH DATE)	EXPENDABLES SPECIAL OPERATIONS (KG)
112401	-0.	-0.	-.0

IDENTIFIER FOR CREW RESCUE EMERGENCY MODE

IDENTIFIER FOR LOGISTICS EMERGENCY MODE

Fig. 6-2 (Cont.)

6.6 EMERGENCY MODES

It may be desirable to buy special modes that can be used as an emergency backup to a regular mode. The MIMOSA computer program costing routine has been set up to handle this possibility. As presently programmed, two types of emergency modes can be considered: (1) crew rescue and (2) emergency logistics. Each type of mode is limited to one launch and is procured only once whether actually used or not per program. The computer program requires input of the mode costs and the list of systems on the one launch. Table 6-1 indicates the required data inputs for emergency modes.

Chapter 7
MISSION-MODE COMPARISON

The object for comparing mission requirements and mode capabilities is to demonstrate the ability of an equipment evolution to perform a scientific program. This chapter explains the operations required for comparing mission modes using the MIMOSA computer program. These operations include a preliminary hand analysis and computer input preparation. A sample match is presented for indicating certain problems that might be encountered by planners.

7.1 HAND ANALYSIS

After the mission has been formulated tentatively (paragraph 5.1) and a mode has been selected for matching, the following simple hand analysis can save considerable computer time:

(1) Calculate the available manhours by multiplying the maximum mode staytime by the active (or surface) mode crew level.
(2) Calculate the approximate scientific manhour capability by multiplying the available manhours by the appropriate factor from Table 7-1.
(3) Total the scientific manhours associated with the mission by summing all experiment phase 2 (operate) manhours.
(4) Check to see that this sum is less than 75 percent of the approximate mode scientific manhours capability. (The 75 percent commitment represents an adequate "fit" at this point in the analysis; other factors might tend to increase the requiment as the computer checks in depth, or the percentage requirement may be changed arbitrarily).
(5) Sum the mass of minor scientific equipment for the experiments making up the mission.
(6) Make sure this required equipment mass is less than the total mode mass margin.

After the foregoing six steps have been completed, the mission and mode are input to the computer (paragraphs 5.4 and 6.3).

Table 7-1

SCIENTIFIC/TOTAL-MANHOURS RATIOS

Mode Crew Level	Ratio of Scientific to Total Manhours	
	Fixed-Base Mode	Mobile-Base Mode
2	0.25	0.20
3	0.33	0.25
6	0.33	0.25

7.2 COMPUTER INPUT PREPARATION

After the mission and mode are input to the computer, control cards must be generated that cause the computer to perform the necessary calculations. Only three types of control card are required for a mission-mode match. Paragraph 10.9 gives detailed instructions for preparing these cards.

The first card is required at the beginning of each computer run. Punching a zero in the first column of this card results in the standard printout for match calculations. Punching the number 1 in the first column results in a detailed diagnostic printout of each computer calculation.

The second type of card is required for each mission-mode match being attempted. This card calls out the mission number and mode identification number. Space is also provided on this card to input a multiplication factor to automatically increase the shirtsleeve and spacesuit manhour numbers called for in the experiment data cards. This factor can be used to account for performance degradation in spacesuits and under reduced gravity. It should be noted that the experiment times called out in the North American Aviation data cards are based on man's capability in shirtsleeves, at normal gravity, in Earth environment.

The third card type, also required for every mission-mode match, identifies all flying and roving vehicles performing traverses and establishes the traverses that each vehicle performs. If the vehicle performing the traverse is a rover and trailer combination, special care is required for computer input.

7.3 SAMPLE MISSION-MODE COMPARISON

Figure 7-1 shows the computer printout resulting from an example mission-mode match involving mission 28 (Fig. 5-1) and mode 503-30114-01 (Fig. 6-1). Most computer runs point out definite deficiencies in the mission-mode match. The example shown here illustrates typical printouts caused by sloppy input and demonstrates proper corrective action. The following paragraphs discuss these printouts in detail.

7.3.1 Computer Printout

The computer printout for mission-mode matching (Fig. 7-1) contains one or two pages of comments followed by various calculation summaries. The comments are verbal messages describing faults or other items of interest concerning the match. The comments shown in the example printout are typical of the many possible messages. Pages 7-6 and 7-7 of the numerical summaries present results of the most important calculations. The calculated mission requirements and the input mode capabilities are displayed side-by-side. The ratios of the two values for various parameters are also shown. A perfect mission-mode match occurs if all these ratios are unity.

Pages 7-8 and 7-9 present the traverse calculations traverse by traverse. Page 7-10 presents traverse calculations vehicle by vehicle (in this case, only one vehicle).

Pages 7-11, 7-12, and 7-13 summarize mission requirements traverse by traverse. These calculations are particularly helpful in "trouble-shooting" mission-mode faults. Page 7-14 summarizes mission requirements at the base. In the example shown here, there were no base experiments.

MISSION-MODE MATCH COMMENTS

SCIENTIFIC PROGRAM A7 MISSION MIX 01 MISSION 28

MISSION LOCATION- PATH 13.5.4.5

NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION- 1

WOULD YOU BELIEVE THE FOLLOWING ABOUT THIS MISSION-MODE MATCH .....

MODE	COMMENTS
503-30114-01	MAYDAY-MAYDAY, FROM HERE ON THE RESULTS ARE GARBAGE
	MAYDAY-MAYDAY, FROM HERE ON THE RESULTS ARE GARBAGE
	MAYDAY-MAYDAY, FROM HERE ON THE RESULTS ARE GARBAGE
	TOTAL MASS OF SCIENTIFIC EQUIPMENT FOR TRAVERSE R-01 EXCEEDS CARGO CAPABILITY OF LRV 2433-04
	CARGO REQUIRED FOR TRAVERSE R-01 EXCEEDS CAPABILITY OF LRV 2433-04 DUE TO SCIENTIFIC EQUIPMENT AND EARTH RETURN MASS
	CARGO REQUIRED FOR TRAVERSE R-01 EXCEEDS CAPABILITY OF LRV 2433-04 DUE TO SCIENTIFIC EQUIPMENT AND EARTH RETURN MASS PLUS MASS OF EXTRA SPACESUITS AND BACKPACKS
	MAYDAY-MAYDAY, FROM HERE ON THE RESULTS ARE GARBAGE
	CARGO REQUIRED FOR TRAVERSE R-03 EXCEEDS CAPABILITY OF LRV 2433-04 DUE TO SCIENTIFIC EQUIPMENT AND EARTH RETURN MASS
	CARGO REQUIRED FOR TRAVERSE R-03 EXCEEDS CAPABILITY OF LRV 2433-04 DUE TO SCIENTIFIC EQUIPMENT AND EARTH RETURN MASS PLUS MASS OF EXTRA SPACESUITS AND BACKPACKS
	MORE THAN ONE ROVING VEHICLE CAN SUPPORT THE MODE CREW LEVEL. BASE ACTIVITY CALCULATIONS HAVE BEEN MADE USING THE PERFORMANCE DATA INPUT WITH THE FIRST VEHICLE ENCOUNTERED IN THE MODE LAUNCH DATA.
	MORE THAN ONE ROVING VEHICLE CAN SUPPORT THE MODE CREW LEVEL. BASE ACTIVITY CALCULATIONS HAVE BEEN MADE USING THE PERFORMANCE DATA INPUT WITH THE FIRST VEHICLE ENCOUNTERED IN THE MODE LAUNCH DATA.
	MORE THAN ONE ROVING VEHICLE CAN SUPPORT THE MODE CREW LEVEL. BASE ACTIVITY CALCULATIONS HAVE BEEN MADE USING THE PERFORMANCE DATA INPUT WITH THE FIRST VEHICLE ENCOUNTERED IN THE MODE LAUNCH DATA.
	MORE THAN ONE ROVING VEHICLE CAN SUPPORT THE MODE CREW LEVEL. BASE ACTIVITY CALCULATIONS HAVE BEEN MADE USING THE PERFORMANCE DATA INPUT WITH THE FIRST VEHICLE ENCOUNTERED IN THE MODE LAUNCH DATA.
	EARTH RETURN CAPABILITY OF MODE IS INSUFFICIENT TO MEET MISSION REQUIREMENTS

Fig. 7-1 Example Computer Printout – Mission-Mode Match No. 1

```
EXPERIMENT 9.9.99.99.92 NOT IN EXPERIMENT DATA
EXPERIMENT 9.9.99.99.92 NOT IN EXPERIMENT DATA
EXPERIMENT 9.9.99.99.92 NOT IN EXPERIMENT DATA
EXPERIMENT 9.9.99.99.92 NOT IN EXPERIMENT DATA
```

Fig. 7-1 (Cont.)

SUMMARY OF MISSION-MODE MATCH CALCULATION PAGE 1

SCIENTIFIC PROGRAM A7
MISSION MIX 01 MISSION NUMBER 28
MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
NOMINAL MISSION START DATE= 1978A
MAX MODE STAYTIME (DAYS)= 90.
MISSION LOCATION- PATH 13.5.4.5
NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION- 1

THE LISTING BELOW SUMMARIZES THE MISSION-MODE CALCULATION PERFORMED BY THE COMPUTER.

ITEM		CALCULATED VALUE	PERMITTED VALUE	RATIO
TOTAL STAYTIME (DAYS)		89.6	90.	.996
TIME FOR ALL ROVING TRAVERSES (DAYS)		44.9		
TIME FOR ALL FLYING TRAVERSES (DAYS)		.0		
TIME FOR BASE ACTIVITIES (DAYS)		38.8		
TIME FOR DEPLOYMENT (DAYS)		6.0		
TOTAL MANHOURS UTILIZED		6454.5	6480.	.996
TOTAL SPACESUIT MANHOURS		1717.0		
SCIENTIFIC - ON ALL TRAVERSES (INPUT MULTIPLIER=2.00)	676.8			
SCIENTIFIC - AT BASE (INPUT MULTIPLIER=2.00)	746.2			
NONSCIENTIFIC - ON ALL TRAVERSES	103.2			
NONSCIENTIFIC - AT BASE	190.8			
TOTAL SHIRTSLEEVE MANHOURS		4737.5		
SCIENTIFIC - ON ALL TRAVERSES (INPUT MULTIPLIER=1.00)	155.2			
SCIENTIFIC - AT BASE (INPUT MULTIPLIER=1.00)	689.7			
NONSCIENTIFIC - ON ALL TRAVERSES	2294.4			
NONSCIENTIFIC - AT BASE	1598.1			
TOTAL EXPENDABLES UTILIZED (KG)		7226.8	9438.	.766
TOTAL EXPENDABLES USED AT THE BASE (KG)		2181.0	0.	*******
USED FOR SYSTEM SUPPORT DURING ALL TRAVERSES	.0			
USED FOR SYSTEM SUPPORT DURING ALL NON-TRAVERSE PERIODS	1397.4			
USED FOR POWER ON BASE EXPERIMENTS	.0			
EXTRA AMOUNT FOR SPACESUIT USE AT BASE	777.6			
EXTRA AMOUNT FOR SPACESUIT USE ON TRAVERSES	.0			
USED FOR SPECIAL OPERATIONS	.0			
UNUSABLE (BOILOFF, ULLAGE, ETC.)	6.0			
TOTAL EXPENDABLES USED BY ROVING AND FLYING VEHICLES (KG)		5045.8	7520.	.671
USED DURING TRAVERSES (SEE FOLLOWING PAGES FOR DETAILS)	4643.8			
USED FOR SPECIAL OPERATIONS	2.0			
UNUSABLE (BOILOFF, ULLAGE, ETC.)	400.0			
TOTAL RESUPPLY EXPENDABLES REQUIRED (KG)		.0	0.	.000
FOR FLYING TRAVERSES		.0		
FOR ROVING TRAVERSES		.0		
FOR BASE USE		.0		

Fig. 7-1 (Cont.)

SUMMARY OF MISSION-MODE MATCH CALCULATION PAGE 2

SCIENTIFIC PROGRAM A7
MISSION MIX 01 MISSION NUMBER 28
MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
NOMINAL MISSION START DATE= 1978A
MAX MODE STAYTIME (DAYS)= 90.
MISSION LOCATION- PATH 13.5.4.5
NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION- 1

THE LISTING BELOW SUMMARIZES THE MISSION-MODE CALCULATION PERFORMED BY THE COMPUTER.

ITEM		CALCULATED VALUE	PERMITTED VALUE	RATIO
TOTAL LFV PROPELLANT UTILIZED (KG)		.0	1030.	.000
TOTAL LFV PROPELLANT RESUPPLIED (KG)		.0	0.	.000
TOTAL MASS MARGIN UTILIZED (KG)		32104.9	47640.	.674
MASS OF MINOR SCIENTIFIC EQUIPMENT		31789.9		
MASS OF SPARE SPACESUITS	5. REQD	165.0		
MASS OF SPARE BACKPACKS	15. REQD	150.0		
TOTAL EARTH RETURN MASS UTILIZED (KG)		1790.0	50.	35.800
FOR BASE EXPERIMENTS		.0		
FOR TRAVERSE EXPERIMENTS		1790.0		

Fig. 7-1 (Cont.)

SCIENTIFIC PROGRAM A7 MODE I.D. NUMBER 503-30114-01
MISSION MIX 01 MISSION NUMBER 28 CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
NOMINAL MISSION START DATE= 1976A MAX MODE STAYTIME (DAYS)= 90.

THE LISTING BELOW SUMMARIZES THE TRAVERSE CALCULATIONS PERFORMED BY THE COMPUTER.

TRAVERSE IDENTIFIER	R-01	R-02	R-03
VEHICLE IDENTIFIER	2433-04	2433-04	2433-04
MINIMUM CREW REQUIRED	2	1	2
VEHICLE CREW LEVEL	3	3	3
CREW AT BASE DURING TRAVERSE	-0	-0	-0
TRAVERSE RANGE (KM)	900.0	350.0	1150.0
MAXIMUM VEHICLE CAPABILITY (KM)	7000.0	7000.0	7000.0
REQUIRED EXCURSION TIME (DAYS)	19.4	4.5	20.9
MAXIMUM VEHICLE CAPABILITY (DAYS)	400.0	400.0	400.0
NUMBER OF STOPS	10.0	10.0	10.0
MASS OF MINOR SCIENTIFIC EQUIPMENT (KG)	12764.5	6227.5	6842.5
EARTH RETURN MASS REQUIRED (KG)	452.0	145.0	1193.0
MASS OF SPACESUIT REPLACEMENTS (KG)	.0	.0	.0
MASS OF BACKPACK REPLACEMENTS (KG)	10.0	.0	10.0
TOTAL CARGO MASS REQUIRED (KG)	13226.5	6372.5	8045.5
MAXIMUM VEHICLE CAPABILITY (KG)	7660.0	7660.0	7660.0
SCIENTIFIC MAN-HOURS ON TRAVERSE	402.8	50.4	378.8
SHIRTSLEEVE	90.8	3.6	60.8
SPACESUIT	312.0	46.8	318.0
NONSCIENTIFIC MAN-HOURS ON TRAVERSE	997.2	273.0	1127.4
SHIRTSLEEVE	952.5	262.6	1079.3
SPACESUIT	44.7	10.3	48.1
SCIENTIFIC MAN-HOURS REQUIRED AT BASE	197.8	30.5	1207.7
SHIRTSLEEVE	115.8	24.3	549.7
SPACESUIT	82.0	6.2	658.0
NONSCIENTIFIC MAN-HOURS REQUIRED AT BASE	.0	.0	.0
SHIRTSLEEVE	.0	.0	.0
SPACESUIT	.0	.0	.0
TRAVERSE EXPENDABLES REQUIRED (KG)	1480.7	532.9	2630.2
MAXIMUM EXPENDABLES PERMITTED (KG)	7520.0	7520.0	7520.0
BASE EXPENDABLES FOR SYSTEM SUPPORT	.0	.0	.0
DELTA V REQUIRED OF LFV (M/S)	.0	.0	.0
SPECIFIC IMPULSE (M/S)	.0	.0	.0
INERT MASS OF LFV (KG)	.0	.0	.0
LFV PROPELLANT REQUIRED (KG)	.0	.0	.0
MAXIMUM PROPELLANT PERMITTED (KG)	.0	.0	.0

Fig. 7-1 (Cont.)

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SUMMARY OF MISSION-MODE MATCH CALCULATION PAGE 4

SCIENTIFIC PROGRAM A7
MISSION MIX 01 MISSION NUMBER 28
MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
NOMINAL MISSION START DATE= 1976A
MAX MODE STAYTIME (DAYS)= 90.

THE FOLLOWING LISTING SUMMARIZES DETAILS OF THE EXPENDABLES CALCULATIONS FOR THE TRAVERSES REQUIRED ON PAGE 1.

TRAVERSE IDENTIFIER	R-01	R-02	R-03
VEHICLE IDENTIFIER	2433-04	2433-04	2433-04
TRAVERSE EXPENDABLES REQUIRED (KG)	1480.7	532.9	2630.2
MAXIMUM EXPENDABLES PERMITTED (KG)	7520.0	7520.0	7520.0
EXPENDABLES USAGE BREAKDOWN (KG)			
VEHICLE SUPPORT BASED ON DAILY USE	606.7	140.1	652.7
EXPERIMENT ENERGY	29.6	105.2	943.4
FOR TRAVELING	666.0	259.0	851.0
FOR STOPS	.0	.0	.0
EXTRA FOR SPACESUIT MANHOURS	178.4	28.6	183.1

NOTE -- WHEN THE MAXIMUM EXPENDABLES PERMITTED FOR A FLYING OR ROVING VEHICLE EQUALS 0, ANY CALCULATED EXPENDABLES REQUIRED ON A TRAVERSE SHOULD BE FOR SPACESUIT MANHOURS (THE REQUIREMENT OF ANY OTHER EXPENDABLES INDICATES AN ERROR IN INPUT DATA). THESE ARE CHARGED AGAINST THE SHELTER, OR ROVING VEHICLE ACTING AS A SHELTER, AND THE EXPENDABLES REQUIRED ON THE TRAVERSE ARE CONSIDERED TO BE EQUAL TO 0.

Fig. 7-1 (Cont.)

SUMMARY OF MISSION-MODE MATCH CALCULATION PAGE 5

SCIENTIFIC PROGRAM A7
MISSION MIX 01 MISSION NUMBER 28 MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
NOMINAL MISSION START DATE= 1978A MAX MODE STAYTIME (DAYS)= 90.

THE FOLLOWING IS A VEHICLE BY VEHICLE SUMMARY OF THE DETAILS OF EXPENDABLES AND PROPELLANT CALCULATIONS FOR THE TRAVERSES REPORTED ON PAGE 1.

VEHICLE IDENTIFIER	2433-04
TOTAL EXPENDABLES REQUIRED	5043.8
MAXIMUM MASS OF EXPENDABLES PERMITTED (KG)	7520.0
MASS OF RESUPPLY EXPENDABLES REQUIRED (KG)	.0
EXPENDABLES USAGE BREAKDOWN (KG)	
VEHICLE SUPPORT BASED ON DAILY USE	1399.5
EXPERIMENT ENERGY	1078.3
FOR TRAVELING	1776.0
FOR STOPS	.0
EXTRA FOR SPACESUIT MANHOURS	390.0
USED FOR SPECIAL OPERATIONS	.0
UNUSABLE (BOILOFF, ULLAGE, ETC.)	400.0
TOTAL MASS OF PROPELLANT REQUIRED (KG)	.0
MAXIMUM MASS OF PROPELLANT PERMITTED (KG)	.0
MASS OF RESUPPLY PROPELLANT REQUIRED (KG)	.0

NOTE -- IF THE MAXIMUM EXPENDABLES PERMITTED ON A VEHICLE EQUAL 0, THEN ALL OF THE EXPENDABLES REQUIRED BY THAT VEHICLE ARE SUPPLIED BY THE SHELTER, OR ROVING VEHICLE ACTING AS A SHELTER, AND THE TOTAL EXPENDABLES REQUIRED AND THE MASS OF RESUPPLY EXPENDABLES SHOULD EQUAL 0. IF NOT, THERE IS AN ERROR IN THE INPUT DATA.

Fig. 7-1 (Cont.)

SCIENTIFIC PROGRAM A7
MISSION MIX 01 MISSION NUMBER 28
MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
MAX MODE STAYTIME (DAYS)= 90.

NOMINAL MISSION START DATE= 1976A
MISSION LOCATION- PATH 13.5.4.5
NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION- 1

THE LISTING BELOW SUMMERIZES THE SCIENTIFIC PROGRAM REQUIREMENTS FOR THIS MISSION.

THERE ARE NO FLYING TRAVERSE EXPERIMENTS

THE FOLLOWING EXPERIMENTS WERE PERFORMED ON TRAVERSE P-01

EXPERIMENT NUMBER	PHASE 2 REPLIC	MANHOURS REQUIRED (--TRAVERSE---) SPSU	(--TRAVERSE---) SHSL	(---AT BASE---) SPSU	(---AT BASE---) SHSL	(----TOTAL----) SPSU	(----TOTAL----) SHSL	EQUIPMENT ENERGY (KW-HR)	EARTH RETURN MASS (KG)	EQUIPMENT MASS CODE	EQUIPMENT MASS KG	VEHICLE CARGO CODE	VEHICLE CARGO KG
9.9.99.99.12	3.	4.0	.0	14.6	9.0	18.6	9.0	1.2	.0		24.0	B	.0
9.0.05.02.01	1.	.6	.0	.2	.0	.8	.0	.0	.0		30.0		30.0
9.9.99.99.36	1.	17.6	4.4	2.0	2.9	19.6	7.3	2.1	7.0		61.0	B	.0
2.1.01.04.12	1.	4.0	22.0	.0	.0	4.0	22.0	22.0	10.0		110.0	B	.0
2.1.02.03.07	1.	.0	.0	4.8	.0	4.8	.0	2.0	1.0	B	.0	B	.0
9.9.99.99.10	1.	22.0	.0	.0	.0	22.0	.0	.0	.0		150.0	B	.0
1.1.01.01.01	1.	.0	.0	7.4	2.0	7.4	2.0	.1	5.0		150.0	B	.0
1.2.01.02.02	1.	.0	.0	4.6	2.0	4.6	2.0	4.0	5.0		290.0	B	.0
9.9.99.99.31	1.	66.0	25.0	.0	.0	66.0	25.0	1.6	30.0		1.7	B	.0
3.4.01.04.02	1.	.0	4.5	.0	.0	.0	4.5	1.0	.0		20.0	B	.0
4.1.01.04.14	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		6000.0		6000.0
2.1.02.03.07	1.	.0	.0	4.4	.0	4.4	.0	2.0	1.0	B	.0		44.0
9.9.99.99.12	1.	1.0	.0	4.2	2.8	5.2	2.8	.4	.0	B	.0		24.0
9.0.05.02.01	1.	.6	.0	.2	.0	.8	.0	.0	.0		30.0		30.0
4.1.01.04.14	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		6000.0		6000.0
9.9.99.99.10	1.	22.0	.0	.0	.0	22.0	.0	.0	.0		150.0		150.0
2.1.02.03.07	1.	.0	.0	4.4	.0	4.4	.0	2.0	1.0	B	.0		44.0
2.1.01.04.12	1.	3.0	20.0	.0	.0	3.0	20.0	22.0	10.0	B	.0		110.0
9.9.99.99.36	1.	11.0	2.2	1.2	2.7	12.2	4.9	2.1	7.0	B	.0		61.0
9.9.99.99.12	3.	3.0	.0	12.6	8.4	15.6	8.4	1.2	.0	B	.0		24.0
4.0.08.04.54	1.	.0	.0	.0	.0	.0	.0	.4	.0		3.5		3.5
4.1.05.03.41	1.	.0	.0	.0	.0	.0	.0	.0	.0		4.0		4.0
4.4.07.04.51	1.	.0	.0	.0	.0	.0	.0	.0	.0		1.0		1.0
9.9.99.99.32	91.	36.4	1.5	.0	18.2	36.4	19.7	4.7	.0		21.0		21.0
9.9.99.99.33	46.	.0	11.2	15.8	14.7	15.8	25.9	3.9	230.0		86.0		86.0
9.9.99.99.34	5.	51.2	.0	1.8	44.6	53.0	44.6	1.0	100.0		57.0		57.0
9.9.99.99.35	3.	49.6	.0	3.8	8.5	53.4	8.5	6.3	45.0		75.0		75.0
TOTALS		312.0	90.8	82.0	115.8	394.0	206.6	80.1	452.0		13264.2		12764.5

Fig. 7-1 (Cont.)

SCIENTIFIC PROGRAM A7
MISSION MIX 01 MISSION NUMBER 28

MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
MAX MODE STAYTIME (DAYS)= 90.

NOMINAL MISSION START DATE= 1978A
MISSION LOCATION- PATH I3.5.4.5
NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION- 1

THE LISTING BELOW SUMMERIZES THE SCIENTIFIC PROGRAM REQUIREMENTS FOR THIS MISSION.

THE FOLLOWING EXPERIMENTS WERE PERFORMED ON TRAVERSE R-02

EXPERIMENT NUMBER	PHASE 2 REPLIC	MANHOURS REQUIRED (--TRAVERSE---) SPSU	(--TRAVERSE---) SHSL	(---AT BASE---) SPSU	(---AT BASE---) SHSL	(----TOTAL----) SPSU	(----TOTAL----) SHSL	EQUIPMENT ENERGY (KW-HR)	EARTH RETURN MASS (KG)	EQUIPMENT MASS CODE	EQUIPMENT MASS KG	VEHICLE CARGO CODE	VEHICLE CARGO KG
4.1.01.04.14	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		6000.0		6000.0
4.0.08.04.54	1.	.0	.0	.0	.0	.0	.0	.4	.0	B	.0		3.5
4.1.05.03.41	1.	.0	.0	.0	.0	.0	.0	.0	.0	B	.0		4.0
4.4.07.04.51	1.	.0	.0	.0	.0	.0	.0	.0	.0	B	.0		1.0
0.1.03.01.59	35.	.0	.0	.0	.0	.0	.0	280.0	.0	B	.0		1.0
9.9.99.99.33	18.	.0	3.6	5.4	5.8	5.4	9.4	1.5	90.0	B	.0		86.0
9.9.99.99.34	2.	20.4	.0	.4	17.0	20.8	17.0	.4	40.0	B	.0		57.0
9.9.99.99.35	1.	16.4	.0	.4	1.5	16.8	1.5	2.1	15.0	B	.0		75.0
TOTALS		46.8	3.6	6.2	24.3	53.0	27.9	284.4	145.0		6000.0		6227.5

Fig. 7-1 (Cont.)

SCIENTIFIC PROGRAM A7
MISSION MIX 01 MISSION NUMBER 28
MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
MAX MODE STAYTIME (DAYS)= 90.

NOMINAL MISSION START DATE= 1978A
MISSION LOCATION- PATH 13.5,4,5
NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION- 1

THE LISTING BELOW SUMMERIZES THE SCIENTIFIC PROGRAM REQUIREMENTS FOR THIS MISSION.

THE FOLLOWING EXPERIMENTS WERE PERFORMED ON TRAVERSE R-03

EXPERIMENT NUMBER	PHASE 2 REPLIC	MANHOURS REQUIRED (--TRAVERSE---) SPSU	(--TRAVERSE---) SHSL	(---AT BASE---) SPSU	(---AT BASE---) SHSL	(----TOTAL----) SPSU	(----TOTAL----) SHSL	EQUIPMENT ENERGY (KW-HR)	EARTH RETURN MASS (KG)	EQUIPMENT MASS CODE	EQUIPMENT MASS KG	VEHICLE CARGO CODE	VEHICLE CARGO KG
1.1.01.01.01	1.	.0	.0	7.4	2.0	7.4	2.0	.1	5.0		150.0	B	.0
1.2.01.02.02	100.	.0	.0	400.6	200.0	400.6	200.0	400.0	500.0		290.0	B	.0
9.9.99.99.31	1.	66.0	25.0	.0	.0	66.0	25.0	1.6	30.0		1.7	B	.0
4.1.01.04.14	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		6000.0	B	.0
2.1.02.03.08	1.	.0	.0	170.0	213.0	170.0	213.0	2100.0	200.0	A	.0	A	.0
9.9.99.99.12	10.	10.0	.0	42.0	28.0	52.0	28.0	4.1	.0		24.0	B	.0
4.2.02.07.04	1.	.0	.0	.0	.0	.0	.0	.0	.0		3.0	B	185.0
4.2.02.07.04	1.	.0	.0	.0	.0	.0	.0	.0	.0		3.0	B	185.0
2.1.02.03.07	1.	.0	.0	4.8	.0	4.8	.0	2.0	1.0	B	.0	B	.0
9.9.99.99.12	1.	1.0	.0	4.2	2.8	5.2	2.8	.4	.0	B	.0	B	.0
4.1.01.04.13	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		2500.0		2500.0
4.1.01.04.12	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		2100.0		2100.0
4.1.01.04.11	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		1300.0		1300.0
4.1.01.04.10	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		80.0		80.0
4.1.01.04.09	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		42.0		42.0
4.1.01.04.08	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		13.0		13.0
4.1.01.04.07	1.	14.0	.0	.0	.0	14.0	.0	.0	.0		19.0		19.0
2.1.01.04.12	1.	4.0	22.0	.0	.0	4.0	22.0	22.0	10.0	B	.0		110.0
9.9.99.99.36	1.	11.0	2.2	1.2	2.7	12.2	4.9	2.1	7.0	B	.0		61.0
9.9.99.99.12	2.	2.0	.0	8.4	5.6	10.4	5.6	.8	.0	B	.0	B	.0
4.0.06.04.54	1.	.0	.0	.0	.0	.0	.0	.4	.0	B	.0		3.5
4.1.05.03.41	1.	.0	.0	.0	.0	.0	.0	.0	.0	B	.0		4.0
4.4.07.04.51	1.	.0	.0	.0	.0	.0	.0	.0	.0	B	.0		1.0
9.9.99.99.32	115.	46.0	.0	.0	23.0	46.0	23.0	6.0	.0	B	.0		21.0
9.9.99.99.33	58.	.0	11.6	17.4	18.6	17.4	30.2	4.9	290.0	B	.0		86.0
9.9.99.99.34	6.	61.2	.0	1.2	51.0	62.4	51.0	1.2	120.0	B	.0		57.0
9.9.99.99.35	2.	32.8	.0	.8	3.0	33.6	3.0	4.2	30.0	B	.0		75.0
TOTALS		318.0	60.8	658.0	549.7	976.0	610.5	2549.8	1193.0		12525.7		6842.5

Fig. 7-1 (Cont.)

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                    SUMMARY OF MISSION-MODE MATCH CALCULATION                    PAGE  9

SCIENTIFIC PROGRAM A7                                  MODE I.D. NUMBER 503-30114-01
     MISSION MIX  01          MISSION NUMBER  26       CREW LEVEL          TOTAL=  3
                                                         PERFORMING EXPERIMENTS=  3
NOMINAL MISSION START DATE= 1978A                     MAX MODE STAYTIME (DAYS)=  90.
MISSION LOCATION= PATH  13.5.4.5
NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION=  1

     THE LISTING BELOW SUMMERIZES THE SCIENTIFIC PROGRAM REQUIREMENTS FOR THIS MISSION.

     THERE ARE NO BASE EXPERIMENTS
```

Fig. 7-1 (Cont.)

7.3.2 The Mayday Message

The Mayday message tells the mission planner that the computer has been instructed to use an experiment, system, or mode identifier that is not in its data storage. Under such conditions, the computer is programmed to seek out some other identifier for the missing experiment, system, or mode so as to terminate the run and insert the substitute set of input values into any subsequent computations. At the same time, the computer prints the Mayday message and identifies the mission experiment, system, or mode.

Usually such trouble is traced to a keypunch error in data input. Such is the case for the example in Fig. 7-1. The computer has announced itself incapable of finding a record of experiment 9.9.99.99.92 (see printout page following Mayday message). It then selected experiment 0.1.03.01.59 and substituted data from this experiment in the places required for 9.9.99.99.92. This substitute experiment appears in the R-02 traverse list (page 7-12, Fig. 7-1). A check of the list of experiments intended for traverse R-02 revealed that 9.9.99.99.92 should really have been 9.9.99.99.32, an experiment that is in the computer data storage.

Mayday messages are simple to diagnose. The important point is that all resulting calculations are subject to doubt. In this case, the computer inserted data for experiment 0.1.03.01.59 instead of 9.9.99.99.92 in traverse R-02 and continued computing. The resulting computation errors in this instance were small. The solution to this error is to correct the experiment identification on the appropriate mission input card.

7.3.3 Excessive Cargo Message

The next three comments (page 7-4, Fig. 7-1) say the cargo capability of LRV 2433-04 on traverse R-01 is excessive. These comments are printed out after successive computation subroutines are completed. An examination of the cargo

figures on page 7-8 shows that the required cargo exceeds the permitted cargo by almost 6,000 kg, with the bulk of the excess coming from minor scientific equipment. The breakdown of the vehicle cargo mass (page 7-11) lists two 6,000-kg masses as required. A check of the experiment layout for this mission revealed that the 6,000-kg mass required for experiment 4.1.01.04.14 (see page 7-11) was never intended to be transported as cargo and that the cargo override had been forgotten. The solution to this problem is to input a cargo override of 0.0 kg for this experiment on the appropriate computer input card for mission 28.

7.3.4 Decimal Point Errors

Two printout comments (page 7-4) indicate excessive cargo on traverse R-03. Referring to page 7-8 for a clue to the excessive cargo, it can be seen that the Earth-return mass for traverse R-03 is quite high (1,193 kg) in comparison with the other traverses. Several large Earth-return masses are noted in the experiment summary on page 7-13. The largest one (500 kg) is associated with experiment 1.2.0.1.02.02. The same experiment on traverse R-01 (page 7-11) requires only 5 kg of Earth-return mass, a discrepancy of two ordersof magnitude between the two entries. Furthermore, the Phase 2 replications show the same discrepancy ratio. Checking the mission input card for the experiment showed that the decimal point was omitted in the input of replications for operation (Phase 2) of the experiment on traverse R-03. When this happened, the computer adjusted the input number to the far left of the field that was available for that number (three spaces). So, instead of an input of 1.0, the computer read 100.0. The solution to the problem is to punch in the decimal point as required.

7.3.5 Routine Statements

Whenever a mode is used that has a rover and a trailer (but no shelter), the computer recognizes two possibilities for supporting the crew – the rover alone or the rover-plus-trailer combination. The performance data on the rover-plus-trailer combination is input to the computer under the trailer identification number (see paragraph

10.6 and 10.9). If there is any activity at a central landing point, the computer must decide which of the two entities is supporting the crew. To overcome this problem, the computer is programmed to accept the first trailer or rover identifier that it encounters in the mode input, and use the data from that system for any base-type calculations, and print out what it has done on the comments page output. It repeats the written notice during subsequent subroutines as it has done in the example in Fig. 7-1. No corrective action is required in these cases.

7.3.6 Excessive Earth-Return Mass Statement

Whenever there is insufficient capability in a mode for returning required mass to Earth, a statement is printed out as shown at the bottom of the comments page of Fig. 7-1. The example mission requires 1,790 kg; the mode supplies only 50 kg (see page 7-7). Some of the required mass is attributable to the missing decimal point discussed in paragraph 7.3.4. An examination of each element of Earth-return mass shows no other mistakes in information content.

The personnel transportation system (1124-01) of the mode is capable of transportating six men, but is being used at a three-man level; this allows an additional 426 kg of Earth-return capability. Furthermore, the available mass margin of that system can be traded off for an additional 310 kg of Earth-return capability. Thus, the maximum Earth-return mass can be as high as 786 kg (310+426+50).

These augmentations are not usually input with the mode data, since other mode usage may not require the maximum Earth-return capability. In any event, the required Earth-return payload for this example exceeds capability, and experiment redefinition or system redesign is in order.

7.3.7 Other Messages

If the mode staytime is exceeded, or more expendables are required, messages are printed in the comments section. In any case, it is advisable to check into every comment printed.

7.3.8 Second Iteration

All the foregoing changes in input were made to the sample mission-mode comparison. The comparison was rerun and the resulting computer printout is presented in Fig. 7-2. All problem messages, except Earth-return mass, have disappeared. The correction of mission input has reduced the amount of required Earth-return mass to 1,295 kg. The possible augmentation (paragraph 7.3.6) permits a total of 786 kg. Thus, the actual ratio is 1,295/786 = 1.65. However, because the accuracy of the Earth-return requirement given with the experiments was questionable, no further input changes were undertaken.

MISSION-MODE MATCH COMMENTS

SCIENTIFIC PROGRAM A7 MISSION MIX 02 MISSION 28

MISSION LOCATION- PATH 13.5,4.5

NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION- 1

WOULD YOU BELIEVE THE FOLLOWING ABOUT THIS MISSION-MODE MATCH .....

MODE	COMMENTS
503-30114-01	MORE THAN ONE ROVING VEHICLE CAN SUPPORT THE MODE CREW LEVEL. BASE ACTIVITY CALCULATIONS HAVE BEEN MADE USING THE PERFORMANCE DATA INPUT WITH THE FIRST VEHICLE ENCOUNTERED IN THE MODE LAUNCH DATA.
	MORE THAN ONE ROVING VEHICLE CAN SUPPORT THE MODE CREW LEVEL. BASE ACTIVITY CALCULATIONS HAVE BEEN MADE USING THE PERFORMANCE DATA INPUT WITH THE FIRST VEHICLE ENCOUNTERED IN THE MODE LAUNCH DATA.
	MORE THAN ONE ROVING VEHICLE CAN SUPPORT THE MODE CREW LEVEL. BASE ACTIVITY CALCULATIONS HAVE BEEN MADE USING THE PERFORMANCE DATA INPUT WITH THE FIRST VEHICLE ENCOUNTERED IN THE MODE LAUNCH DATA.
	MORE THAN ONE ROVING VEHICLE CAN SUPPORT THE MODE CREW LEVEL. BASE ACTIVITY CALCULATIONS HAVE BEEN MADE USING THE PERFORMANCE DATA INPUT WITH THE FIRST VEHICLE ENCOUNTERED IN THE MODE LAUNCH DATA.
	EARTH RETURN CAPABILITY OF MODE IS INSUFFICIENT TO MEET MISSION REQUIREMENTS

Fig. 7-2 Example Computer Printout – Mission-Mode Match No. 2

SUMMARY OF MISSION-MODE MATCH CALCULATION PAGE 1

SCIENTIFIC PROGRAM A7
MISSION MIX 02 MISSION NUMBER 28
MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
NOMINAL MISSION START DATE= 1976A
MAX MODE STAYTIME (DAYS)= 90.
MISSION LOCATION- PATH 13.5.4.5
NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION- 1

THE LISTING BELOW SUMMARIZES THE MISSION-MODE CALCULATION PERFORMED BY THE COMPUTER.

ITEM		CALCULATED VALUE	PERMITTED VALUE	RATIO
TOTAL STAYTIME (DAYS)		72.6	90.	.806
TIME FOR ALL ROVING TRAVERSES (DAYS)		45.3		
TIME FOR ALL FLYING TRAVERSES (DAYS)		.0		
TIME FOR BASE ACTIVITIES (DAYS)		21.3		
TIME FOR DEPLOYMENT (DAYS)		6.0		
TOTAL MANHOURS UTILIZED		5225.7	6480.	.806
TOTAL SPACESUIT MANHOURS		1278.3		
SCIENTIFIC - ON ALL TRAVERSES (INPUT MULTIPLIER=2.00)	690.8			
SCIENTIFIC - AT BASE (INPUT MULTIPLIER=2.00)	350.2			
NONSCIENTIFIC - ON ALL TRAVERSES	104.1			
NONSCIENTIFIC - AT BASE	133.2			
TOTAL SHIRTSLEEVE MANHOURS		3947.5		
SCIENTIFIC - ON ALL TRAVERSES (INPUT MULTIPLIER=1.00)	155.2			
SCIENTIFIC - AT BASE (INPUT MULTIPLIER=1.00)	498.7			
NONSCIENTIFIC - ON ALL TRAVERSES	2308.6			
NONSCIENTIFIC - AT BASE	984.9			
TOTAL EXPENDABLES UTILIZED (KG)		6056.4	9438.	.642
TOTAL EXPENDABLES USED AT THE BASE (KG)		1240.0	0.	*******
USED FOR SYSTEM SUPPORT DURING ALL TRAVERSES	.0			
USED FOR SYSTEM SUPPORT DURING ALL NON-TRAVERSE PERIODS	852.4			
USED FOR POWER ON BASE EXPERIMENTS	.0			
EXTRA AMOUNT FOR SPACESUIT USE AT BASE	381.6			
EXTRA AMOUNT FOR SPACESUIT USE ON TRAVERSES	.0			
USED FOR SPECIAL OPERATIONS	.0			
UNUSABLE (BOILOFF, ULLAGE, ETC.)	6.0			
TOTAL EXPENDABLES USED BY ROVING AND FLYING VEHICLES (KG)		4816.4	7520.	.640
USED DURING TRAVERSES (SEE FOLLOWING PAGES FOR DETAILS)	4414.4			
USED FOR SPECIAL OPERATIONS	2.0			
UNUSABLE (BOILOFF, ULLAGE, ETC.)	400.0			
TOTAL RESUPPLY EXPENDABLES REQUIRED (KG)		.0	0.	.000
FOR FLYING TRAVERSES		.0		
FOR ROVING TRAVERSES		.0		
FOR BASE USE		.0		

Fig. 7-2 (Cont.)

SUMMARY OF MISSION-MODE MATCH CALCULATION PAGE 2

SCIENTIFIC PROGRAM A7
MISSION MIX 02 MISSION NUMBER 28

MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
MAX MODE STAYTIME (DAYS)= 90.

NOMINAL MISSION START DATE= 1978A
MISSION LOCATION- PATH I3.5.4.5
NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION- 1

THE LISTING BELOW SUMMARIZES THE MISSION-MODE CALCULATION PERFORMED BY THE COMPUTER.

ITEM		CALCULATED VALUE	PERMITTED VALUE	RATIO
TOTAL LEV PROPELLANT UTILIZED (KG)		.0	1030.	.000
TOTAL LEV PROPELLANT RESUPPLIED (KG)		.0	0.	.000
TOTAL MASS MARGIN UTILIZED (KG)		31988.9	47640.	.671
MASS OF MINOR SCIENTIFIC EQUIPMENT		31789.9		
MASS OF SPARE SPACESUITS	3. REQD	99.0		
MASS OF SPARE BACKPACKS	10. REQD	100.0		
TOTAL EARTH RETURN MASS UTILIZED (KG)		1295.0	50.	25.900
FOR BASE EXPERIMENTS		.0		
FOR TRAVERSE EXPERIMENTS		1295.0		

Fig. 7-1 (Cont.)

SUMMARY OF MISSION-MODE MATCH CALCULATION PAGE 3

SCIENTIFIC PROGRAM A7
MISSION MIX 02 MISSION NUMBER 28
MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
NOMINAL MISSION START DATE= 1978A
MAX MODE STAYTIME (DAYS)= 90.

THE LISTING BELOW SUMMARIZES THE TRAVERSE CALCULATIONS PERFORMED BY THE COMPUTER.

TRAVERSE IDENTIFIER	R-01	R-02	R-03
VEHICLE IDENTIFIER	2433-04	2433-04	2433-04
MINIMUM CREW REQUIRED	2	1	2
VEHICLE CREW LEVEL	3	3	3
CREW AT BASE DURING TRAVERSE	-0	-0	-0
TRAVERSE RANGE (KM)	900.0	350.0	1150.0
MAXIMUM VEHICLE CAPABILITY (KM)	7000.0	7000.0	7000.0
REQUIRED EXCURSION TIME (DAYS)	19.4	4.9	20.9
MAXIMUM VEHICLE CAPABILITY (DAYS)	400.0	400.0	400.0
NUMBER OF STOPS	10.0	10.0	10.0
MASS OF MINOR SCIENTIFIC EQUIPMENT (KG)	6764.5	6247.5	6842.5
EARTH RETURN MASS REQUIRED (KG)	452.0	145.0	698.0
MASS OF SPACESUIT REPLACEMENTS (KG)	.0	.0	.0
MASS OF BACKPACK REPLACEMENTS (KG)	10.0	.0	10.0
TOTAL CARGO MASS REQUIRED (KG)	7226.5	6392.5	7550.5
MAXIMUM VEHICLE CAPABILITY (KG)	7660.0	7660.0	7660.0
SCIENTIFIC MAN-HOURS ON TRAVERSE	402.8	64.4	378.8
SHIRTSLEEVE	90.8	3.6	60.8
SPACESUIT	312.0	60.8	318.0
NONSCIENTIFIC MAN-HOURS ON TRAVERSE	997.2	268.1	1127.4
SHIRTSLEEVE	952.5	276.8	1079.3
SPACESUIT	44.7	11.3	48.1
SCIENTIFIC MAN-HOURS REQUIRED AT BASE	197.8	37.5	613.7
SHIRTSLEEVE	115.8	31.3	351.7
SPACESUIT	82.0	6.2	262.0
NONSCIENTIFIC MAN-HOURS REQUIRED AT BASE	.0	.0	.0
SHIRTSLEEVE	.0	.0	.0
SPACESUIT	.0	.0	.0
TRAVERSE EXPENDABLES REQUIRED (KG)	1480.7	450.1	2483.6
MAXIMUM EXPENDABLES PERMITTED (KG)	7520.0	7520.0	7520.0
BASE EXPENDABLES FOR SYSTEM SUPPORT	.0	.0	.0
DELTA V REQUIRED OF LEV (M/S)	.0	.0	.0
SPECIFIC IMPULSE (M/S)	.0	.0	.0
INERT MASS OF LEV (KG)	.0	.0	.0
LEV PROPELLANT REQUIRED (KG)	.0	.0	.0
MAXIMUM PROPELLANT PERMITTED (KG)	.0	.0	.0

Fig. 7-2 (Cont.)

SCIENTIFIC PROGRAM A7
MISSION MIX 02 MISSION NUMBER 28
NOMINAL MISSION START DATE= 1978A

MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
MAX MODE STAYTIME (DAYS)= 90.

THE FOLLOWING LISTING SUMMARIZES DETAILS OF THE EXPENDABLES CALCULATIONS FOR THE TRAVERSES REQUIRED ON PAGE 1.

TRAVERSE IDENTIFIER	R-01	R-02	R-03
VEHICLE IDENTIFIER	2433-04	2433-04	2433-04
TRAVERSE EXPENDABLES REQUIRED (KG)	1480.7	450.1	2483.6
MAXIMUM EXPENDABLES PERMITTED (KG)	7520.0	7520.0	7520.0
EXPENDABLES USAGE BREAKDOWN (KG)			
VEHICLE SUPPORT BASED ON DAILY USE	606.7	152.8	652.7
EXPERIMENT ENERGY	29.6	2.3	796.9
FOR TRAVELING	666.0	259.0	851.0
FOR STOPS	.0	.0	.0
EXTRA FOR SPACESUIT MANHOURS	178.4	36.0	183.1

NOTE -- WHEN THE MAXIMUM EXPENDABLES PERMITTED FOR A FLYING OR ROVING VEHICLE EQUALS 0, ANY CALCULATED EXPENDABLES REQUIRED ON A TRAVERSE SHOULD BE FOR SPACESUIT MANHOURS (THE REQUIREMENT OF ANY OTHER EXPENDABLES INDICATES AN ERROR IN INPUT DATA). THESE ARE CHARGED AGAINST THE SHELTER, OR ROVING VEHICLE ACTING AS A SHELTER, AND THE EXPENDABLES REQUIRED ON THE TRAVERSE ARE CONSIDERED TO BE EQUAL TO 0.

Fig. 7-2 (Cont.)

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SUMMARY OF MISSION-MODE MATCH CALCULATION PAGE 5

SCIENTIFIC PROGRAM A7
MISSION MIX 02 MISSION NUMBER 28 MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
NOMINAL MISSION START DATE= 1978A MAX MODE STAYTIME (DAYS)= 90.

THE FOLLOWING IS A VEHICLE BY VEHICLE SUMMARY OF THE DETAILS OF EXPENDABLES AND PROPELLANT CALCULATIONS FOR THE TRAVERSES REPORTED ON PAGE 1.

VEHICLE IDENTIFIER	2433-04
TOTAL EXPENDABLES REQUIRED	4814.4
MAXIMUM MASS OF EXPENDABLES PERMITTED (KG)	7520.0
MASS OF RESUPPLY EXPENDABLES REQUIRED (KG)	.0
EXPENDABLES USAGE BREAKDOWN (KG)	
VEHICLE SUPPORT BASED ON DAILY USE	1412.1
EXPERIMENT ENERGY	828.8
FOR TRAVELING	1776.0
FOR STOPS	.0
EXTRA FOR SPACESUIT MANHOURS	397.4
USED FOR SPECIAL OPERATIONS	.0
UNUSABLE (BOILOFF, ULLAGE, ETC.)	400.0
TOTAL MASS OF PROPELLANT REQUIRED (KG)	.0
MAXIMUM MASS OF PROPELLANT PERMITTED (KG)	.0
MASS OF RESUPPLY PROPELLANT REQUIRED (KG)	.0

NOTE -- IF THE MAXIMUM EXPENDABLES PERMITTED ON A VEHICLE EQUAL 0, THEN ALL OF THE EXPENDABLES REQUIRED BY THAT VEHICLE ARE SUPPLIED BY THE SHELTER, OR ROVING VEHICLE ACTING AS A SHELTER, AND THE TOTAL EXPENDABLES REQUIRED AND THE MASS OF RESUPPLY EXPENDABLES SHOULD EQUAL 0. IF NOT, THERE IS AN ERROR IN THE INPUT DATA.

Fig. 7-2 (Cont.)

SUMMARY OF MISSION-MODE MATCH CALCULATION PAGE 5

SCIENTIFIC PROGRAM A7
MISSION MIX 02 MISSION NUMBER 28
MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
MAX MODE STAYTIME (DAYS)= 90.

NOMINAL MISSION START DATE= 1976A
MISSION LOCATION- PATH 13.5.4.5
NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION- 1

THE LISTING BELOW SUMMERIZES THE SCIENTIFIC PROGRAM REQUIREMENTS FOR THIS MISSION.

THERE ARE NO FLYING TRAVERSE EXPERIMENTS

THE FOLLOWING EXPERIMENTS WERE PERFORMED ON TRAVERSE R-01

EXPERIMENT NUMBER	PHASE 2 REPLIC	MANHOURS REQUIRED (--TRAVERSE---) SPSU	(--TRAVERSE---) SHSL	(---AT BASE---) SPSU	(---AT BASE---) SHSL	(----TOTAL----) SPSU	(----TOTAL----) SHSL	EQUIPMENT ENERGY (KW-HR)	EARTH RETURN MASS (KG)	EQUIPMENT MASS CODE	EQUIPMENT MASS KG	VEHICLE CARGO CODE	VEHICLE CARGO KG
9.9.99.99.12	3.	4.0	.0	14.6	9.0	18.6	9.0	1.2	.0		24.0	B	.0
9.0.05.02.01	1.	.6	.0	.2	.0	.8	.0	.0	.0		30.0		30.0
9.9.99.99.36	1.	17.6	4.4	2.0	2.9	19.6	7.3	2.1	7.0		61.0	B	.0
2.1.01.04.12	1.	4.0	22.0	.0	.0	4.0	22.0	22.0	10.0		110.0	B	.0
2.1.02.03.07	1.	.0	.0	4.8	.0	4.8	.0	2.0	1.0	B	.0	B	.0
9.9.99.99.10	1.	22.0	.0	.0	.0	22.0	.0	.0	.0		150.0	B	.0
1.1.01.01.01	1.	.0	.0	7.4	2.0	7.4	2.0	.1	5.0		150.0	B	.0
1.2.01.02.02	1.	.0	.0	4.6	2.0	4.6	2.0	4.0	5.0		290.0	B	.0
9.9.99.99.31	1.	66.0	25.0	.0	.0	66.0	25.0	1.6	30.0		1.7	B	.0
3.4.01.04.02	1.	.0	4.5	.0	.0	.0	4.5	1.0	.0		20.0	B	.0
4.1.01.04.14	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		6000.0	B	.0
2.1.02.03.07	1.	.0	.0	4.4	.0	4.4	.0	2.0	1.0	B	.0		44.0
9.9.99.99.12	1.	1.0	.0	4.2	2.8	5.2	2.8	.4	.0	B	.0		24.0
9.0.05.02.01	1.	.6	.0	.2	.0	.8	.0	.0	.0		30.0		30.0
4.1.01.04.14	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		6000.0		6000.0
9.9.99.99.10	1.	22.0	.0	.0	.0	22.0	.0	.0	.0		150.0		150.0
2.1.02.03.07	1.	.0	.0	4.4	.0	4.4	.0	2.0	1.0	B	.0		44.0
2.1.01.04.12	1.	3.0	20.0	.0	.0	3.0	20.0	22.0	10.0	B	.0		110.0
9.9.99.99.36	1.	11.0	2.2	1.2	2.7	12.2	4.9	2.1	7.0	B	.0		61.0
9.9.99.99.12	3.	3.0	.0	12.6	8.4	15.6	8.4	1.2	.0	B	.0		24.0
4.0.08.04.54	1.	.0	.0	.0	.0	.0	.0	.4	.0		3.5		3.5
4.1.05.03.41	1.	.0	.0	.0	.0	.0	.0	.0	.0		4.0		4.0
4.4.07.04.51	1.	.0	.0	.0	.0	.0	.0	.0	.0		1.0		1.0
9.9.99.99.32	91.	36.4	1.5	.0	18.2	36.4	19.7	4.7	.0		21.0		21.0
9.9.99.99.33	46.	.0	11.2	15.8	14.7	15.8	25.9	3.9	230.0		86.0		86.0
9.9.99.99.34	5.	51.2	.0	1.8	44.6	53.0	44.6	1.0	100.0		57.0		57.0
9.9.99.99.35	3.	49.6	.0	3.8	8.5	53.4	8.5	6.3	45.0		75.0		75.0
TOTALS		312.0	90.8	82.0	115.8	394.0	206.6	80.1	452.0		13264.2		6764.5

Fig. 7-2 (Cont.)

SCIENTIFIC PROGRAM A7
MISSION MIX 02 MISSION NUMBER 28
MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
NOMINAL MISSION START DATE= 1978A
MAX MODE STAYTIME (DAYS)= 90.
MISSION LOCATION- PATH 13.5.4.5
NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION- 1

THE LISTING BELOW SUMMERIZES THE SCIENTIFIC PROGRAM REQUIREMENTS FOR THIS MISSION.

THE FOLLOWING EXPERIMENTS WERE PERFORMED ON TRAVERSE P-02

EXPERIMENT NUMBER	PHASE 2 REPLIC	MANHOURS REQUIRED (--TRAVERSE---) SPSU	(--TRAVERSE---) SHSL	(---AT BASE---) SPSU	(---AT BASE---) SHSL	(----TOTAL----) SPSU	(----TOTAL----) SHSL	EQUIPMENT ENERGY (KW-HR)	EARTH RETURN MASS (KG)	EQUIPMENT MASS CODE	EQUIPMENT MASS KG	VEHICLE CARGO CODE	VEHICLE CARGO KG
4.1.01.04.14	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		6000.0		6000.0
4.0.08.04.54	1.	.0	.0	.0	.0	.0	.0	.4	.0	B	.0		3.5
4.1.05.03.41	1.	.0	.0	.0	.0	.0	.0	.0	.0	B	.0		4.0
4.4.07.04.51	1.	.0	.0	.0	.0	.0	.0	.0	.0	B	.0		1.0
9.9.99.99.32	35.	14.0	.0	.0	7.0	14.0	7.0	1.8	.0	B	.0		21.0
9.9.99.99.33	18.	.0	3.6	5.4	5.8	5.4	9.4	1.5	90.0	B	.0		86.0
9.9.99.99.34	2.	20.4	.0	.4	17.0	20.8	17.0	.4	40.0	B	.0		57.0
9.9.99.99.35	1.	16.4	.0	.4	1.5	16.8	1.5	2.1	15.0	B	.0		75.0
TOTALS		60.8	3.6	6.2	31.3	67.0	34.9	6.2	145.0		6000.0		6247.5

Fig. 7-2 (Cont.)

SCIENTIFIC PROGRAM A7
MISSION MIX 02 MISSION NUMBER 28
MODE I.D. NUMBER 503-30114-01
CREW LEVEL TOTAL= 3
PERFORMING EXPERIMENTS= 3
MAX MODE STAYTIME (DAYS)= 90.

NOMINAL MISSION START DATE= 1978A
MISSION LOCATION- PATH 13.5,4.5
NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION- 1

THE LISTING BELOW SUMMERIZES THE SCIENTIFIC PROGRAM REQUIREMENTS FOR THIS MISSION.

THE FOLLOWING EXPERIMENTS WERE PERFORMED ON TRAVERSE R-03

EXPERIMENT NUMBER	PHASE 2 REPLIC	MANHOURS REQUIRED (--TRAVERSE---) SPSU	(--TRAVERSE---) SHSL	(---AT BASE---) SPSU	(---AT BASE---) SHSL	(----TOTAL----) SPSU	(----TOTAL----) SHSL	EQUIPMENT ENERGY (KW-HR)	EARTH RETURN MASS (KG)	EQUIPMENT MASS CODE	EQUIPMENT MASS KG	VEHICLE CARGO CODE	VEHICLE CARGO KG
1.1.01.01.01	1.	.0	.0	7.4	2.0	7.4	2.0	.1	5.0		150.0	B	.0
1.2.01.02.02	1.	.0	.0	4.6	2.0	4.6	2.0	4.0	5.0		290.0	B	.0
9.9.99.99.31	1.	66.0	25.0	.0	.0	66.0	25.0	1.6	30.0		1.7	B	.0
4.1.01.04.14	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		6000.0	B	.0
2.1.02.03.08	1.	.0	.0	170.0	213.0	170.0	213.0	2100.0	200.0	A	.0	A	.0
9.9.99.99.12	10.	10.0	.0	42.0	28.0	52.0	28.0	4.1	.0		24.0	B	.0
4.2.02.07.84	1.	.0	.0	.0	.0	.0	.0	.0	.0		3.0	B	185.0
4.2.02.07.84	1.	.0	.0	.0	.0	.0	.0	.0	.0		3.0	B	185.0
2.1.02.03.07	1.	.0	.0	4.8	.0	4.8	.0	2.0	1.0	B	.0	B	.0
9.9.99.99.12	1.	1.0	.0	4.2	2.8	5.2	2.8	.4	.0	B	.0	B	.0
4.1.01.04.13	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		2500.0		2500.0
4.1.01.04.12	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		2100.0		2100.0
4.1.01.04.11	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		1300.0		1300.0
4.1.01.04.10	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		80.0		80.0
4.1.01.04.09	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		42.0		42.0
4.1.01.04.08	1.	10.0	.0	.0	.0	10.0	.0	.0	.0		13.0		13.0
4.1.01.04.07	1.	14.0	.0	.0	.0	14.0	.0	.0	.0		19.0		19.0
2.1.01.04.12	1.	4.0	22.0	.0	.0	4.0	22.0	22.0	10.0	B	.0		110.0
9.9.99.99.36	1.	11.0	2.2	1.2	2.7	12.2	4.9	2.1	7.0	B	.0		61.0
9.9.99.99.12	2.	2.0	.0	8.4	5.6	10.4	5.6	.8	.0	B	.0	B	.0
4.0.08.04.54	1.	.0	.0	.0	.0	.0	.0	.4	.0	B	.0		3.5
4.1.05.03.41	1.	.0	.0	.0	.0	.0	.0	.0	.0	B	.0		4.0
4.4.07.04.51	1.	.0	.0	.0	.0	.0	.0	.0	.0	B	.0		1.0
9.9.99.99.32	115.	46.0	.0	.0	23.0	46.0	23.0	6.0	.0	B	.0		21.0
9.9.99.99.33	58.	.0	11.6	17.4	18.6	17.4	30.2	4.9	290.0	B	.0		86.0
9.9.99.99.34	6.	61.2	.0	1.2	51.0	62.4	51.0	1.2	120.0	B	.0		57.0
9.9.99.99.35	2.	32.8	.0	.8	3.0	33.6	3.0	4.2	30.0	B	.0		75.0
TOTALS		318.0	60.8	262.0	351.7	580.0	412.5	2153.8	698.0		12525.7		6842.5

Fig. 7-2 (Cont.)

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                    SUMMARY OF MISSION-MODE MATCH CALCULATION          PAGE  9

 SCIENTIFIC PROGRAM A7                                    MODE I.D. NUMBER 503-30114-01
       MISSION MIX  02          MISSION NUMBER  28        CREW LEVEL          TOTAL=  3
                                                            PERFORMING EXPERIMENTS=  3
 NOMINAL MISSION START DATE= 1976A                        MAX MODE STAYTIME (DAYS)=  90.
 MISSION LOCATION- PATH   13.5.4.5
 NUMBER OF TIMES AT THIS LOCATION COUNTING THIS MISSION-  1

 THE LISTING BELOW SUMMERIZES THE SCIENTIFIC PROGRAM REQUIREMENTS FOR THIS MISSION.

 THERE ARE NO BASE EXPERIMENTS
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Fig. 7-2 (Cont.)

Chapter 8
EXPLORATION PROGRAM GENERATION

A candidate lunar exploration program results from scheduling a specific set of mission-mode combinations. Each such scheduled set exhibits unique values for various parameters. These parameters include total cost, annual costs, launch rate, and equipment start dates. In the MIMOSA analysis procedure, the planner establishes a tentative mission schedule, and the MIMOSA computer program adjusts that schedule to fit given launch rates and calculates the resulting values for the various lunar program parameters. This chapter discusses the two special aspects of lunar program generation – mission scheduling and computer usage.

8.1 MISSION SCHEDULING

In lunar program generation, the program planner establishes the schedule of missions by specifying the particular 6-mo time period of each mission start. The mission start date is input with the original mission data, but this date can be altered easily on any subsequent computer run.

Generally, study ground rules will dictate the mission start dates for any particular program. Most often, these rules involve financial constraints imposed in the form of launch-rate limits and maximum funding levels. Sometimes specific dates are dictated for new R&D, or a requirement is established as to the timing for introduction of new hardware. Integration with current or projected NASA plans will also affect scheduling.

8.2 COMPUTER USAGE

The MIMOSA computer program performs nearly all the cost and funding calculations for a candidate lunar program. If the data for all missions and modes are input

properly (paragraph 5.4 and 6.3), only four types of control cards are needed to initiate the costing routine. Paragraph 10.10 presents detailed instructions for preparing these cards.

A first card is required for each candidate program. This card identifies the program (i.e., titles the printout), establishes the maximum Saturn launch rate before funds must be expended to improve facilities, and sets "flags" for the computer as to whether certain cost calculation options are desired. There are three permitted options: to consider emergency modes (paragraph 6.6), to procure backup or spare equipment (item 33, Table 4-2), and to exceed a predetermined Saturn launch rate.

A second type of card is required to input the necessary Saturn launch-rate limit.

The third type of card inputs the mission-mode combinations to be costed. The combinations can be input in any order except where the start of one mission depends on completion of another mission. Space is provided with each input to override any start date previously given for a mission.

The fourth set of cards inputs the cost for facility launch-rate improvements. The effects of up to ten incremental step-ups in launch rate may be costed.

Figure 8-1 displays a portion of the computer printout for an example exploration program. This program performs a scientific effort of about 54,000 scientific man-hours. The program has three major steps in its post-Apollo equipment evolution. The first step involves use of a LM shelter and a personnel taxi for 14-day missions. The second step, beginning in 1976, calls for a Saturn uprating to 125 percent of present payload for three-man LOR delivery, a cryogenic logistics vehicle for direct cargo delivery, and use of a three-man rover and trailer. The third step, beginning in 1981, involves a 175 percent Saturn for eventual six-man direct delivery. Mission 28 is the same example mission described in paragraphs 5.3 and 7.3.

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                                COSTING SECTION COMMENTS

                    SUMMARY OF LUNAR EXPLORATION PROGRAM  EXAMPLE

          SCIENTIFIC PROGRAM  A7        MISSION MIX  03            NUMBER OF MISSIONS =  26

     WOULD YOU BELIEVE THE FOLLOWING COMMENTS FROM THE COSTING SECTION .....

      UNABLE TO LOCATE A BOOSTER FOR TRANSPORTATION SYSTEM 121101 WHICH IS BEING USED FOR TEST LAUNCH OF SYSTEM 212101
     SYSTEM 117101 HAS NO MISSION-ORIENTED USES BUT IS USED FOR A TEST LAUNCH OF ANOTHER SYSTEM.
     SYSTEM 117202 HAS NO MISSION-ORIENTED USES BUT IS USED FOR A TEST LAUNCH OF ANOTHER SYSTEM.
     SYSTEM 117204 HAS NO MISSION-ORIENTED USES BUT IS USED FOR A TEST LAUNCH OF ANOTHER SYSTEM.
     SYSTEM 121101 HAS NO MISSION-ORIENTED USES BUT IS USED FOR A TEST LAUNCH OF ANOTHER SYSTEM.
     SYSTEM 121401 HAS NO MISSION-ORIENTED USES BUT IS USED FOR A TEST LAUNCH OF ANOTHER SYSTEM.
     THE NONRECURRING COST CURVE FOR MINOR SCIENTIFIC EQUIP. BEGINS EARLIER THAN 1967A
     THE NONRECURRING COST CURVE FOR MINOR SCIENTIFIC EQUIP. BEGINS EARLIER THAN 1967A
     THE NONRECURRING COST CURVE FOR MINOR SCIENTIFIC EQUIP. BEGINS EARLIER THAN 1967A
     THE NONRECURRING COST CURVE FOR MINOR SCIENTIFIC EQUIP. BEGINS EARLIER THAN 1967A
     THE NONRECURRING COST CURVE FOR MINOR SCIENTIFIC EQUIP. BEGINS EARLIER THAN 1967A
     THE NONRECURRING COST CURVE FOR MINOR SCIENTIFIC EQUIP. BEGINS EARLIER THAN 1967A
     THE NONRECURRING COST CURVE FOR MINOR SCIENTIFIC EQUIP. BEGINS EARLIER THAN 1967A
```

Fig. 8-1 Example Computer Printout – Integration and Cost

SUMMARY OF LUNAR EXPLORATION PROGRAM EXAMPLE PAGE 1

SCIENTIFIC PROGRAM A7 MISSION MIX 03 NUMBER OF MISSIONS = 26

THE FOLLOWING COSTS, IN MILLIONS, WERE CALCULATED FOR THIS LUNAR EXPLORATION PROGRAM

TOTAL NONRECURRING COST	6852.9	TOTAL RECURRING COST	18705.8
NONRECURRING DEVELOPMENT	6565.4	RECURRING PROCUREMENT	15125.2
COST OF FACILITIES	287.5	RECURRING OPERATIONS	3580.6

TOTAL PROGRAM COST 25558.7

THE FOLLOWING ITEMS OF EXPLORATION EQUIPMENT ARE REQUIRED

EQUIPMENT NAME	IDENTIFIER	R / D START	FIRST USED	NUMBER PROCURED MISS	T/L	SPARES	COST SUMMARY (MILLIONS) NONRECURRING R / D	NONRECURRING C OF F	RECURRING HDWE	RECURRING OPNS
PERS TRANSP-LOR(2-MAN)	1111-01	N / A	1971A	5	0	1	.0	.0	4.8	.0
PERS TRANSP - AAP FUNDED	1111-04	N / A	1970B	1	0	1	.0	.0	.0	.0
PERS TRANSP-LOR(3-MAN)	1112-05	1973B	1976A	9	0	1	33.6	.0	7.5	.0
PERS TRANSP-DIR(6-MAN)	1124-01	1979A	1981B	11	0	2	10.7	.0	4.8	.0
LOG. TRANSP-LOR,4000KG	1132-03	N / A	1971A	6	0	1	.0	.0	5.5	.0
LOG. TRANSP - AAP FUNDED	1132-04	N / A	1970B	1	0	1	.0	.0	.0	.0
LOG. TRANSP-DIR,16000KG	1144-01	1974A	1976A	14	0	2	5.7	.0	3.0	.0
LOG. TRANSP-DIR,25000KG	1147-01	1979B	1981B	17	0	2	5.7	.0	3.5	.0
ORB. TRANSP,SATURN 5	1152-01	N / A	1971B	2	0	1	.0	.0	2.6	.0
ORBITER TRANS-AAP FUNDED	1152-03	N / A	1970A	1	0	1	.0	.0	.0	.0
DEVELOPMENT TEST TRANSP	1171-01	N / A	1975B	0	4	1	.0	.0	.0	.0
DEVELOPMENT TEST TRANSP	1172-02	N / A	1975A	0	2	1	.0	.0	.0	.0
DEVELOPMENT TEST TRANSP	1172-04	N / A	1980B	0	2	1	.0	.0	.0	.0
ATLAS-AGENA LAUNCH VEH.	1211-01	N / A	1970A	0	1	1	.0	.0	6.4	1.5
SATURN 1B LAUNCH VEHICLE	1214-01	N / A	1975B	0	4	4	.0	.0	.0	.0
SATURN 5 LAUNCH VEH.	1221-01	N / A	1971A	13	0	2	.0	.0	2099.5	270.0
APOLLO SAT. V LAUNCH VEH	1221-03	N / A	1970A	3	0	1	.0	.0	.0	.0
UPRATED SATURN 5	1231-01	1972A	1976A	23	0	3	570.0	42.0	2760.3	483.6
UPRATED SATURN 5	1251-01	1977B	1981B	28	0	3	818.0	135.0	3673.1	576.6
CM-LOR-3-MAN	1311-01	N / A	1971A	13	0	2	.0	.0	903.0	226.5
CM-LOR-3-MAN	1311-02	1973B	1976A	9	0	1	28.2	.0	608.5	151.0
SM-LOR(STOR)-3-MAN	1321-01	N / A	1971A	13	0	2	.0	.0	328.1	61.5
SM-LOR(STOR)-3-MAN	1321-04	1973B	1976A	9	0	1	47.6	.0	212.4	39.0
PERS DESC STG-LOR STOR	1331-01	1967B	1970B	6	0	1	20.5	.0	101.6	22.4
PERS DESC STG-LOR STOR	1332-02	1972B	1976A	9	0	1	129.0	.0	206.5	35.0
PERS ASC STG-LOR 2-MAN	1341-01	1967B	1970B	6	0	1	11.1	.0	246.8	62.3
PERS ASC STG-LOR 3-MAN	1342-01	1972B	1976A	9	0	1	117.0	.0	354.1	90.0
LOG.DESC STG-LOR STOR	1351-03	1968A	1970B	7	0	1	105.7	.0	172.5	67.2
CM-DIRECT-6-MAN	1412-02	1977B	1981B	11	0	2	565.5	.0	1092.6	205.4
PERS BRAKING STG-DIR	1421-02	1976B	1981B	11	0	2	459.4	24.0	78.8	15.6
LOG.BRAK STG-DIR CRYO	1423-02	N / A	1976A	14	0	2	.0	.0	113.1	20.8
LOG.BRAK STG-DIR CRYO	1423-04	N / A	1981B	17	0	2	.0	.0	131.3	24.7
PERS LANDING STG-DIR	1431-03	N / A	1981B	11	0	2	.0	.0	119.7	19.5

Fig. 8-1 (Cont.)

SCIENTIFIC PROGRAM A7 MISSION MIX 03 NUMBER OF MISSIONS = 26

THE FOLLOWING ITEMS OF EXPLORATION EQUIPMENT ARE REQUIRED (CONT.)

EQUIPMENT NAME	IDENTIFIER	R / D START	FIRST USED	NUMBER PROCURED MISS	T/L	SPARES	COST SUMMARY (MILLIONS) NONRECURRING R / D	NONRECURRING C OF F	RECURRING HDWE	RECURRING OPNS
LOG.LAND.STG-DIR CRYO	1433-02	1971B	1976A	14	0	2	598.8	24.0	215.1	33.6
LOG. LANDNG STG-DIR-CRYO	1433-04	1977A	1981B	17	0	2	687.3	24.0	274.1	43.7
PERS RET.STG-DIR CRYO	1454-01	1977B	1981B	11	0	2	334.1	12.0	311.0	49.4
ORBIT LAUNCHED PROBE	2121-01	1968B	1970A	7	0	1	57.5	.0	26.3	2.4
SURFACE LAUNCHED PROBE	2132-02	1974B	1978A	20	0	2	37.7	.0	45.5	4.4
ORBITER RACK	2222-02	1967B	1970A	3	0	3	1.0	.0	.0	.0
PERSONNEL SHELTER,2-MAN	2321-01	1967B	1970B	6	0	1	110.8	.0	145.8	25.2
PERSONNEL SHELTER,6-MAN	2325-05	1980B	1985B	1	0	1	484.3	.0	87.7	11.4
LRV-NO CABIN	2421-01	1967B	1970B	7	0	1	58.0	2.0	39.2	4.0
ROVING VEH 3 MAN 90 DAYS	2423-03	1969B	1976A	16	0	2	421.0	2.0	347.2	27.0
TRAILER-MULTIPURPOSE-LRG	2433-04	1975A	1978A	9	0	1	51.8	2.5	84.0	2.0
LFV-EXPLORATION,2-MAN	2512-03	1967B	1970B	2	0	1	48.0	.0	7.8	.6
LFV-RETURN TO ORBIT	2521-02	1974A	1978A	5	0	1	62.2	.0	19.8	1.8
REACTOR PWR SUPPLY-20 KW	2721-02	1979A	1985B	1	0	1	135.8	20.0	27.8	.0
300-M DRILL W/FUEL CELL	3213-02	1974B	1978A	5	0	1	11.3	.0	10.8	.0
15-M PARAB. RADIO TELESC	3223-01	1981B	1985B	1	0	1	4.1	.0	3.6	.0
RADIO TELESC-MILLS CROSS	3224-02	N / A	1985B	1	0	1	.0	.0	.0	.0
X-RAY TELESCOPE	3231-01	1978B	1985B	1	0	1	38.8	.0	6.2	1.0
OPTICAL TELESCOPE 1METER	3242-01	1970A	1974B	1	0	1	28.7	.0	11.2	1.0
2-M OPTICAL TELESCOPE	3242-04	1979B	1985B	1	0	1	152.2	.0	24.6	1.2
2.5-M OPTICAL TELESCOPE	3243-01	1978B	1985B	1	0	1	226.8	.0	35.2	1.4

Fig. 8-1 (Cont.)

SUMMARY OF LUNAR EXPLORATION PROGRAM EXAMPLE PAGE 3

SCIENTIFIC PROGRAM A7 MISSION MIX 03 NUMBER OF MISSIONS = 26

THE FOLLOWING EXPLORATION CONCEPT MODES ARE REQUIRED

MODE IDENTIFIER	CREW LEVEL TOTAL	CREW LEVEL AT SITE	STAY TIME (DAYS)	FIRST USED	NUMBER USED	COST SUMMARY (MILLIONS) NONRECURRING R / D	NONRECURRING C OF F	RECURRING HDWE	RECURRING OPNS
303-10021-02	3	3	28	1970A	1	.0	.0	.0	25.2
303-10022-02	3	3	28	1971B	2	.0	.0	.0	50.4
402-10011-01	3	2	14	1971A	1	.0	.0	.0	16.7
402-10011-03	3	2	14	1972A	3	.0	.0	.0	50.1
402-10012-01	3	2	14	1970B	1	.0	.0	.0	16.7
402-10081-01	3	2	14	1974B	1	.0	.0	.0	54.5
406-30161-01	6	6	180	1985B	1	.0	.0	.0	93.4
406-30161-02	6	6	720	1986A	1	.0	.0	.0	68.2
503-20162-01	3	3	90	1976A	7	.0	.0	.0	176.4
503-20191-01	3	3	90	1978A	1	.0	.0	.0	80.4
503-20201-01	3	3	90	1980B	1	.0	.0	.0	54.5
503-30083-01	3	3	90	1982A	1	.0	.0	.0	25.2
503-30094-01	3	3	90	1981B	2	.0	.0	.0	109.0
503-30103-01	3	3	90	1982B	2	.0	.0	.0	109.0
503-30114-01	3	3	90	1983B	1	.0	.0	.0	68.2

Fig. 8-1 (Cont.)

COST REPORT FOR LUNAR EXPLORATION PROGRAM EXAMPLE PAGE 6

SCIENTIFIC PROGRAM A7 MISSION MIX 03 NUMBER OF MISSIONS = 26

THE FOLLOWING SCHEDULES AND COSTS WERE CALCULATED FOR THIS LUNAR EXPLORATION PROGRAM

CALENDAR YEAR	MISSION START	SATURN LAUNCH RATE MISSION USE 1B	5	5UPR	DEVELOPMENT USE 1B	5	5UPR	COST SUMMARY (MILLIONS) NONRECURRING R / D	C OF F	RECURRING HDWE	OPNS	FY ANNUAL COST (MIL.)	CUM. COST (BIL.)
1967A								4.8				4.8	
								27.3	.1	25.5			
1968A								64.8	1.0	51.2		169.9	.2
								105.3	9	179.9	4.0		
1969A								127.7		305.6	6.5	730.0	.9
								105.9	1	400.2	19.9		
1970A	07		1					59.4	.2	461.9	73.8	1121.3	2.0
	08		2					53.3	.9	436.7	92.3		
1971A	09		2					59.9	.8	428.3	111.1	1183.3	3.2
	10		1					74.5	1.0	388.8	97.0		
1972A	11		2					124.8	4.0	397.4	89.9	1177.4	4.4
	12		2					177.7	12.0	398.1	86.8		
1973A								228.5	19.0	393.4	72.5	1388.0	5.8
	14 13		3					299.0	19.0	358.5	128.2		
1974A								325.0	11.0	371.1	89.1	1600.9	7.4
	15		3					324.6		401.0	86.8		
1975A							1	250.4	.1	458.9	50.2	1571.9	8.9
					1		1	116.4	.2	508.8	79.4		
1976A	16			2				47.3	.9	467.5	119.7	1340.1	10.3
	17			2				46.9	1.8	480.2	98.7		
1977A	18			2				44.1	3.5	471.6	125.0	1271.8	11.6
	19			2				117.7	17.0	411.4	123.8		
1978A	20			5				240.1	33.0	388.1	125.3	1456.4	13.0
								404.5	56.5	378.2	102.8		
1979A	22 21			4				537.4	58.9	403.2	130.2	2071.7	15.1
	23			2				589.8	34.4	443.1	89.0		
1980A								547.1	4.4	548.6	76.1	2332.6	17.4
	24			4			1	422.4	4.4	534.3	111.2		
1981A					3		1	235.6	2.4	529.8	100.9	1941.0	19.4
	25			3				121.8		451.8	125.7		
1982A	26			2				143.0		517.5	99.0	1458.7	20.8
	27			3				154.7		507.9	99.1		
1983A								148.1		522.8	115.9	1548.5	22.4
	28			4				128.1		482.9	142.8		
1984A	29			3				79.9		445.7	110.7	1390.0	23.8
	30			3				27.8		360.2	128.3		
1985A										305.3	119.6	941.2	24.7
	31			6						198.0	129.2		
1986A	32			1						160.1	75.7	563.0	25.3
				1						104.5	71.2		
1987A				1						46.8	44.2	266.7	25.5
				1						.4	29.0	29.4	
TOTAL		0	16	51	4	0	4	6565.4	287.5	15125.2	3580.6	25558.7	25.6

Fig. 8-1 (Cont.)

COST REPORT FOR LUNAR EXPLORATION PROGRAM EXAMPLE PAGE 7

SCIENTIFIC PROGRAM A7 MISSION MIX 03 NUMBER OF MISSIONS = 26

THE FOLLOWING FISCAL YEAR COSTS WERE CALCULATED FOR THIS LUNAR EXPLORATION PROGRAM

COST SUMMARY (MILLIONS)

FISCAL YEAR	NONRECURRING COSTS R/D	C OF F	TOTAL	RECURRING COSTS HDWE	OPNS	TOTAL	FY ANNUAL COST (MIL.)	CUM. COST (BIL.)
1967	4.8		4.8				4.8	
1968	92.1	1.1	93.2	76.8		76.8	169.9	.2
1969	233.0	.9	233.9	485.6	10.5	496.1	730.0	.9
1970	165.3	.3	165.6	862.0	93.7	955.7	1121.3	2.0
1971	113.2	1.7	114.9	865.0	203.4	1068.4	1183.3	3.2
1972	199.3	5.0	204.3	786.2	186.9	973.1	1177.4	4.4
1973	406.1	31.0	437.1	791.5	159.3	950.8	1388.0	5.8
1974	624.0	30.0	654.0	729.6	217.3	946.9	1600.9	7.4
1975	575.0	.1	575.1	859.9	137.0	996.9	1571.9	8.9
1976	163.6	1.1	164.7	976.3	199.1	1175.4	1340.1	10.3
1977	91.0	5.3	96.3	951.8	223.7	1175.5	1271.8	11.6
1978	357.8	50.0	407.8	799.5	249.1	1048.6	1456.4	13.0
1979	941.9	115.4	1057.3	781.4	233.0	1014.4	2071.7	15.1
1980	1137.0	38.8	1175.8	991.7	165.1	1156.8	2332.6	17.4
1981	658.0	6.8	664.8	1064.1	212.1	1276.2	1941.0	19.4
1982	264.8		264.8	969.3	224.7	1194.0	1458.7	20.8
1983	302.8		302.8	1030.7	215.0	1245.7	1548.5	22.4
1984	208.0		208.0	928.5	253.5	1182.0	1390.0	23.8
1985	27.8		27.8	665.5	247.9	913.4	941.2	24.7
1986				358.1	204.9	563.0	563.0	25.3
1987				151.3	115.4	266.7	266.7	25.5
				.4	29.0	29.4	29.4	
TOTAL	6565.4	287.5	6852.9	15125.2	3580.6	18705.8	25558.7	25.6

Fig. 8-1 (Cont.)

SCIENTIFIC PROGRAM A7 MISSION MIX 03 NUMBER OF MISSIONS = 26

THE FOLLOWING SUMMARIZES EXPLORATION EQUIPMENT COSTS CALCULATED FOR THIS LUNAR EXPLORATION PROGRAM.

	SYSTEM 2423-03 ROVING VEH 3 MAN 90 DAYS							SYSTEM 2433-XX TRAILER-MULTIPURPOSE-LRG						
	NONRECURRING		NO. PROCURED			RECURRING		NONRECURRING		NO. PROCURED			RECURRING	
	R / D	C OF F	MISS	T/L	SPR	HDWE	OPNS	R / D	C OF F	MISS	T/L	SPR	HDWE	OPNS
1967A														
1968A														
1969A	18.0	.1												
1970A	28.0	.2												
	50.0	.9												
1971A	55.0	.8												
	58.0													
1972A	55.0													
	45.0													
1973A	40.0													
	30.0					10.6								
1974A	25.0					24.5								
	17.0		1		1	27.6	1.4							
1975A			1			20.3	2.3	4.5	.1					
			1			19.8	1.5	12.0	.2					
1976A			1			15.0	1.5	14.0	.9				4.3	
			1			15.5	1.5	13.0	.8				8.5	
1977A						21.9	.8	8.3	.5	1		1	4.7	.2
			2			20.3	1.4							.2
1978A			1			10.5	2.3							
						8.4	.8						2.2	
1979A			1			10.3	.7						4.2	
						17.6	.8			1			4.4	.1
1980A			1			27.0	.7						6.1	.1
			1		1	19.7	2.2			1			8.4	.1
1981A			1			10.2	2.3			1			6.3	.2
						12.8	.8			1			4.3	.2
1982A			1			18.2	.7						6.0	.1
			1			13.6	1.5			1			8.2	.1
1983A			1			10.0	1.5			1			6.2	.2
						8.1	.8			1			4.2	.2
1984A			1			5.5	.7						3.9	.1
							.8			1			2.2	.1
1985A														.1
1986A														
1987A														
TOTAL	421.0	2.0	16	0	2	347.2	27.0	51.8	2.5	9	0	1	84.0	2.0

Fig. 8-1 (Cont.)

The cost printout has five major parts: a comments page, a breakdown of costs by equipment item and by mode, a schedule and funding summary given by 6-mo increments, a funding summary by fiscal year, a launch rate distribution table, and a usage and funding summary for each item of equipment. The computer provides almost 50 pages of printout; only 7 sample pages are shown in the figure. The remainder consists of cost and procurement histories of each mode and system used in the program in a format similar to Page 8-1, Fig. 8-1.

The annual funding summary shows a peak post-Apollo funding requirement of over $2.3 billion in FY 1980. This peak, which could be smoothed by adjustment of mission start dates, is caused by combined costs for nonrecurring R&D and recurring equipment procurement at the time of the second Saturn uprating.

Chapter 9
PROGRAM DATA SUMMARY

In the MIMOSA analysis procedure, a lunar exploration planning question is answered by studying one or more associated candidate lunar programs. To do this efficiently requires means of collecting and displaying the pertinent calculated data. This chapter suggests a standard format for data display in the form of an Exploration Program Summary.

The experience gained from the MIMOSA contract study resulted in a special summary format for presenting program data considered of greatest value to planners. A sample of this format is given in Appendix A. The format consists of the following seven parts:

- General Description – gives a brief description of the exploration program and defines the assumptions and guidelines used for program generation
- Scientific Program Description – gives a general verbal explanation of the science program objectives
- Lunar Surface Exploration Pattern – displays locales and paths for a program on a lunar map
- Cost and Schedule Summary – summarizes the major program cost and schedule data. The Saturn launch rate appears above a bar chart showing the timing of the major steps in the equipment evolution. Numbers inside each bar indicate the number of missions performed each year. In the middle of the summary is a graphical display of nonrecurring and total costs by fiscal year. A table at the bottom shows the breakdown of the required annual funding.
- Post-Apollo Mission Summary – identifies and tabulates data on each mission in the program. The mission summary lists mission dates,

mission locations, mode used, number of launches, staytime, total and scientific manhours, total cargo and scientific mass, mass reserve, and total traverse range. Total cargo mass refers to the total useful landed mass (mission equipment + scientific equipment). The mass reserve represents the unused mass delivery potential of the mode (i. e., landed payload capability less total cargo) and indicates the "overkill" of the mission by mode. Large values occur in the example in Appendix A because a fixed scientific program size was established before any missions and modes were matched. The resulting missions did not fully tax the mode capabilities. In practice, the scientific requirements would be tailored to produce more efficient usage of the mode capability. The traverse range given in the mission summary is the actual distance traveled in the performance of the mission, and this often exceeds scientific requirements

- Equipment Usage and Cost Summary – records the major items of exploration equipment used in a program, details the quantities procured, and displays the resulting cost breakdown for each item. The identification numbers given for individual exploration equipment allow easy reference to the MIMOSA Data Book for detailed descriptions and performance data
- Scientific Program Operation Summary – displays cumulative scientific manhours and mass for a program and relates these to cumulative cost as a function of calendar time

Chapter 10
MIMOSA COMPUTER PROGRAM INPUT INSTRUCTIONS

The MIMOSA Program will require the routine handling of large amounts of technical and resource data. A computer program has been devised to assist the data organizing task and to perform certain calculations. Both of these tasks would require many manhours of tedious labor if done by hand.

A computer performs only the instructions it is given and acts only on the data it is presented. The purpose of this chapter is to present the steps that must be followed to provide the computer with the proper data and instructions.

10.1 GENERAL COMPUTER INFORMATION

The MIMOSA computer program has been written in FORTRAN IV for the Univac 1107 and is compatible with the faster Univac 1108. The program consists of three major routines as shown in Table 10-1.

The logic instructions to run the program are stored on reels of magnetic tape. The instructions for the first and third routines are written on one reel. The Mission/Mode Comparison Routine is written on another reel. A list of all the instructions on these tapes is held by NASA/MSFC. Flow diagrams of the program logic for routines 2 and 3, are presented as separate Appendixes (K and L) to this volume.

All input data used by the three routines are stored on two additional reels of magnetic tape. The input data for a given lunar exploration program are grouped into six categories on the two tapes in the order shown in Table 10-2.

Table 10-1

MIMOSA COMPUTER PROGRAM ROUTINES

Routine		Functions	Approximate Number of Instruction Cards	Estimated Run Time (min)	
No.	Name			1107	1108
1	Input and Update	• Generates memory tapes from card inputs • Updates tapes • Copies all or part of any data record	7,000	15 min to perform any function	3 min to perform any function
2	Mission/ Mode Comparison	• Compares mode capabilities with mission requirements (~45 tests) • Indicates possible problems in matching mode to mission	9,000	12 min for ~ 30 comparisons	2-1/2 min for ~ 30 comparisons
3	Integration and Cost	• Establishes lunar program schedule • Determines systems used vs. projected time • Calculates non-recurring and recurring costs vs. projected time	8,000	12 min for ~ 30 mission programs	2-1/2 min for ~ 30 mission programs

Table 10-2
DATA FILES USED BY MIMOSA COMPUTER PROGRAM

Reel	File Order	Max. No. of Entries Per File
Mission/Mode Tape	Missions	50
	Exploration Concept Modes	100
	Emergency Modes	25
System/Experiment Tape	Systems	200
	Subsystem State-of-the-Art Advances	50
	Experiments	500

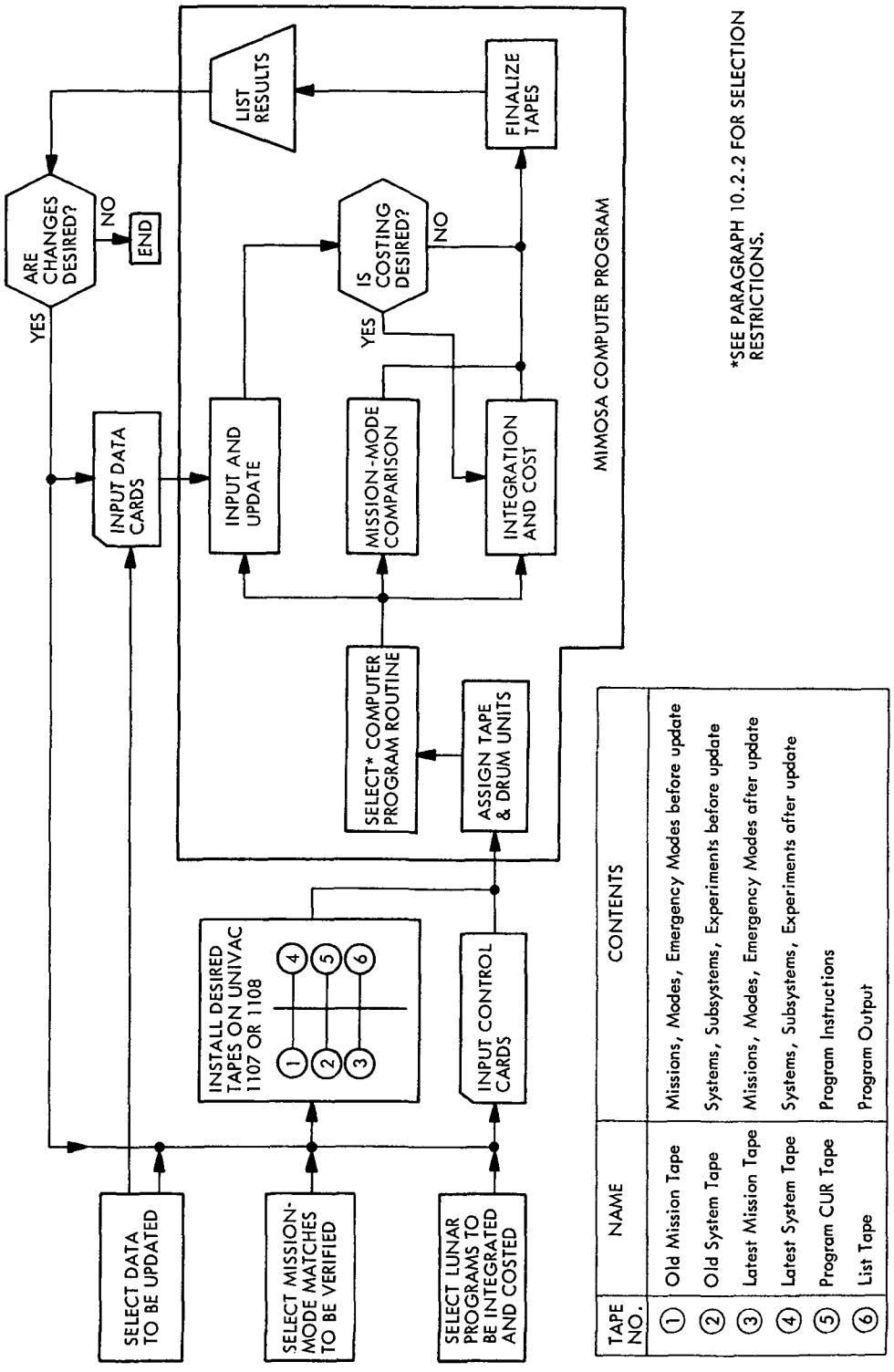
A new Mission/Mode Tape is normally generated for each different lunar exploration program investigated because of the limited number of missions permitted on a tape. However, a common System/Experiment Tape can usually be maintained for all programs.

10.1.1 Man/Computer Interface

Figure 10-1 presents the man/computer interface associated with the MIMOSA computer program. The program planner must perform the following three principal tasks:

- Select the magnetic tapes to be used
- Prepare control cards (for program control)
- Prepare data cards

The computer assigns tape and drum units based on instructions in the control cards. It then reads in the appropriate program tape and initiates the Complex Utility Routine (CUR) built into the computer by Univac.



TAPE NO.	NAME	CONTENTS
①	Old Mission Tape	Missions, Modes, Emergency Modes before update
②	Old System Tape	Systems, Subsystems, Experiments before update
③	Latest Mission Tape	Missions, Modes, Emergency Modes after update
④	Latest System Tape	Systems, Subsystems, Experiments after update
⑤	Program CUR Tape	Program Instructions
⑥	List Tape	Program Output

Fig. 10-1 Data Handling Procedure Between Man and Computer

As shown in Fig. 10-1, the computer program is written so that the Integration and Cost routine may be used back-to-back with the Input and Update Routine. Any other combination of routines requires submittal of separate sets of control cards.

10.1.2 Tape Handling Philosophy

All computer instructions and input data required by the MIMOSA computer program are stored on reels of magnetic tape. Figure 10-1 lists the total assembly of tapes that may be utilized by the computer. Only Tapes 3, 4, and 5 (Latest Mission/Mode, Latest System/Experiment, and Program CUR) are required for operation of the Mission/Mode Comparison and the Integration and Cost Routines.

Tapes 1 or 2 (Old Mission/Mode or Old System/Experiment tapes) are needed only if any part of the data on one of these tapes is to be transferred to another tape. This occurs when updating or copying all or part of a data file. For example, if it is desired to update a mission contained on an existing Mission/Mode Tape, the existing tape becomes the Old Mission/Mode Tape. All mission and mode data contained on the Old Mission/Mode Tape are read into the computer, the revision is made, and the updated files are written onto the Latest Mission/Mode Tape. The planner ends up with two tape reels of mission/mode data. The old tape can be a backup to the latest tape, or the old tape can be reused if a mistake occurs in the updating operation.

The List Tape (tape 6) is used to store the computer output for subsequent printout. The Univac 1108 uses on-line printers so that a list tape is only needed if more than one copy of the output is desired.

10.1.3 Sequence Numbers

Another key concept in the operation of the MIMOSA program is the use of sequence numbers. Sequence numbers are punched into columns 77–80 of nearly every input

data card.* The computer program requires sequence numbers for the following reasons:

(1) The Univac 1107/1108 cannot read any card properly unless it knows in advance the format in which every item is written on that card. It must know whether it is going to read letters or numbers and, if numbers, whether they are in decimal or exponential form. Sequence numbers provide a reference for the computer and allow the computer program to determine the proper format for each control card or data card.

(2) The data files for modes, emergency modes, systems, subsystem state-of-the-art (SOTA) advances, and experiments are fixed in length. This means that the precise location on tape or drum storage is known for every possible bit of data allowed in each of these files. Sequence numbers are used to assure that each data bit is placed in its proper location.

The sequence number on an input card takes the form:

A B C D

where A = data category number (i.e., 2 = control, 3 = mission, 4 = mode, 5 = system, 6 = subsystem SOTA advance, 7 = emergency mode)

BC = subfile number

D = number to indicate location of the data on the input card in relation to the rest of the data for the subfile

A subfile is a set of related information in a data file. For example, in the system file, separate subfiles are maintained such as general data, nonrecurring R&D cost, nonrecurring cost of facilities, recurring procurement cost, recurring operations costs, expendables usage, and manhours usage.

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*Some cards for the mission data file are excepted; SKIP and LAST cards are used instead. (See paragraph 10.1.4.) Cards for the experiment data file are excepted because only two cards are input for each experiment.

D numbers run consecutively up to the last card for the subfile. For the last card, an "L" is punched instead of a number. This special signal alerts the computer of subfile completion. It should be emphasized that sequence numbers require special attention. Mistakes in sequencing cause the computer to lose its way. If a mistake is encountered, the computer has been programmed to print a diagnostic message and to skip to the next meaningful set of cards; if this is not possible, abort of the computer run follows immediately.

10.1.4 SKIP, LAST, and STOP Cards

Other special sequence cards are required for the proper assimilation of data by the computer. These cards have only the letters SKIP, LAST, or STOP, punched in columns 77–80.

SKIP and LAST cards have a major influence on mission data input. A mission data file is variable in length. This means that each element of data is packed on the computer memory tape or drum with no gaps. Because some missions are small and others large, the precise address of any particular bit of data is unknown. The computer, therefore, needs a guide to help it find the limits of any mission subfile; the SKIP card is used for this purpose.

The data for any mission is arranged in the following order (see also paragraph 10.5.1):

(1) General mission data (one card – fixed amount of data)
(2) Experiments to be performed at base (one card per experiment)
(3) General data for first traverse (one card – fixed amount of data)
(4) Experiments to be performed on first traverse (one card per experiment)
(5) General data for second traverse (one card – fixed amount of data)
(6) Experiments to be performed on second traverse (one card per experiment).

The sequence can continue for up to 24 traverses.

Obviously, the computer must be told when the subfile on a new traverse is being started. The SKIP card alerts the computer that "data on a new traverse follows." It must precede each general data card for a new traverse.

The LAST card signals the computer that data input on each mission has been completed and to prepare for data on a new mission. LAST cards also signal the end of data input for each mode, emergency mode, system, and subsystem SOTA advance (Note: experiments are excepted since each has a fixed number of input cards).

A STOP card signals the computer that data input has ended for each input category. Thus, a STOP card is used (in place of the LAST card) when data on the final mission, mode, system, etc., in the file is input. The STOP card has the same message for every file (including experiments). In addition, STOP cards are placed at the end of the set of control cards for the Mission/Mode Comparison Routine and the Integration and Cost Routine.

Any combination of two or more SKIP, LAST, and STOP cards back-to-back will abort a computer run. These cards, along with the sequence numbers on the data cards, guide the computer through the input data, and, incidently, serve as important aids in rapidly stacking cards for computer input.

10.2 STACKING CARDS FOR COMPUTER RUNS

For any single run, only one of the following computer routine combinations may be employed:

- Input and Update Routine only
- Mission/Mode Comparison Routine only
- Integration and Cost Routine only
- Input and Update Routine followed by Integration and Cost Routine

Separate runs must be made to obtain other combinations.

The Input and Update Routine operates on the Mission/Mode data tape and the System/Experiment data tape. The routine can only do one of two things to each tape on any single run: generate a new tape from cards, or revise an existing tape. Hence, if any one of the three data files on either tape is to be generated from cards, all three data files must be generated from cards.

Figures 10-2 through 10-5 display the card stacking required for each of the above computer routine combinations. Note that card stacking can be done on a building-block concept. The procedure for stacking each block of cards can be found in the subsections indicated.

10.3 GENERAL INPUT INSTRUCTIONS

At the beginning of a computer run with the Univac 1107/1108, cards are required that perform three functions:

- Ensure proper cost accounting for use of the computer
- Establish that tapes are properly assigned
- Begin the program

Table 10-3 presents the cards required by Lockheed Computer Operations. Similar cards will probably be required by other organizations operating this program. Cards 5 through 12 should be standard on all machines.

10.3.1 Tape Assignment

Because all data and instructions for the MIMOSA Program are on tape, it is essential that there be proper identification of tape usage. For Lockheed submittals, three cards (No. 1, 5, and 11 in Table 10-3) are devoted to tape assignment.

Possible confusion on tape usage occurs because the three principal tape handlers (the tape library, the computer itself, and the computer operator) identify tapes by different methods:

- The libraries at most computer centers store tapes according to a specific inhouse numbering system. Each reel of tape has its own number.

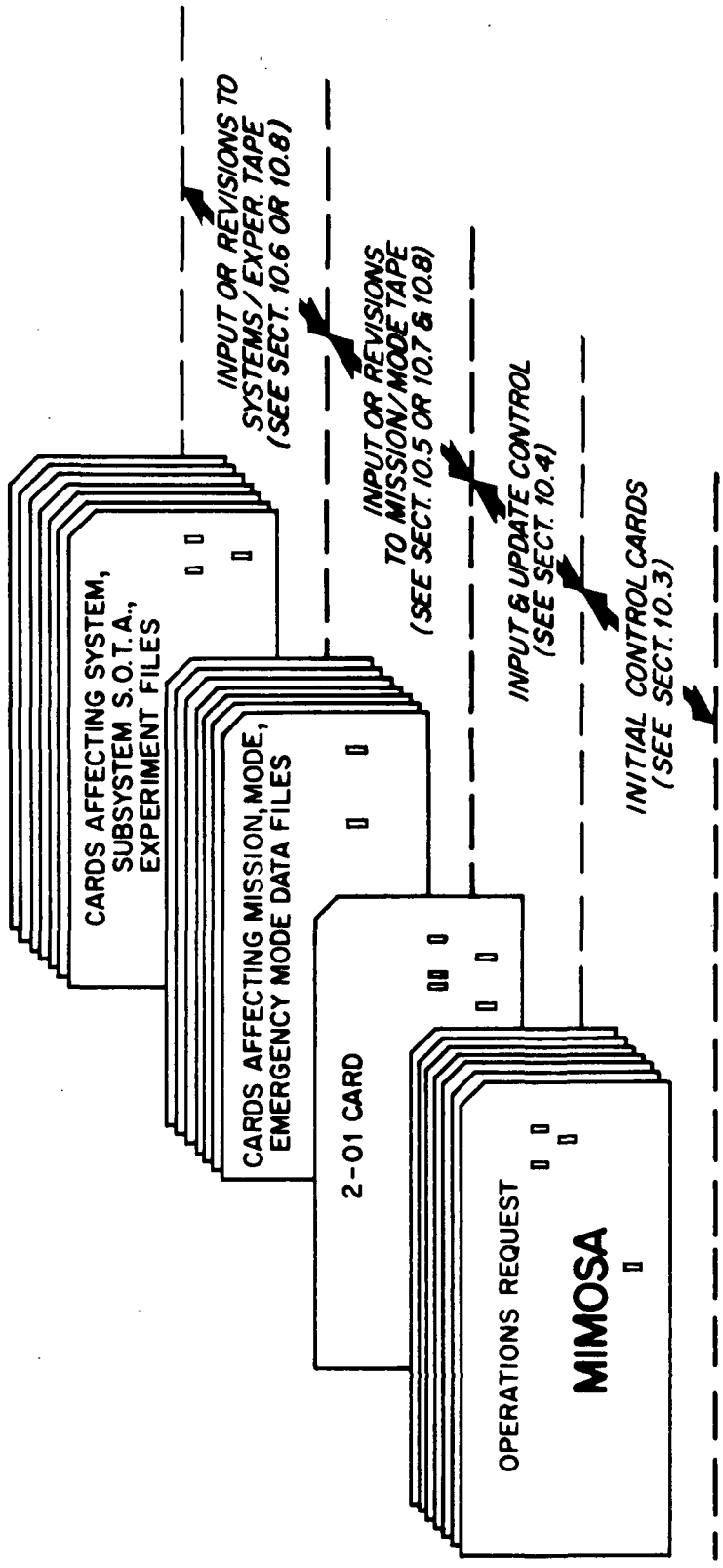


Fig. 10-2 Computer Card Stack – Input and Update Routine Only

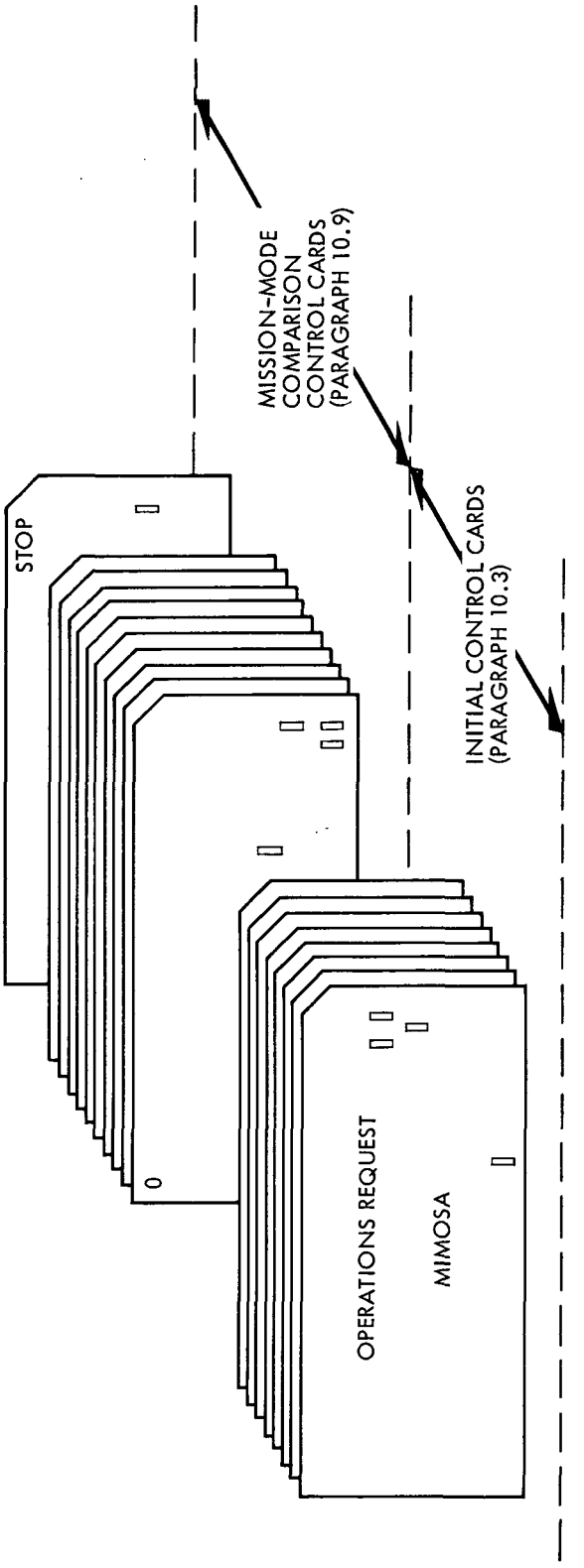


Fig. 10-3 Computer Card Stack – Mission-Mode Comparison Routine

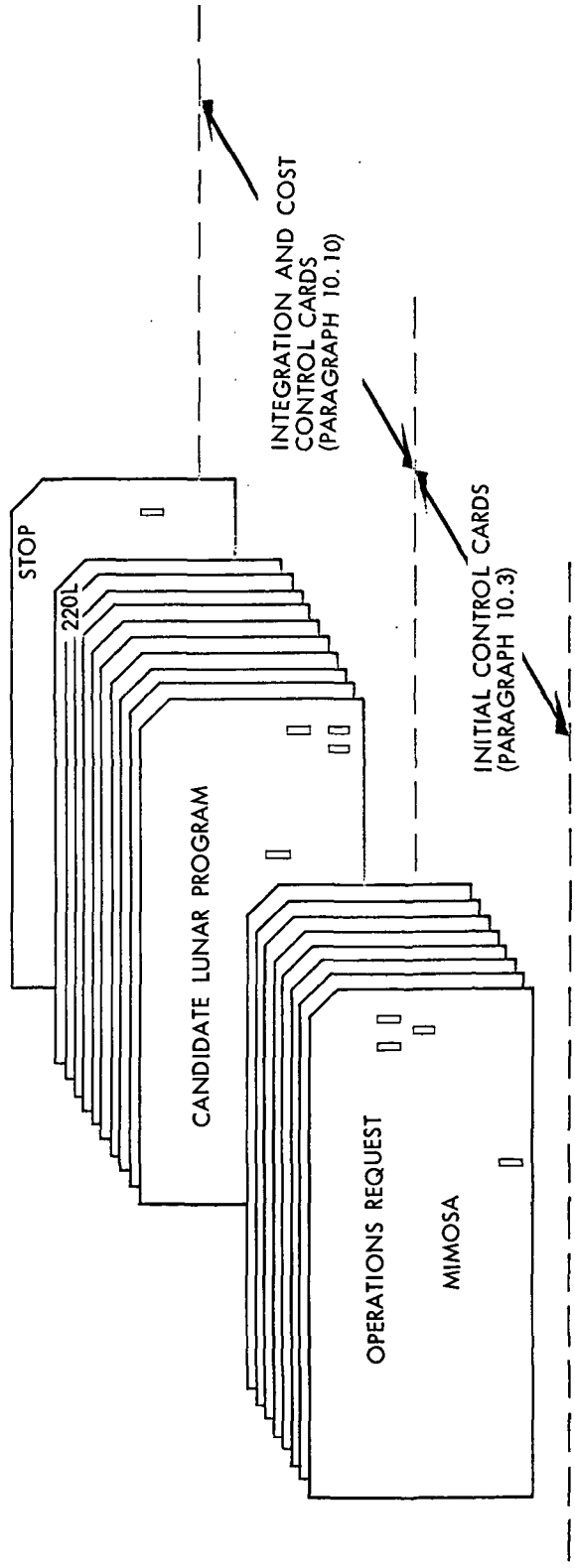


Fig. 10-4 Computer Card Stack – Integration and Cost Routine

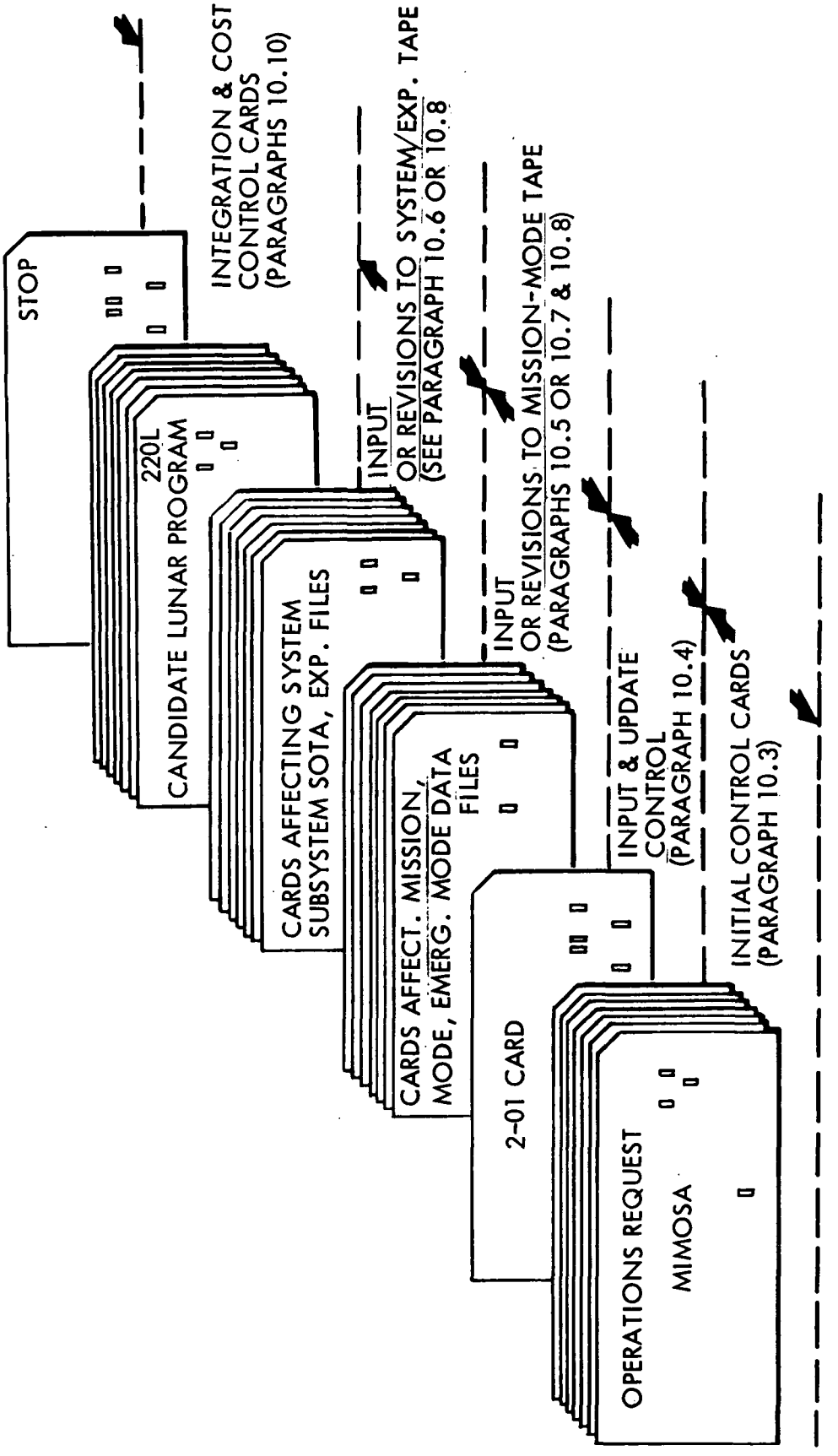


Fig. 10-5 Computer Card Stack – Input and Update Routine Followed by Integration and Cost Routine

Table 10-3

GENERAL INPUT INSTRUCTION CARDS

Number	Name	Card Punch (Column)												Function
		1	2	3	4	5	6	7	8	9	10	11	12	
1	Operations Request													Standard form request for computer run (Lockheed only)
2	Run Card					See Note A								Establishes max computer run time allowed and max number of output pages (Lockheed only)
3	Output Tape Request	7 8	D	S		T	P	R						Sets up machine to write Fortran output on magnetic tape. (This card used only when output tape is desired.)
4	LID Card			Lockheed Identification Card										Standard LMSC cost accounting card
5	Tape Assignment	7 8	R	ϕ	H			A	S	G				Tape setup assignment, and check to ensure proper tape use. See Section 10.1.2 for additional instructions.
6	Execute CUR	7 8	L		X	Q	T		C	U	R			Initiates Complex Utility Routine in machine.
7	CUR Tape Read-In							I	N		D			Reads in MIMOSA CUR tape
8	Tape Rewind							T	R	I		D		Rewinds and interlocks CUR tape
9	Table of Contents							T	Ø	C				Sets up printout of subroutines on the CUR tape which gives the date that subroutine became effective.
10a	Subroutine Execution	7 8		X	Q	T		M	I	M	Ø	S	A	Initiates start of Input and Update Routine or Integration and Cost Routine (used only if one or both of these routines are desired).
10b	Subroutine Execution	7 8		X		T		M	N	P	R	Ø	G	Initiates start of Mission-Mode. Comparison Routine (used only if this Routine is desired).
11	Control Card 1-01					See Table 10-5								Establishes for the program which tapes are to be used and purpose of each tape.
12	Control Card 1-02					See Table 10-6								Establishes for program logic which MIMOSA ROUTINE is desired.

NOTE A: The first fourteen columns of this card are punched standard by Lockheed Computer Operators. The following is punched beginning in Column 15:

, XXX YYY

where

XXX = run time in minutes (e.g., 005, 010)
YYY = max page count (e.g., 050, 100, 400)

For most computer submittals, XXX = 005 and YYY = 400 will suffice.

- The Univac 1107 and 1108 identify tapes being used on any given run with a two-digit numbering system. For example, a tape 16 must be read, a tape 17 is needed for additional data, a tape 25 must be written on, etc.
- The computer operator handles tapes only by letter (tapes A, B, C, etc.).

Fortunately, Univac has established an equivalence between the letters used by the computer operator and the two-digit numbers internal to the machine. Table 10-4 shows the letter and number designations that apply to the MIMOSA tapes.

Table 10-4
MIMOSA TAPE ASSIGNMENTS

Tape Name	Letter Code Assigned	Equivalent Tape Unit No.
Old Mission/Mode Tape	B	16
Old System/Experiment Tape	C	17
Latest Mission/Mode Tape	E	25
Latest System/Experiment Tape	F	26
Program CUR Tape	D	18

It is necessary to ensure that the proper reel of tape coming from the library is assigned the right letter code by the operator. For example, a reel of tape containing mission and mode data must be assigned as either B or E. At Lockheed the letter code to be assigned to each tape requested from the library for a given run is designated on the Operation Request Card (card 1, Table 10-3). The same designation is punched into the Tape Assignment Card (card 5, Table 10-3). If the assignments on the two cards do not agree, the computer operator aborts the run.

Beginning in Column 15 of the Tape Assignment Card, the tapes to be used are assigned letter codes in the following format:

Column 15

B = XXXX, C = YYYY, E = ZZZ, etc.

with no spaces permitted. The letters XXXX, YYYY, etc., represent the numbers given the tape reels by the library. If it is not desired to use an Old Mission/Mode Tape or an Old System/Experiment Tape, they are not mentioned on this card.

It is also necessary on another card to tell the computer which Mission/Mode and System/Experiment tapes it will be operating on. This is done with Control Card 1-01 (card 11, Table 10-3). Table 10-5 gives the required punch inputs for this card depending on the tapes desired.

Table 10-5
INSTRUCTIONS FOR FILLING OUT CONTROL CARD 1-01

If it is desired to use any of these tapes →	Old Mission/Mode	Latest Mission/Mode	Old System/Exper.	Latest System/Exper.
Punch these corresponding numbers →	16	25	17	26
Into these columns →	1, 2	3, 4	5, 6	7, 8

For example, the Mission/Mode Comparison Routine uses only the Latest Mission/Mode and Latest System/Experiment tapes. Control Card 1-01 for this routine would be punched as follows:

Column	1	2	3	4	5	6	7	8
Punch			2	5			2	6

10.3.2 Selection of Routine

Control Card 1-02 instructs the machine to call in the MIMOSA program routine that is desired. As discussed in subsection 10.2, only four possibilities are permitted for any one run. These are shown in Table 10-6.

Table 10-6
INSTRUCTIONS FOR FILLING OUT CONTROL CARD 1-02

Computer Routine Desired	Required Input on Control Card 1-02 (Column) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Input and Update	U P D A T E
Mission/Mode Comparison	C Ø M P A R
Integration and Cost	I N T E G
Input and Update followed by Integration and Cost	U P D A T E I N T E G

10.4 INPUT AND UPDATE CONTROL CARD

The Input and Update Routine of the MIMOSA Program is used to input and revise the great amount of technical data used by the other two computer routines. Seven options are available. These are summarized in Table 10-7.

A Control Card 2-01 is used to specify the options to be performed by the computer. Table 10-8 gives the instructions for filling out this card. Three key rules must be followed:

1. If one of the options is required for one data file (see Table 10-2) on a data tape, that option or some other option must be specified for the other two files on that tape. For example, if it is desired to UPDATE Systems only, then the Copy option must be used for Subsystem SOTA Advances and for Experiments.

Table 10-7

OPTIONS FOR INPUT AND UPDATE ROUTINE

Name	Code Name	Purpose
Generate	GENER	Generate a data file on tape from card input
Update	UPDATE	Update or modify a data file from card input
Delete	DELETE	Remove a set of data records from an existing data file
Insert	INSERT	Insert (i.e., add) a new set of data records to an existing file
Copy	COPY	Copy a complete data file on a category from an Old tape onto a Lates tape without modification or change of order.
Copsel	COPSEL	Copy a selected subset of data records from an Old tape onto a Latest tape without modification, but in any desired order, to form a new data file.
List	LIST	Obtain a printout of the contents of the Old Data file for any category

Table 10-8

INSTRUCTIONS FOR FILLING OUT CONTROL CARD 2-01

Tape	File	Begin Update Option Code Name (Table 10-7) in Column ...	If Print of Tape File Before Update is Desired, Write ' LIST in Columns ...
Mission/Mode	Missions	1	43–46
	Modes	7	47–50
	Emergency Modes	13	51–54
System/ Experiment	Systems	25	59–62
	Subsystem	31	63–66
	Experiments	37	67–70

IMPORTANT: Be sure to input sequence number "201L" in Columns 77–80.

2. If the generate option (code name GENER) is used for one file on a data tape, the generate option must be used for all three files on that tape. This means that the Old tapes (Tapes 1 and 2 in Fig. 10-1) are not used, and that the Latest tapes (Tapes 3 and/or 4) are generated directly from cards.
3. If it is desired to LIST the file that exists for one of the files on the Old tape, then one of the other options (except GENER) must be exercised for all the files on that tape. The most common option is to COPY the files from the Old tape on to a Latest tape.

10.5 MISSION-MODE TAPE GENERATION

The Mission/Mode Tape contains three data files: missions, modes, and emergency modes. To generate one of these data files from cards requires generation of all three data files. Figure 10-6 shows how the cards are stacked.

10.5.1 Mission Input

Table 10-9 summarizes the input cards that must be filled out for each mission used in the computer program. Figure 10-7 shows how these cards would be stacked for three example missions.

The following five important rules must be observed in setting up the cards:

- If there are no base experiments on the mission, 3-02 control cards should be omitted.
- A SKIP card must precede every 3-03 card.
- At least one 3-04 card must follow each 3-03 card.
- A LAST card must follow the final data card for each mission except the last mission. A STOP card must follow the data on the last mission. If the mission is to have no experiments, the LAST or STOP card may follow the 3-01 card.
- The experiments intended for a particular traverse must follow the 3-03 card for that traverse.

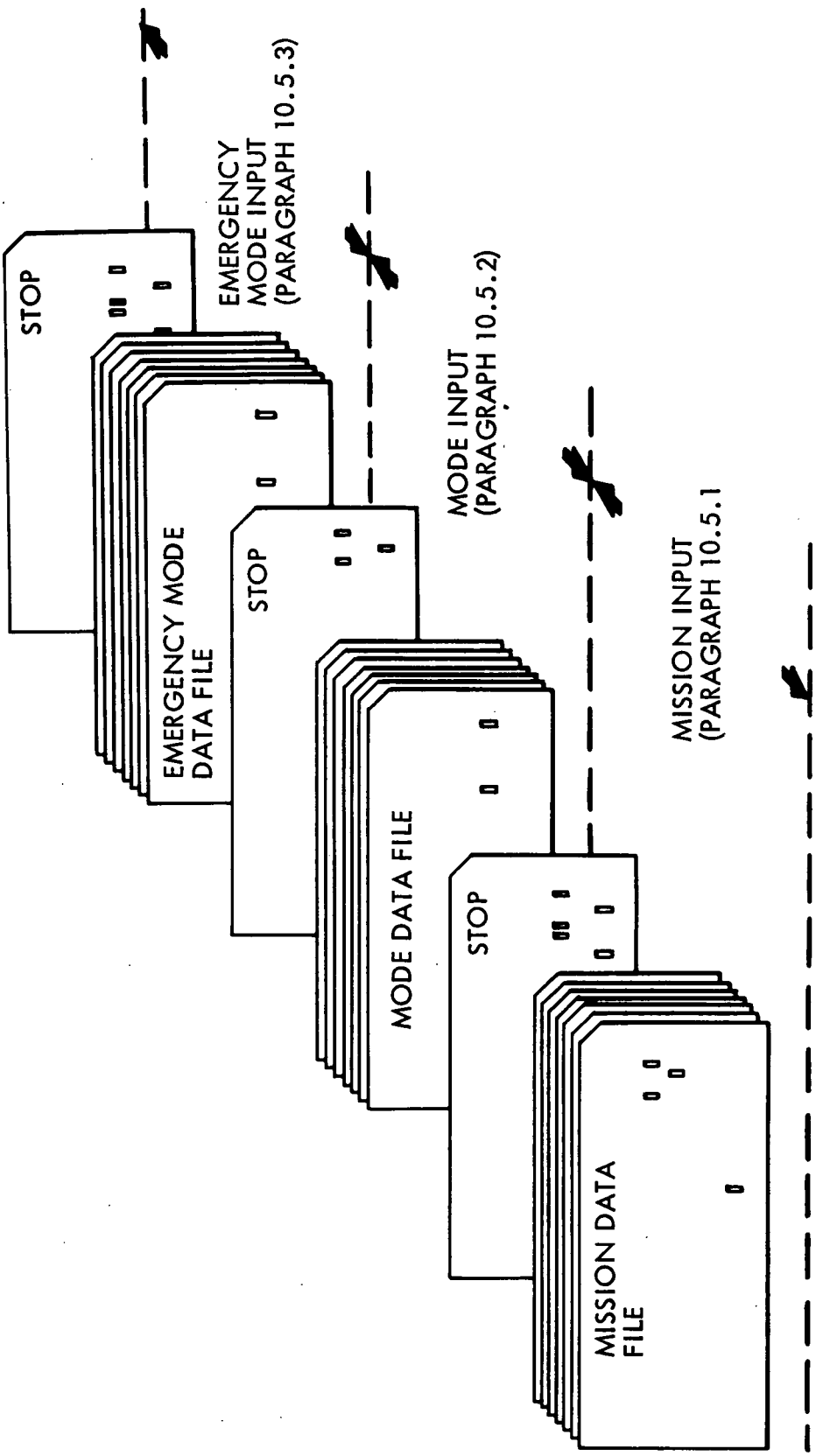


Fig. 10-6 Computer Card Stack – Generation of Mission-Mode Tape

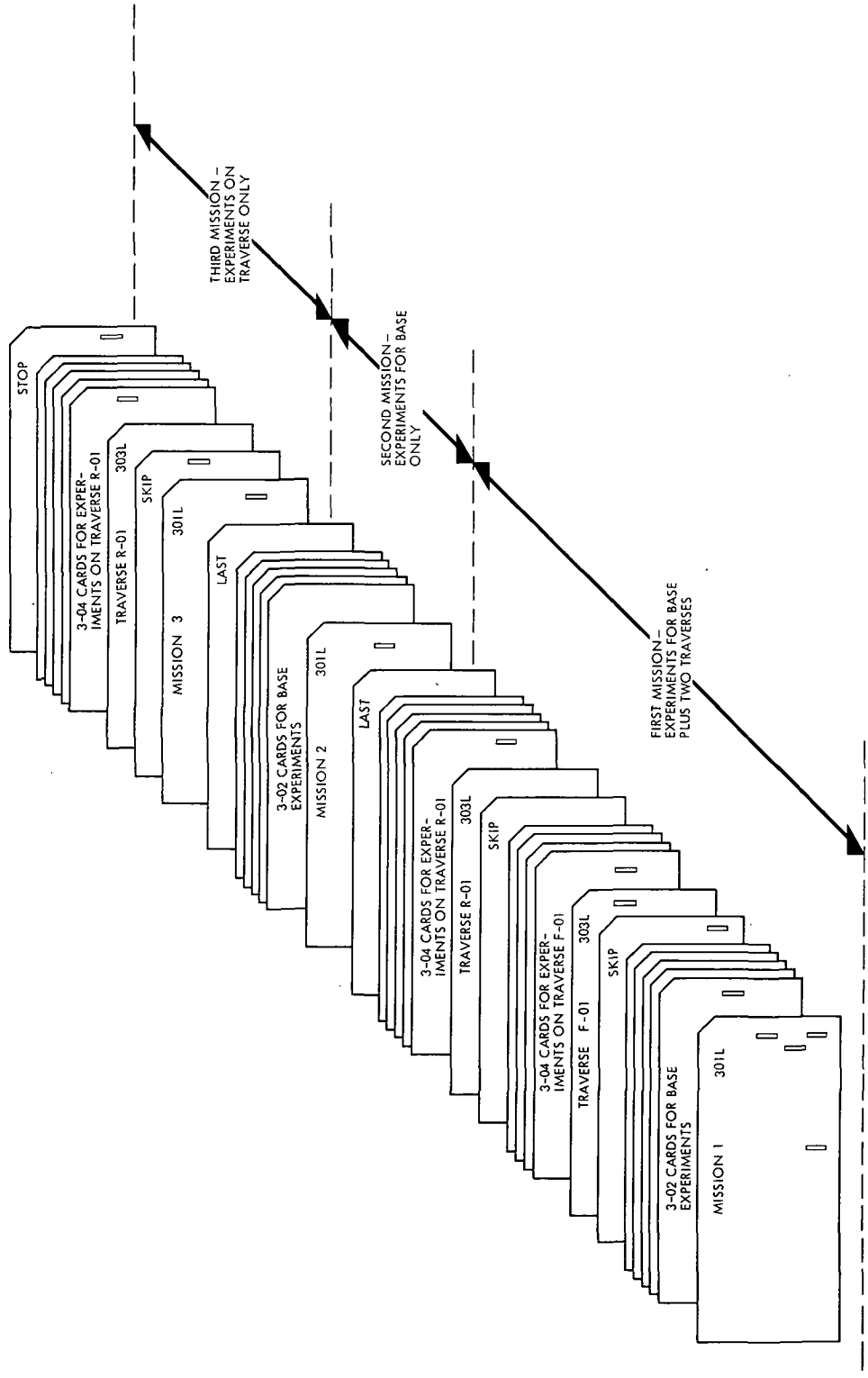


Fig. 10-7 Computer Card Stack – Generation of Mission Data File

Table 10-9

MISSION INPUT CARDS

Card ID No.	Card Name	Maximum Cards	Sequence No. (Columns)				Comments
			77	78	79	80	
3-01	Mission Input – General	1	3	0	1	L	Use one card per mission.
3-02	Mission Input – Base Experiments	100		*			Use one card per base experiment; 100 experiments permitted. Omit cards if no base experiments are desired.
3-03	Mission Input – Traverse Data	24	3	0	3	L	Use one card per traverse. Input flying traverses first. This card must always be preceded by a card with SKIP written in columns 77-80
3-04	Mission Input – Traverse Experiment	50		*			At least one card, but no more than 50 cards, must follow each 3-03 card.

*Sequence number is not needed.

Examination of the instructions for the 3-2 and 3-04 cards shows much commonality between the two required inputs. If care is taken, the same card can be prepared for an experiment whether that experiment is used at base or on a traverse.

Appendix B presents the detailed instructions for filling out each mission input card. This appendix was written by a computer reading punched cards. This computer-generated documentation will be relatively easy to maintain and to keep up-to-date.

10.5.2 Mode Input

Table 10-10 summarizes the input cards that must be filled out for each exploration concept mode used in the MIMOSA program. All cards must be input in the order shown. With the exception of Card No. 4-20, at least one of each card type must be filled out for every mode. Card 4-20 may be omitted if an emergency mode identification is not desired.

Instructions for filling out each card type are given in Appendix C. A LAST card (see paragraph 10.1.4) must be placed at the end of the set of cards for each mode except the last mode. A STOP card is placed at the end of the last mode to be input.

10.5.3 Emergency Mode Input

The use of the emergency mode concept is an optional feature of the MIMOSA Program. This concept allows a crew rescue emergency mode and a logistic emergency mode to be identified (see Card No. 4-20) for each exploration concept mode. When each exploration concept mode is used the first time in a lunar program, the equipment association with each of its emergency modes is procured once. The purpose of the emergency-mode input is to give the required costs and to identify those systems that must be procured.

Table 10-10

MODE INPUT CARDS

Card ID No.	Card Name	Maximum Cards	Sequence No. (Columns)			
			77	78	79	80
4-01	Mode Input – General	1	4	0	1	L
4-02	Mode Input – Operations	1	4	0	2	L
4-03	Mode Nonrecurring R&D Cost Curve	3	4	0	3	*
4-04	Mode Cost of Facilities Curve	3	4	0	4	*
4-05	Mode Recurring Hardware Cost Curve	3	4	0	5	*
4-06	Mode Operations Support Cost Curve	3	4	0	6	*
4-07	Mode Input – Launch Identification	8	4	0	7	*
4-10	Mode Input – Systems on Each Launch	120	4	1	**	*
4-20	Mode Input – Emergency Modes	1	4	2	0	L

*Column 80 = 1, 2, ... L, depending on number of cards needed. (The letter "L" is always used on the last card of a series.)
**Column 79 on Card No. 4-10 is the launch identification number.

Table 10-11 summarizes the input cards that must be filled out for each emergency mode. All cards must be input in the order shown.

Appendix D gives instructions for filling out each card type. A LAST card must be placed at the end of the set of cards for each emergency mode except the last mode. A STOP card is placed at the end of all emergency modes to be input.

Emergency modes may be ignored in the cost of any lunar exploration program by proper input of one of the control cards (see paragraph 10.10, Card No. 2-21) of the

Integrating and Cost Routine. If it is desired to ignore emergency modes, the following should be done:

(1) Input a card with:
- DUMMY in columns 1 – 5
- 701L in columns 77 – 80

(2) Place a STOP card behind the dummy card to signal the end of emergency mode input.

Table 10-11

EMERGENCY MODE INPUT CARDS

Card ID No.	Card Name	Maximum Cards	Sequence No. (Columns) 77	78	79	80
7-01	Emergency Mode Input – General	1	7	0	1	L
7-03	Emergency Mode Nonrecurring R&D Cost Curve	3	7	0	3	*
7-04	Emergency Mode Cost of Facilities Curve	3	7	0	4	*
7-05	Emergency Mode Recurring Hardware Cost Curve	3	7	0	5	*
7-06	Emergency Mode Operations Support Cost Curve	3	7	0	6	*
7-11	Emergency Mode Input – Systems Procured	15	7	1	1	*

*1, 2, ... L, depending on number of cards needed. (The letter "L" is always used on the last card of a series.)

10.6 SYSTEM/EXPERIMENT TAPE GENERATION

The System/Experiment Tape contains three data files: system, subsystem state-of-the-art advances*, and experiments. To generate one of these data files from cards requires generation of all three data files. Figure 10-8 shows how the cards are stacked.

10.6.1 System Input

The data on exploration equipment (i.e., systems) used for lunar programs are placed first on the System/Experiment Tape. Table 10-12 summarizes the input cards required for each system. Ten of the 16 card types listed are required input for all systems. For certain groups of systems, one or two additional cards must be input. For example, the input for a lunar flying vehicle (LFV) requires cards 5-01 through 5-10 plus 5-13 and 5-14.

Instructions for filling out each card type are given in Appendix E. A LAST card must be placed at the end of the set of cards for each system except the last system. A STOP card is placed at the end of all systems to be input.

Three points require special attention:

(1) Certain system identification numbers trigger subroutines in the computer program. The following identifiers must be used:

11XX-XX = Transportation systems
121X-XX = Non-Saturn launch vehicles
1213-XX = Saturn IB launch vehicle
122X-XX = Saturn V launch vehicle

*SOTA advances refer to large development programs required to advance technology to ensure the feasibility of a particular subsystem. For the Data Book, they may be treated in the same manner as systems.

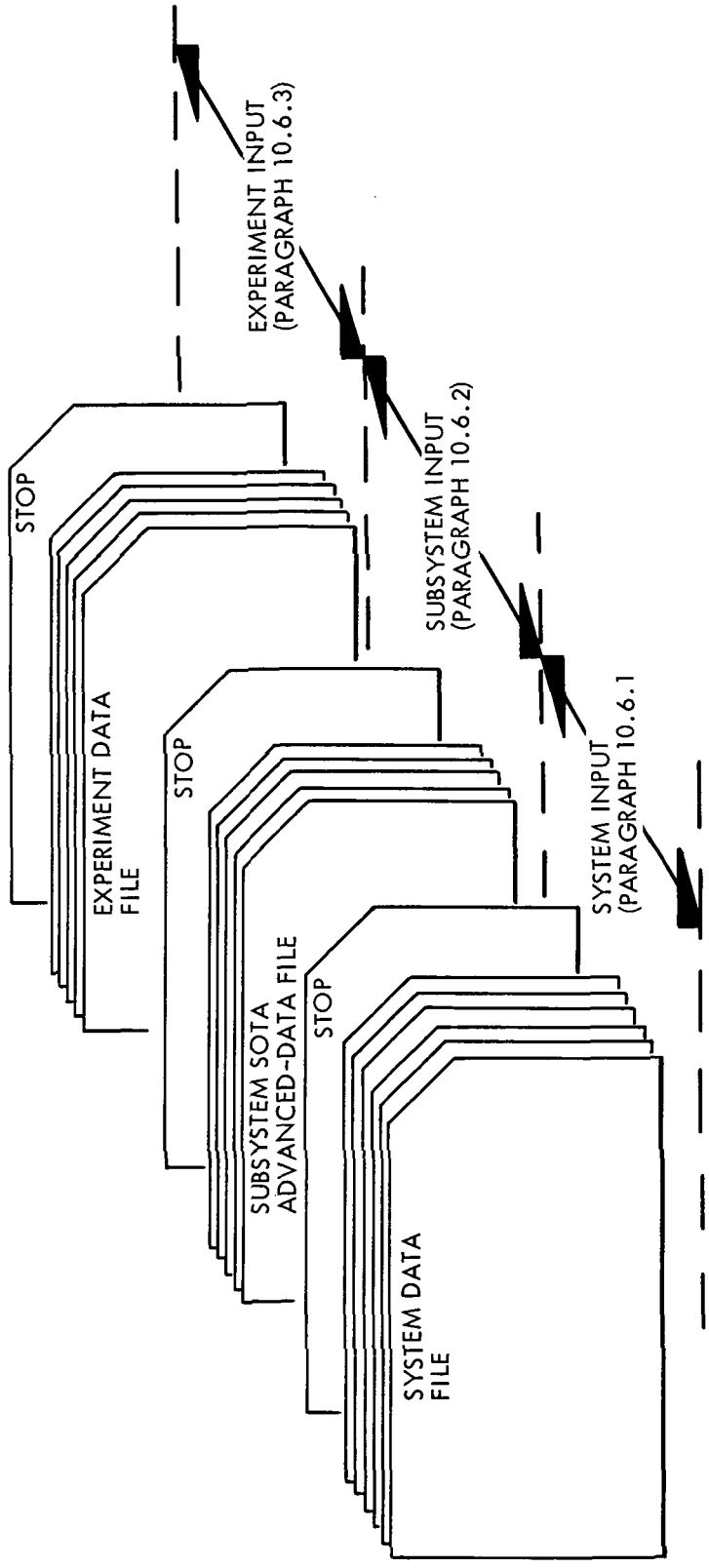


Fig. 10-8 Computer Card Stack – Generation of System/Experiment Tape

123X-XX thru 127X-XX = Saturn V upratings
222X-XX = Manned orbiters
232X-XX = Personnel shelters
24XX-XX = Roving vehicle of any type
243X-XX = Roving vehicle trailer
25XX-XX = Flying vehicle
2711-XX = Fuel resupply for flying vehicles
2712-XX = Expendables resupply
2713-XX = Fuel regeneration systems
3XXX-XX = Major scientific equipment

Table 10-12

SYSTEM INPUT CARDS

Card ID No.	Card Name	Maximum Cards	Where Applicable	Sequence No. (Columns)				Comments
				77	78	79	80	
5-01	System Input – General	1	All systems	5	0	1	L	
5-02	System Input – Sub System SOTA ID	3		5	0	2	*	
5-03	System Cost Curve	3		5	0	3	*	Nonrecurring R&D
5-04	System Cost Curve	3		5	0	4	*	Nonrecurring Cost of Facilities
5-05	System Cost Curve	3		5	0	5	*	Recurring hardware procurement
5-06	System Cost Curve	3		5	0	6	*	Recurring operations support

Table 10-12 (Cont.)

Card ID No.	Card Name	Maximum Cards	Where Applicable	Sequence No. (Columns)				Comments
				77	78	79	80	
5-07	Percent Cost Reduction	2	All systems	5	0	7	*	Learning curve
5-08	R&D Flight Table	2		5	0	8	*	Development flights
5-09	System Expendables	5		5	0	9	*	One card for each crew level
5-10	System Manhour Requirement, Nonscientific Operations	5	All systems	5	1	0	*	One card for each crew level
5-11	System Input – Personnel Shelter Only	1	Shelter only	5	1	1	L	
5-12	System Input – LRV Only	5	LRV only	5	1	2	*	One card for each crew level
5-13	System Input – LFV Only	5	LFV only	5	1	3	*	One card for each crew level
5-14	System Input – LFV Stops vs. Range/Table	2	LFV	5	1	4	*	
5-15	System Input – Major Science Equipment Only	5	Major scien. eqpmt. only	5	1	5	*	

Table 10-12 (Cont.)

Card ID No.	Card Name	Maximum Cards	Where Applicable	Sequence No. (Columns)				Comments
				77	78	79	80	
5-16	System Input – Transportation System Only	1	Trans. system only	5	1	6	L	Identifies flight systems

*1, 2, ... L, depending on the number of cards needed. (The letter "L" is always used on the last card of the series.)

(2) When a trailer is combined with a rover in a tandem rover-trailer configuration, that combination exhibits different performance characteristics than either the rover or trailer acting by itself. To ensure proper performance data input, each trailer concept can be input into the computer by use of one of several identification numbers. The first four digits of the identification number establish the trailer concept and the last two digits establish how the trailer is to be used in the mode. Thus, 2436-01 stands for Trailer 2436 used by itself, 2436-02 stands for Trailer 2436 used in combination with LRV "A", 2436-03 stands for use in combination with LRV "B", etc. The performance data input with each identifier is the performance of the trailer or the particular trailer-rover combination. This is different for each identifier. However, the same cost data can be input for all variations of a given trailer concept if it is assumed that the cost of a particular trailer concept is independent of the manner in which it is used.

(3) Unmanned systems are treated as manned systems with a crew level of zero. If a system can operate both manned and unmanned, inputs for expendables (Card 5-09), nonscientific manhour requirements (Card 5-10), LRV-only data (Card 5-12), and LFV-only data (Card 5-13) may be made for zero as well as other crew levels.

10.6.2 Subsystem State-of-the-Art Advance Input

The ability to display and separately cost advances in the state-of-the-art (SOTA) of subsystem concepts is another feature of the MIMOSA computer program. Use of this feature results in the tabulation of nonrecurring R&D and cost of facilities expenditures vs. projected time for each advance required in a given lunar program.

The subsystem SOTA advances required to achieve a given system are listed for that system using the 5-02 card (see Table 10-12). Table 10-13 summarizes the cards that must be filled out for each SOTA advance that is identified. Instructions for filling out these cards are given in Appendix F. A LAST card must be placed at the end of the set of cards for each subsystem advance except the last subsystem. A STOP card is placed at the end of all subsystems to be input.

If no subsystem SOTA advance is called out in the entire system file, the following should be done:

(1) Input a card with:
- DUMMY in columns 1 – 5
- sequence number 601L in columns 77 – 80

(2) Follow the dummy card with a STOP card to signal the end of the subsystem file.

Table 10-13
SUBSYSTEM SOTA ADVANCE INPUT CARDS

Card ID No.	Card Name	Maximum Cards	Sequence No. (Columns)			
			77	78	79	80
6-01	Subsystem Input – General	1	6	0	1	L
6-02	Subsystem Cost Curve – Nonrecurring	3	6	0	2	*
6-03	Subsystem Cost Curve – Nonrecurring Cost of Facilities	3	6	0	3	*

*1, 2, . . . , L, depending on number of cards needed. (The letter "L" is always used on the last card of a series.)

10.6.3 Experiment Input

The format for input of data on scientific program experiments was derived by North American Aviation under NASA contract NAS-8-20258 (Scientific Mission Support for Extended Lunar Exploration). North American chose six types of data cards with which to describe an experiment for computer handling. Lockheed selected two of these six for use in MIMOSA.

Type 1 Card – Experiment Summary
Type 3 Card – Experiment Operations

A single Type 1 card presents summary information on an experiment. This information includes the experiment name, equipment mass, development time, and cost.

A single Type 3 card presents the number of manhours estimated to perform an experiment. The performance of an experiment is broken up into four phases:

Phase 1 – Setup
Phase 2 – Operate
Phase 3 – Analysis
Phase 4 – Takedown

Shirtsleeve and spacesuit manhours at base or on traverse (as needed) are given for each phase. The manhours, however, are for performance of an experiment in a shirtsleeve environment on Earth. They have to be multiplied by a special factor to compensate for lunar gravity and (where applicable) for spacesuit use. The factors are input with one of the control cards for the Mission/Mode Comparison Routine (see paragraph 10.9).

North American also adopted special formats for presentation of numbers on a data card. Two of these formats applicable to MIMOSA are shown in Table 10-14.

Table 10-14
FORMATS USED FOR NUMBERS ON EXPERIMENT INPUT CARDS

Format Type	Format	Meaning
1	A B 0 C	$A.B \times 10^{C}$
	A B 5 C	$A.B \times 10^{-C}$
2	A B	$A \times 10^{B}$

Appendix G presents the instructions for preparing the two cards for each experiment. It is essential that both cards be input for every experiment. No LAST card is required after each experiment; however, a STOP must follow the final Type 3 card.

10.7 MISSION INPUT REVISION

The discussion in paragraphs 10.5 and 10.6 has centered on making original data inputs to the computer. The next two sections discuss how to revise the data on an existing tape.

The space reserved on the magnetic tape or computer drum for data concerning any specific mission varies with the quantity of that data. The data is packed in much the same way as taking several shopping lists and attaching them end-to-end. This "variable length" format is required because up to 15,779 data cells would have to be set aside for a single mission, and to fix this length for 50 missions would saturate the computer core storage.

"Variable length" format places a severe restriction on updating. No experiment or traverse can be added or removed from any given mission. To do so would require moving all following data to new locations on the tape. This is a most complicated maneuver.

Another restriction must be born in mind when using the updating procedure. It is not possible to correct or update the identifier of a mission or of an experiment called out for that mission. This is because of several checks built into the logic to assure proper card sequencing. In order to correct any one identifier, a whole new mission, with a different mission identifier, must be added to the tape file.

There are four updating options possible for missions:

- Change existing data (except identifiers)
- Delete whole missions
- Add whole missions
- Copy a selected subset of missions onto a new tape in any order

10.7.1 Procedure for Changing Existing Data (Except Identifiers)

(a) Write UPDATE into columns 1 – 6 of the 2-01 card (see paragraph 10.4). Do this only once for a single computer run.

(b) For each mission to be revised, supply a card that contains the following:
- The mission identifier in columns 1 – 8, exactly as it appears in columns 1 – 8 of the 3-01 card
- The sequence number 202L in columns 77 – 80

(c) Supply the 3-01 card. This may be the original or a card with revised data in columns 9 – 50.

(d) Follow the 3-01 card with any 3-02 card correcting the data for any base experiment. Update any experiments in the order in which they appear on the tape file. Only revisions in columns 28 – 75 are permitted.

(e) After the last revised 3-02 card, or after the 3-01 card if no base experiments are to be revised, place a SKIP, LAST, or STOP card for whichever message applies:

SKIP = revisions for traverse data follow
LAST = revisions for additional missions follow
STOP = no more mission update follows

(f) Follow a SKIP card with the 3-03 card for any traverse in which data revisions are desired. This may be the original 3-03 card for that traverse or a card with revised data in columns 31 – 60. Correct the traverses in the order in which they appear on the mission tape file.

(g) Follow the 3-03 card by any 3-04 card correcting the data for any experiment on the indicated traverse. Update any experiments in the order in which they appear on the traverse file. Only revisions in columns 28 – 74 are permitted.

(h) After the last 3-04 card for the traverse, place a SKIP, LAST, or STOP card for whichever message applies.

SKIP = revisions for another traverse of the same mission follows

LAST = revisions for another mission follows

STOP = no more mission update follows

10.7.2 Procedure for Deleting Whole Missions

(a) Write DELETE into columns 1 – 6 of the 2-01 card for the computer run (see paragraph 10.4).

(b) Supply cards for each mission to be deleted. Fill out this card as instructed in paragraph 10.7.1 above.

(c) Place a STOP card after the last card from 2(b).

10.7.3 Procedure for Adding Whole Missions

(a) Write INSERT into columns 1 – 6 of the 2-01 card for the computer run (see paragraph 10.4).

(b) Assemble the cards for the additional missions in the manner used to generate a mission file (see paragraph 10.5.1).

(c) Make sure a LAST card is at the end of the data for each mission except the final mission. Place a STOP card at the end of the final mission.

10.7.4 Procedure for Copying a Selected Subset of Missions onto Another Tape

(a) Write COPSEL into columns 1 – 6 of the 2-01 card for the computer run (see paragraph 10.4).
(b) Prepare cards for each mission desired on the new tape. Prepare the card as instructed in paragraph 10.7.3 (b) above.)
(c) Place these cards in the order desired for the missions on the new tape. Place a STOP card at the end of the stack.

10.8 MODE, SYSTEM, SUBSYSTEM, AND EXPERIMENT INPUT REVISION

The space permitted on magnetic tape and in the computer memory for the data file for each mode, emergency mode, system, subsystem, SOTA advance, and experiment is fixed. Each file can be thought of as a box into which data of any amount can be placed up to the limit of the box. Fixed record length permits the insertion, deletion, or correction of any item of data.

Each item of data is presented to the machine in the form of "words." These words can take on two formats: alphabetic (called "A") or numeric with a variable decimal point position (called "F"). A-format is used for identifiers and text that is read by the machine exactly as presented. F-format presents numbers in a manner that permits flexible use of the decimal point. Tables H-1 through H-5 in Appendix H identify the format relating to each input item. Different techniques are required by the Univac 1107 and 1108 to handle A-format and F-format data. This constraint of the computer forces the use of a special updating procedure.

Three types of cards are used to update the fixed length data records. These cards are summarized in Table 10-15. The first card (Card 2-02) locates the identifier of the specific data record to be changed. The second card (Card 2-03) updates A-format information. The third card (Card 2-04) allows F-format revisions. See Appendix H for instructions on preparing these cards.

Table 10-15
FIXED RECORD UPDATE INPUT CARDS

ID No.	Card Name	Maximum Cards	Sequence No. (Columns)				Card Function
			77	78	79	80	
2-02	Computer Control	1	2	0	2	L	To locate tape data record
2-03	A-Format Changes	Any	2	0	3	L	To make A-format update
2-04*	F-Format Changes	Any	2	0	4	L	To make F-format update

*The first 2-04 card of any sequence must be preceded by a SKIP card.

After a tape record file has been generated, there are five options that can be used to modify that file:

- Change an existing record (except identifiers)
- Delete an entire data record
- Add an entire data record
- Copy an entire record file onto another tape
- Copy a selected subset of records onto another tape in any order

Any changes to file records must be made for each file in the order in which that file appears on the tapes (i.e., Tape 1: modes, emergency modes; Tape 2: systems, subsystem, experiments). If one option is selected for one file on a tape, an option must be selected for all other file on that tape. If no changes to the other files are desired, then the COPY option should be used.

10.8.1 Procedure for Changing an Existing Record

To change an existing record (including the adding or deleting of data bits but not including changes in identifier number), perform the following steps.

(a) Write UPDATE in the appropriate columns of the 2-01 card (see paragraph 10.4) for the data file to be changed. Do this only once for a single computer run.

(b) Prepare a 2-02 card giving the identifier of each specific data record within the file that is to be revised. Directions for filling out the 2-02 card are presented in Appendix H.

(c) Prepare a 2-03 card for each A-format change to be made in the data record. Directions for filling out the 2-03 card are presented in Appendix H.

(d) After the last 2-03 card, or after the 2-02 card if no A-format changes are desired, place a SKIP, LAST, or STOP card for whichever message applies:
SKIP = F-format changes for this data record follow
LAST = No more changes for this data record are desired; changes to another data record within the data file follow.
STOP = No more changes in this file are desired.

(e) Follow a SKIP card with 2-04 cards for all of the F-format changes desired.

(f) After the last 2-04 card, place a LAST or STOP card for whichever of the messages in (d) applies.

(g) See Fig. 10-9 as an aid in stacking cards.

10.8.2 Procedure for Deleting Entire Data Records

(a) Write DELETE in the appropriate columns of the 2-01 card (see paragraph 10.4) for the data file in which deletions are desired.

(b) Prepare 2-02 cards for each data record to be deleted. Directions for filling out a 2-02 card are presented in Appendix H.

(c) Place a STOP card after the last 2-02 card.

10.8.3 Procedure for Adding Entire Data Records

(a) Write INSERT in the appropriate columns of the 2-01 card (see paragraph 10.4) for the data file to which records are to be added.

(b) Assemble cards for each new data record in the same manner as when generating a data tape (see 10.5.2, 10.5.3, and 10.6).

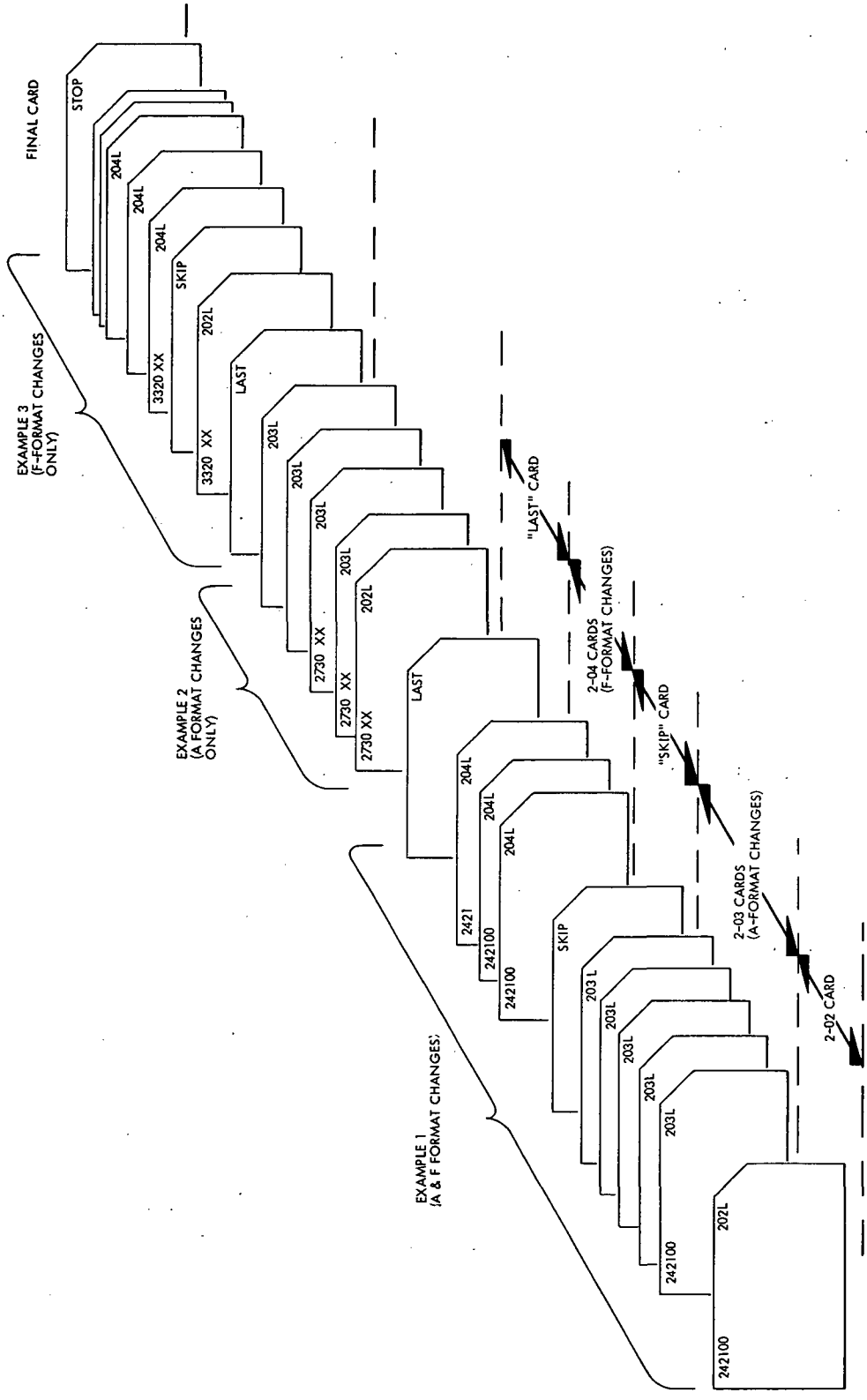


Fig. 10-9 Computer Card Stack – Update of Existing Fixed-Length Data Records

10.8.4 Procedure for Copying an Entire Record File

To copy an entire record file onto another tape, write COPY in the appropriate columns of the 2-01 card (see paragraph 10.4) for the data category. No other cards are needed.

10.8.5 Procedure for Copying a Selected Subset of Records onto Another Tape in any Order

(a) Write COPSEL in the appropriate columns of the 2-01 card (see paragraph 10.4) for the data file for which the data records are to be transferred.
(b) Prepare 2-02 cards for each data record desired on the new tape. Directions for filling out a 2-02 card are presented in Appendix H.
(c) Arrange the 2-02 cards into the order desired for the data records on the new tape.
(d) Place a STOP card after the last 2-02 card.

10.9 MISSION-MODE COMPARISON CONTROL CARDS

Operation of the Mission/Mode Comparison Routine requires a set of control cards. Table 10-16 summarizes the types of cards required. Only one 2-10 card is required for each computer run. At least one each of the 2-11 and 2-12 cards are needed for every comparison of mission and mode. Figure 10-10 shows how to stack the cards for a run. Instructions for preparing the 2-11 and 2-12 cards are given in Appendix I.

The number punched in column 1 of the 2-10 card determines the output format for the run. If a zero is punched, the computer prints the standard output of 6 – 8 pages for each comparison (see Fig. 7-1). If a number 1 is punched in column 1, a detailed diagnostic printout of the calculation process will be generated. The detailed printout is only valuable in troubleshooting the program logic.

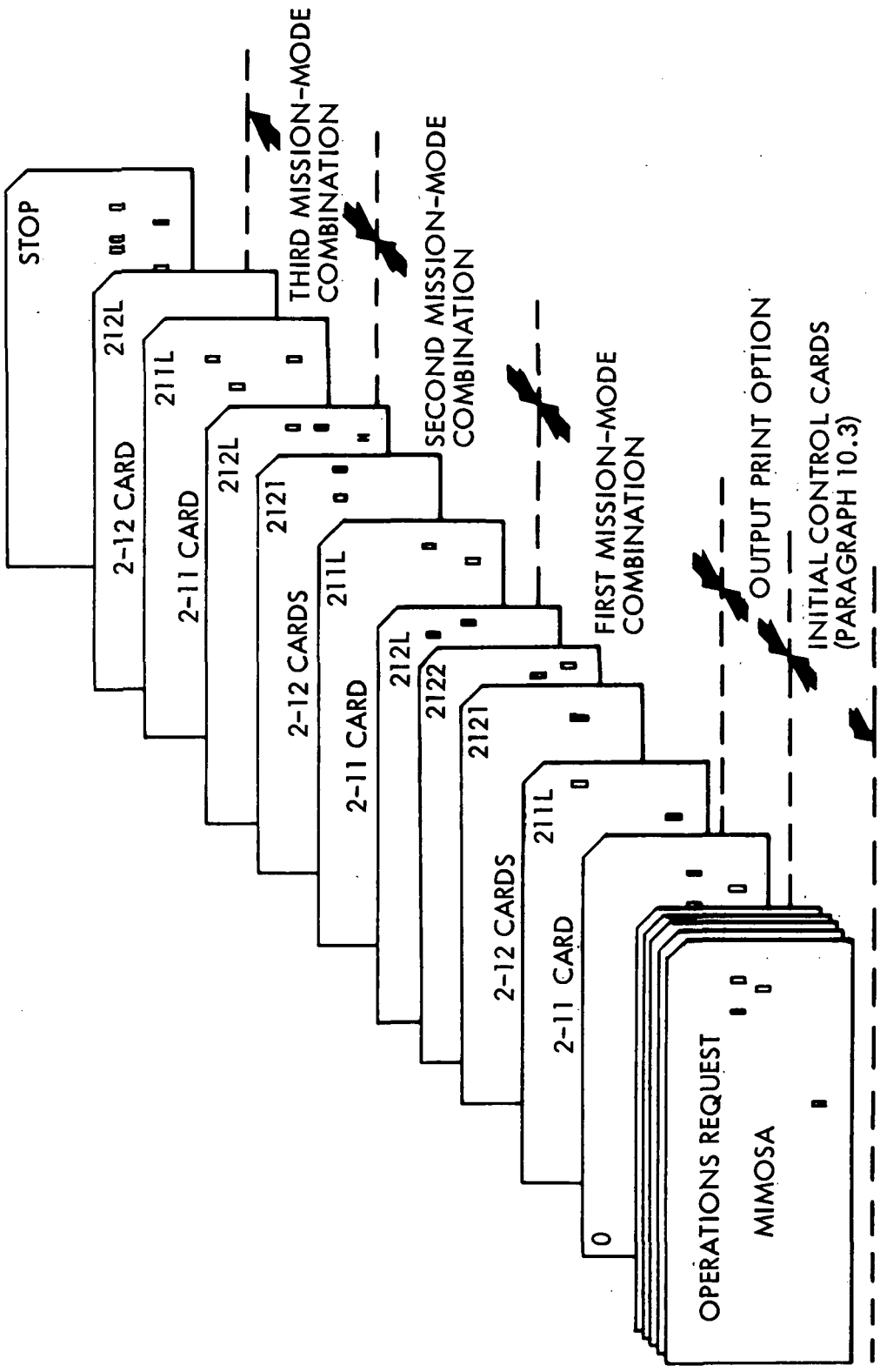


Fig. 10-10 Computer Card Stack – Control of Mission-Mode Comparison Routine

Table 10-16
MISSION-MODE COMPARISON CONTROL CARDS

Card ID No.	Card Name	Maximum Cards	Sequence No. (Columns)				Comments
			77	78	79	80	
2-11	Printout Option	1	-	-	-	-	0 in column 1 yields standard printout; 1 in column 1 yields diagnostic printout.
2-11	Mission/Mode Identification	1	2	1	1	L	Any number or comparisons can be run at one time.
2-12	Traverse-Vehicle Identification	3	2	1	2	*	At least one 2-12 card must follow each 2-11 card.

*1, 2, or L, depending on maximum number of cards needed. (The letter L is always used on the last card of a series.)

The 2-11 card specifies which mission and mode are to be matched. Provision also is made for multiplying the shirtsleeve and spacesuit manhours stored with the experiment data (see paragraph 10.6.3) by special factors. These factors alter the manhour numbers to account for effects of reduced gravity and spacesuit mobility problems.

The 2-12 card identifies the roving and flying system configurations used during the mission and establishes the traverses performed by each. For traverses performed by a rover alone, the rover identifier is input on the control card. For traverses performed by a rover-trailer combination, the trailer identifier (i.e., the special 6-digit Data Book number that identifies a trailer concept used with a particular rover) is input on the control card. In addition, a space is provided on the control card to input the identifier of the particular performance data from the trailer input (which is the performance of the rover-trailer combination) and to ignore the rover performance data (see paragraph 10.6.1).

10.10 INTEGRATION AND COST CONTROL CARDS

Operation of the Integration and Cost Routine requires three types of control cards. Table 10-17 summarizes these cards. The 2-20 card inputs the title for the lunar

program printout, establishes the maximum number of Saturn launches, N , permitted by existing facilities during each calendar year, and allows exercising of various cost options. Two 2-21 cards input a table of maximum permitted launches during each year. The 2-22 card establishes exactly which mission/mode combinations will constitute the lunar program. The 2-23 card allows input of the cost curves for a change of facilities that will allow an increase in annual launch rate from N to some value M , from M to P , and so on. Up to 10 possible launch-rate increments may be input.

Table 10-17
INTEGRATION AND COST CONTROL CARDS

Card ID No.	Card Name	Maximum Cards	Segment No. (Columns)				Comments
			77	78	79	80	
2-20	Integration and Cost Control – General	1	2	2	0	L	One card per run
2-21	Launch Rate Limit vs. Calendar Year	2	2 2	2 2	1 1	1 L	Two cards required each run
2-22	Mission/Mode Combinations	17	2	2	2	*	50 mission/mode combinations may be used per lunar program
2-23	Launch Rate Improvement Cost Curve	20	2	**	**	*	Two sets of curves required per step in launch rate improvement

*1, 2, . . . , L depending on maximum number of cards desired. (The letter "L" is always used on the last card of a series.)
**Columns 78 and 79 of Card 2-23 take the form "XX"
where XX = 23 for nonrecurring R&D of first step in launch rate
= 24 for nonrecurring Cost of Facilities of first step in launch rate
= 25 for nonrecurring R&D of second step in launch rate
= 26 for nonrecurring Cost of Facilities of second step in launch rate
⋮
= 41 for nonrecurring R&D of tenth step in launch rate
= 42 for nonrecurring Cost of Facilities of tenth step in launch rate

The cards are input in the order shown in Fig. 10-11. Care must be taken in assembling the 2-22 cards so that missions that are dependent on each other are called out in proper order. A STOP card at the end of the stack signals completion of the card input. Instructions for filling out the cards are given in Appendix J.

10.11 COMPUTER INPUT CHECKLISTS

Despite the care taken in preparing input cards, errors still occur. The use of checklists may help to avoid these errors.

10.11.1 Mission Input Checklist

The following checklist should be used before submitting cards for generation of each mission tape:

(1) List each mission ID number exactly as it appears in columns 1 – 8 of the 301L card.
(2) Check that the mission start date on each 301L card begins in column 31.
(3) Check that the "related mission" number in columns 39 – 40 of the 301L is exactly as it appears in columns 7 – 8 of the related mission's 301L card.
(4) Check that a SKIP card precedes each 303L card used to call out a traverse for the mission.
(5) Check that the traverse ID for each 303L card begins in column 13.
(6) Check that a LAST card appears after the end of the data cards for each mission, except that after the final mission a STOP card appears.

10.11.2 Mode Input Checklist

The following checklist should be used before submitting cards for generation of each new mode tape:

(1) Check that the mode ID appears in columns 1 – 12 of each 401L card.
(2) Check that the number given in column 75 of the 401L card equals the number of 407X cards.

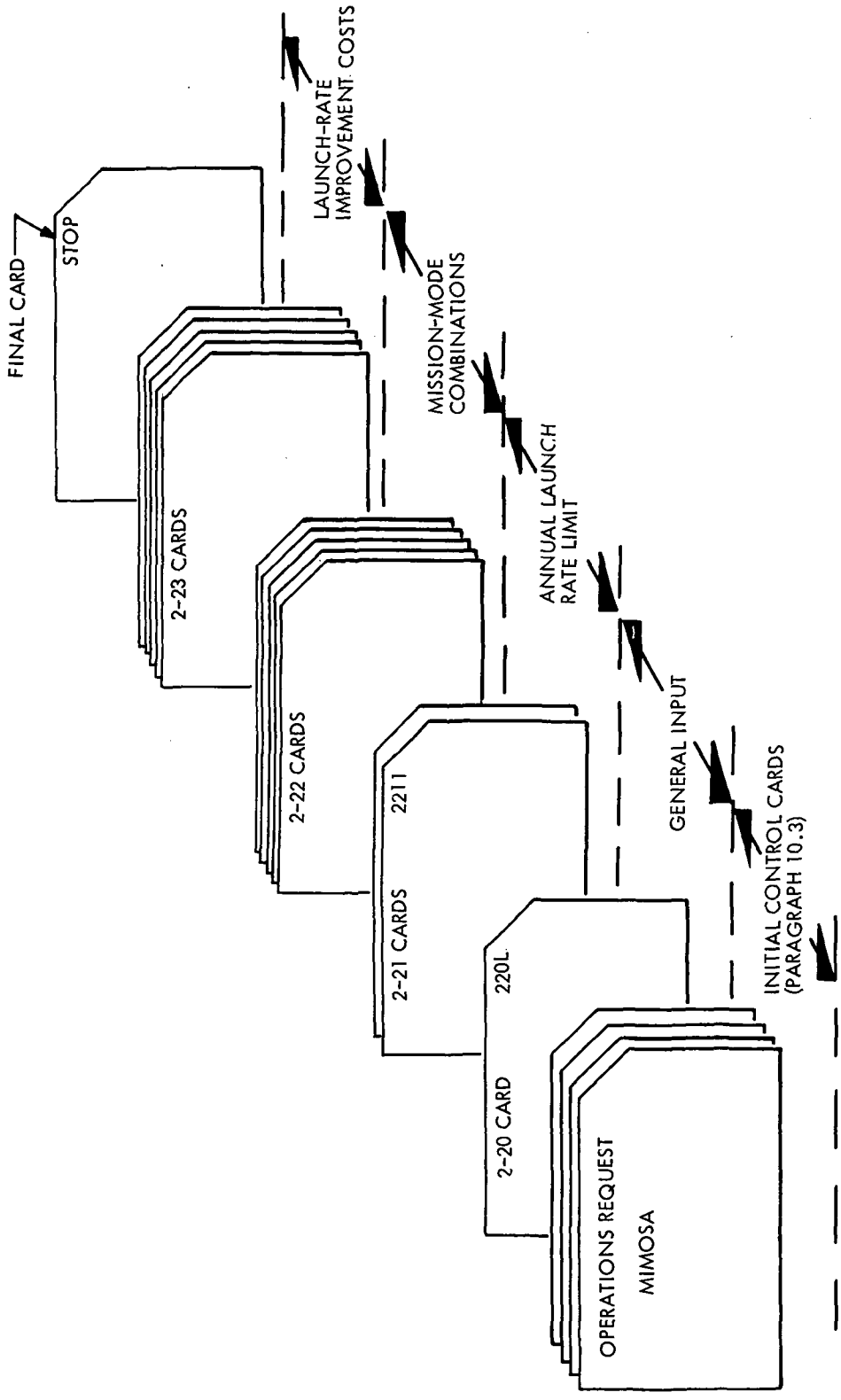


Fig. 10-11 Computer Card Stack – Control of Integration and Cost Routine

(3) Check that all systems required for the mode as given in the 41XX cards are included in the Latest System/Experiment Tape. Any missing systems must be added to that tape.

(4) Check that the number in column 15 of each 41XX cards also appears in column 79 of that same card.

(5) Check that the sequence numbers in columns 77 – 80 of each card are in proper order.

(6) Check that a LAST card appears after the end of the data cards for each mode, except that a STOP card appears after the final mode.

10.11.3 Mission-Mode Match Checklist

The following checklist should be used before submitting control cards for each mission-mode match computer run:

(1) Check that the mission ID number appears in columns 13 – 20 of each 211L card.

(2) Check that the data for the mission appear on the Latest Mission/Mode tape.

(3) Check that the mode ID number appears in columns 25 – 36 of the appropriate 211L card.

(4) Check that the mode appears on the Latest Mission/Mode Tape.

(5) Check that the shirtsleeve and spacesuit manhour multipliers appear in columns 50 – 55 and 60 – 65, respectively, on the 211L card.

(6) Check that the mode ID number on each 212X card exactly matches the mode ID number on the 211L card.

(7) Check that the traverse ID numbers given on the 212X card start in columns 31, 37, 43, 49, 55, and 61.

(8) Check that each traverse called out on the 212X cards appears on the mission tape (and vice versa).

10.11.4 Exploration Program Cost Checklist

The following checklist should be used before submitting control cards for each exploration program cost run on the computer.

(1) Check that only mission ID numbers appear in columns 1 – 8, 26 – 33, and 51 – 58 of the 222X cards.

(2) Check that only the accompanying mode ID numbers appear in columns 9 – 20, 34 – 45, and 59 – 70 of the 222X cards.

(3) Check that the data for each mission appears on the Latest Mission/Mode Tape.

(4) Check that each mode appears on the Latest Mission/Mode Tape.

(5) Check that the sequence numbers on the 222X cards are in the proper order.

Appendix A

EXAMPLE LUNAR PROGRAM SUMMARY

(Ref. Chapter 9)

The example lunar exploration program accomplishes a 55,000 manhour scientific program using the so-called "path approach" (Scientific Program A). The first nine post-Apollo missions use Saturn Apollo Applications (AAP) hardware and extend through 1974. The second evolutionary hardware step utilizes an uprated Saturn (125% Saturn V) and a direct logistics landing vehicle (LLV). The earliest date allowed for introduction of this new hardware is 1976. A further objective is to introduce the 175% Saturn V at the earliest practicable date.

Eight locales and twenty different paths are to be explored. No rigid cost constraints were specified but the funding target was set at 1 to 2 billion dollars per year. Launch rates are three or four per year through 1975, four per year through 1977, and six to eight per year thereafter. Transportation system costs for the first two post-Apollo missions are included in the Apollo run-out costs.

As developed with these objectives and within these constraints, the example exploration program introduces the 125% Saturn and the LLV in 1976 and the 175% Saturn in 1981. The program is completed with a large astronomy mission to Grimaldi, beginning in late 1985 and requiring 10 launches. The total number of Saturn launches is 77, including 6 Apollo missions and 4 test launches (2 each for the 2 Saturn upratings). The total post-Apollo cost is 25.6 billion dollars spread over about 20 years. The program indicates a cost of about 2 billion dollars for development of the 125% Saturn and the LLV. Funds must be committed in 1969. A further commitment of the order of 3 billion dollars for development of the 175% Saturn must be made in about 1976.

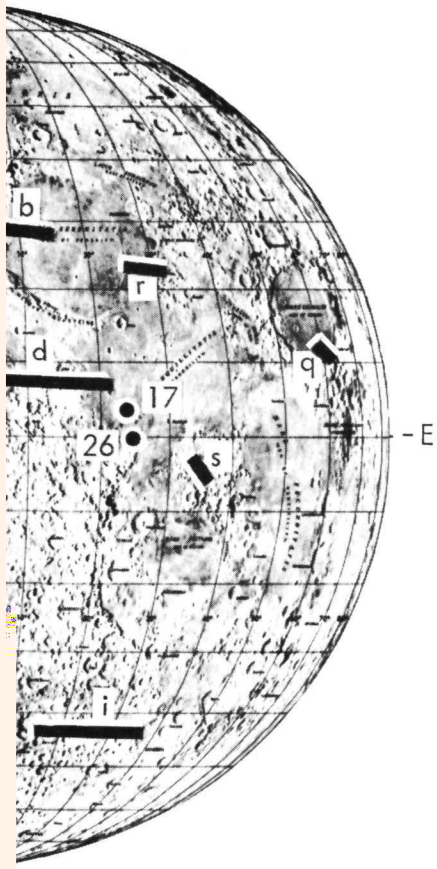
During its early and intermediate phases, Program A is essentially a plan for geoscientific exploration of the moon, with emphasis toward the end on establishment of major facilities for radio and optical astronomy. The total mass of scientific equipment is 153,000 kg; the masses of the geoscientific and astronomical equipment are about equal.

Program A uses the path approach for surface exploration of the moon, which involves 20 paths with a total path length of 8,500 km. In addition, there are missions to eight widely separated locales, each covering an exploration area of about 100 sq km.

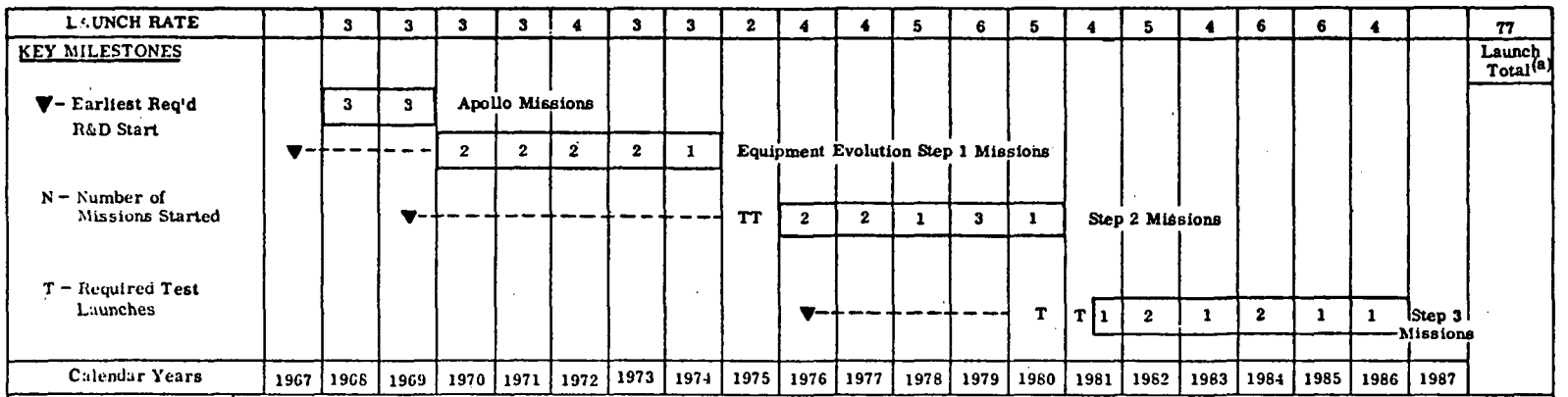
The subsurface structure of the moon is probed to depths of 200 km by means of active seismic reflection and refraction techniques. Experiments in active seismology require detonations or surface impacts with energies ranging from the equivalent of 0.5 to 6,000 kg of TNT. The total amount of explosives used in Program A is equivalent to 156,000 kg of TNT. Core-drill samples from a depth of 300 m are acquired at five locales.

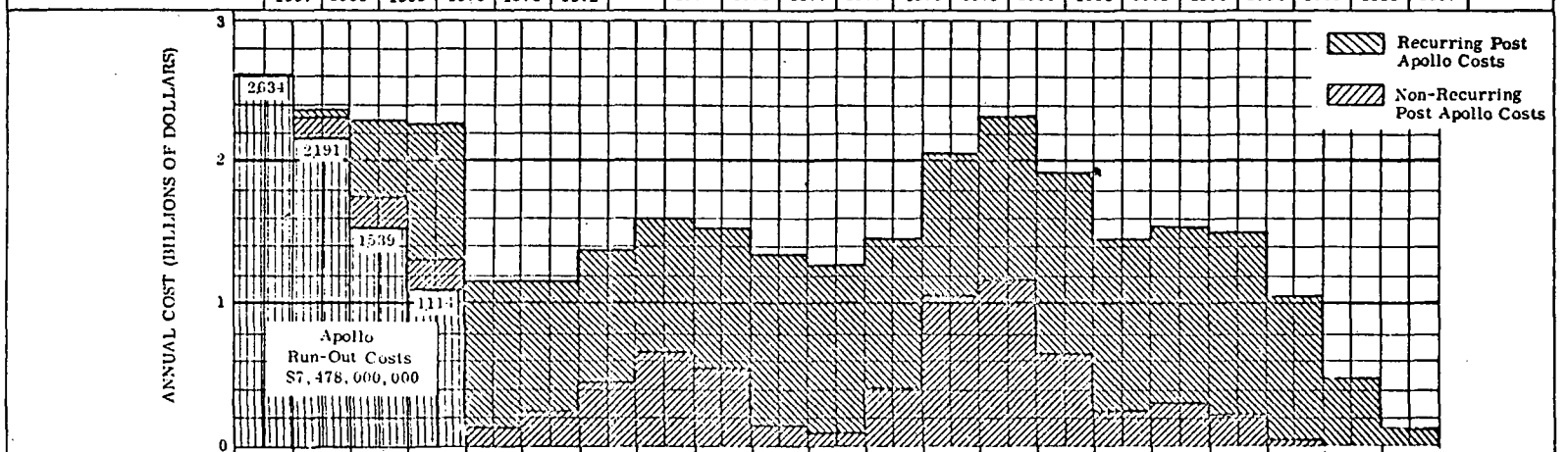
The astronomical facility comprises two types of radio telescopes, three optical telescopes, and one x-ray telescope. The radio telescopes operate at relatively low frequencies (0.3 to 1.0 MHz) that are not observable with earth-based radio telescopes and at relatively short wavelengths (in the millimeter and submillimeter ranges) that are troublesome to earth-based radio telescopes because of atmospheric interference. The apertures of the optical telescopes are 1 and 2.5 m, and they are designed primarily for operation at wavelengths in the far ultraviolet region, which is excluded from observation by earth-based telescopes because of atmospheric absorption. The x-ray telescope uses grazing-incidence double-reflection optics with an aperture diameter of 1 m and an angular resolution of 1 arcsec.

The total number of distinct scientific experiments, considering all scientific disciplines, is 198, and a total of 54,000 manhours is allocated for the performance of those experiments.


b
r
d
q
17
26
s
E
i

COST AND SCHEDULE SUMMARY





Fiscal Years		1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	TOTALS
POST APOLLO COSTS	TOTAL (MILLIONS)	5	170	730	1121	1183	1177	1367	1601	1572	1340	1272	1456	2071	2333	1941	1460	1582	1514	1060	488	125	25,588
Non-Recur	R&D	5	92	233	165	113	199	406	624	575	164	91	358	942	1137	658	265	303	208	28			6,566
Non-Recur	C OF F		1	1		2	5	31	30		1	5	50	115	39	7							287
Recurring	PROCUREMENT		77	485	862	865	786	791	730	860	976	952	799	781	992	1064	970	1064	1053	760	300	70	15,237
Recurring	OPERATIONS			11	94	203	187	159	217	137	199	224	249	233	165	212	225	215	253	272	188	55	3,498

(a) Includes six Apollo launches.

POST-APOLLO MISSION SUMMARY

Mission No.	Mission Start	Mission Location (paths – locales)	Mode Identification Number	Number of Launches	Map Reference	Stay Time (days)	Total Man-hours	Scientific Man-hours	Total Cargo (kg)	Scientific Equipment (kg)	Mass Reserve (kg)	Total Traverse (km)
7	70A	Orbiter 1	303-10021-02	1	–	27	1908	636	4183	1737	(11,230)	–
8	70B	Ranger VIII Landing Site	402-10012-01	2	17	15	729	180	4716	575	381	150
9	71A	Moltke B	402-10011-01	2	26	16	733	180	4719	575	378	150
10	71B	Orbiter 2	303-10022-02	1	–	27	1908	636	5031	1777	(10,382)	–
11	72A	Tycho	402-10011-03	2	11	16	780	197	4173	482	920	150
12	72B	First Visit to Grimaldi, Astronomical Location	402-10011-03	2	21	16	747	190	4221	581	855	90
13	73B	Orbiter 3	303-10022-02	1	–	27	1908	636	5031	1777	(10,382)	–
14	73B	South Pole	402-10011-03	2	16	18	837	213	4165	458	973	150
15	74B	Second Visit to Grimaldi, Astronomical Location	402-10081-01	3	21	18	864	115	6375	2407	3674	–
16	76A	Capella M	503-20162-01	2	s	10	678	204	10,502	623	6798	300
17	76B	Copernicus – Dark Halo Craters Southeast of Copernicus	503-20162-01	2	n–5	27	1937	809	11,135	1235	5165	300
18	77A	Southeast Serenitatis	503-20162-01	2	r	10	667	199	20,964	602	5818	300
19	77B	Mare Crisium	503-20162-01	2	q	9	647	189	10,323	443	5977	300
20	78A	M Imbr, M Imbr to M Seren, P Putr to M Vapor	503-20191-01	5	a,b,c	105	7582	2372	62,608	42,024	2592	3900
21	79A	Mare Humorum	503-20162-01	2	o	15	1085	310	10,517	637	5783	600
22	79A	North Pole	503-20162-01	2	t	9	647	189	10,323	443	5977	300
23	79B	Mare Smythii	503-20162-01	2	p	27	1948	544	10,493	593	5807	1200
24	80B	Central Farside	503-20201-01	4	f	48	3470	1216	48,900	29,548	0	1200
25	81B	Marius Hills to Aristarchus	503-30094-01	3	j	41	2949	998	37,499	19,331	13,301	1200
26	82A	Ptol to Alphon,C High,M Nub to St Wall – Alphon, St Wall	503-30083-01	2	f,g,h–2,18	65	4636	2192	25,400	8539	0	2300
27	82B	Mare Orientale	503-30103-01	3	m	36	2600	1213	48,762	29,536	2278	1200
28	83B	P Putr to M Vapor, M Vapor to M Tranq, Si Medii	503-30114-01	4	c,d,e	73	5226	1695	61,949	42,417	14,251	2400
29	84A	Southern Highlands	503-30103-01	3	i	36	2597	1211	48,748	29,522	2292	1200
30	84B	Northern Farside	503-30094-01	3	k	34	2429	748	37,209	19,094	14,734	1200
31	85B	Third Visit to Grimaldi, Astronomical Location	406-30161-01	6	21	822	118,433	37,466	118,051	75,720	8949	60
32	86B	Fourth Visit to Grimaldi, Astronomical Location	406-30161-02	4	21	0	0	0	0	0	0	0
Total						1547	167,944	54,538	605,515	310,676	106,905	18,650

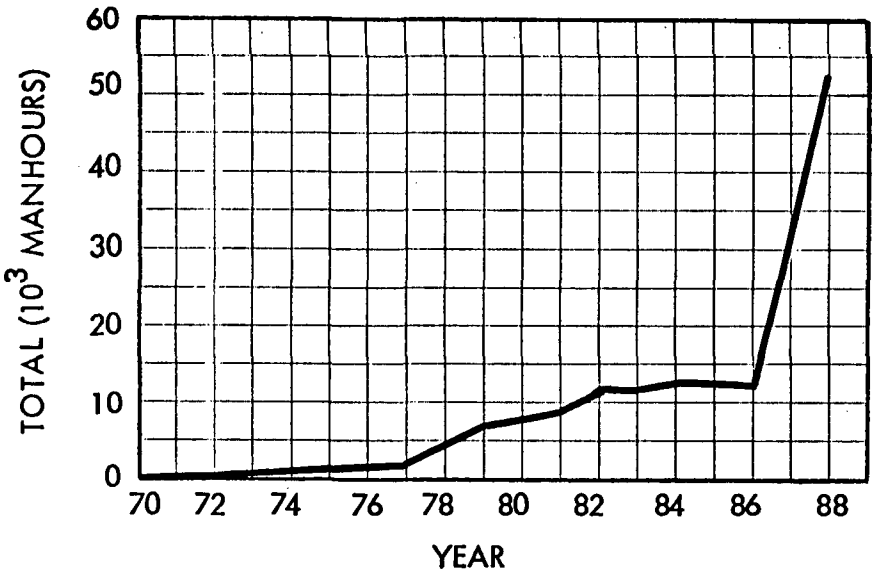
EQUIPMENT USAGE AND COST SUMMARY

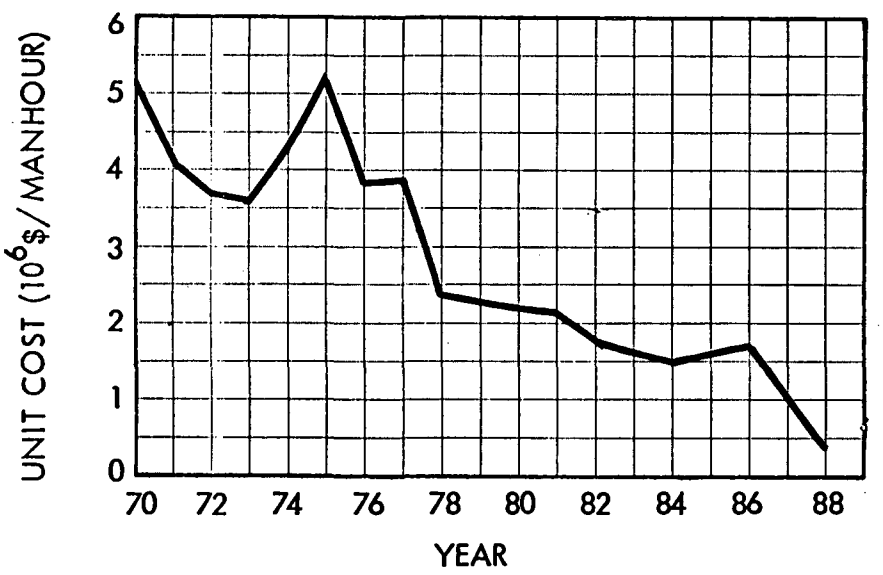
Equipment Identification		R&D Start	First/ Last Use	Number Procured		Cost Summary (Millions of Dollars)				
						Nonrecurring		Recurring		Total Cost
ID No.	Name			Operations	Spares	R&D	C of F	Procurement	Operation	
	Launch Vehicles									
1221-01	100% Saturn V	–	71A/74B	13	2	–	–	2100	270	2370
1221-03	100% Saturn V (Apollo funded)	–	68A/70B	9	1	–	–	–	–	–
1231-01	125% Saturn V	72A	76A/79B	23	3	570	42	2760	484	3856
1251-01	175% Saturn V	77A	80A/86A	28	3	818	135	3799	548	5300
	Subtotals					1388	177	8659	1302	11,526
	Flight Systems									
1311-01/1321-01	CSM – LOR – Three-Man	–	71A/74B	13	2	–	–	1231	288	1519
1311-02/1321-04	CSM – LOR – Three-Man	73B	76A/79B	9	1	76	–	821	190	1087
1331-01/1341-01	LM Taxi – Two-Man	67B	70B/74B	6	1	32	–	348	85	465
1332-02/1342-01	LM Taxi – Three-Man	72B	76A/79B	9	1	246	–	561	125	932
1412-02/1454-01	CSM – Direct – Six-Man	77B	81A/86A	11	2	900	12	1070	172	2154
1421-02/1431-03	Personnel Braking and Landing Stages	76B	81A/86A	11	2	459	24	221	31	735
1423-02/1433-02	LLV – 125% Saturn V	71B	76A/79B	14	2	599	24	328	55	1006
1423-04/1433-04	LLV – 175% Saturn V	76B	80A/85A	17	2	687	24	405	69	1185
	Subtotal					2999	84	4985	1015	9083
	Mission Equipment									
2121-01	Orbit-Launched Probe	68B	70A/73B	7	1	58	–	26	2	86
2132-02	Surface-Launched Probe	74B	78A/84B	20	2	38	–	46	4	88
2222-02	Orbiter Rack	67B	70A/73B	3	1	1	–	–	–	1
2321-01/1351-03	LM Shelter – Two-Man	67B	70B/74B	6/7[a]	1	217	–	318	92	627
2325-05	Shelter – Six-Man	80A	85A/–	1	1	484	–	88	11	583
2421-01	LSSM	67B	70B/73B	7	1	58	2	39	4	103
2423-03	LRV – Three-Man – 90 Days	69B	76A/85A	16	2	421	2	347	27	797
2433-04	Trailer – Large Multipurpose	75A	78A/85A	9	1	52	3	84	2	141
2512-03	LFV – Two-Man Exploration	67B	70B/71A	2	1	48	–	8	1	57
2521-02	LFV – Return to Orbit	74A	78A/84B	5	1	62	–	20	2	84
2721-02	Nuclear Power Supply – 20 kw	78B	85A/–	1	1	136	20	28	–	184
	Subtotal					1575	27	1004	145	2751
	Major Scientific Equipment									
3213-02	300-m Drill With Fuel Cell	74B	78A/84B	5	1	11	–	11	–	22
3223-01	15-m Parabolic Radio Telescope	81A	85A/–	1	1	4	–	4	–	8
3224-02	Radio Telescope – Mills Cross	79B	85A/–	1	1	30	–	4	1	35
3231-01	X-Ray Telescope	78A	85A/–	1	1	39	–	6	1	46
3242-01	1-m Optical Telescope	70A	74B/–	1	1	29	–	11	1	41
3242-04	2-m Optical Telescope	79A	85A/–	1	1	152	–	25	1	178
3243-01	2.5-m Optical Telescope	78A	85A/–	1	1	227	–	35	1	263
	Subtotal					492	–	96	5	593
	Total					6454	288	14,744	2467	23,953

(a) One 1351-03 used to deliver 1-m optical telescope.

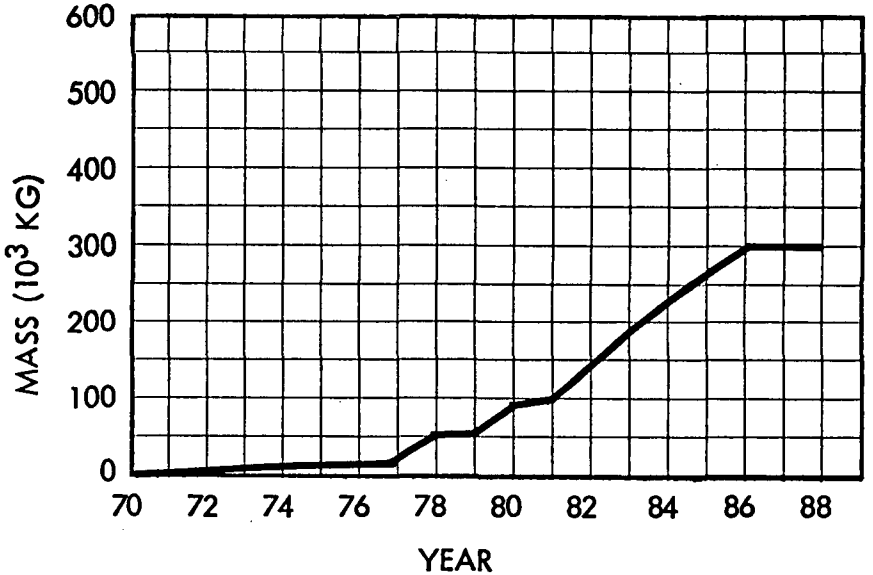
SCIENTIFIC PROGRAM OPERATIONAL SUMMARY

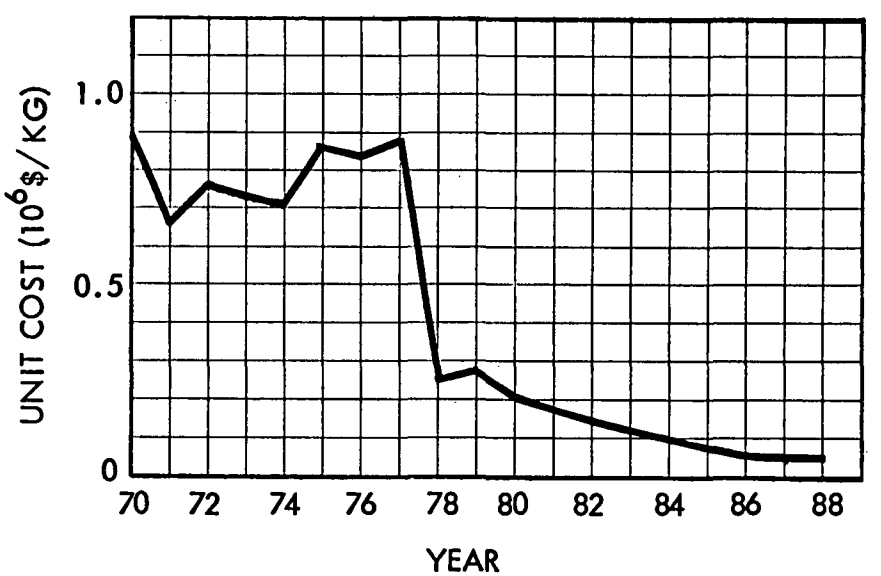
SCIENTIFIC MANHOURS





SCIENTIFIC EQUIPMENT MASS





Appendix B

DETAILED INSTRUCTIONS FOR PREPARING MISSION INPUT CARDS

(Ref. Paragraph 10.5.1)

MISSION INPUT - GENERAL

THIS CARD IS USED TO IDENTIFY EACH MISSION AND TO RELATE THE MISSION TO OTHERS IN THE LUNAR PROGRAM.

1-28 MISSION IDENTIFIER. INPUT AN IDENTIFIER THAT UNIQUELY LABELS THIS MISSION WITHIN THE FIRST EIGHT COLUMNS. THE FOLLOWING INPUT FORMAT WILL BEST MATCH THE COMPUTER INTERNAL LOGIC AND OUTPUT PRINT ROUTINE.

1-3 SCIENTIFIC PROGRAM IDENTIFIER. USE ANY COMBINATION OF LETTERS AND NUMBERS TO LABEL THE SCIENTIFIC PROGRAM UNDER CONSIDERATION. START THE INPUT IN COLUMN 1.

5-6 MISSION MIX IDENTIFIER. IDENTIFY THE GROUP OF MISSIONS BEING DERIVED TO ACCOMPLISH THE SCIENTIFIC PROGRAM GIVEN ABOVE.

7-8 NUMBER OF THIS MISSION IN THE SEQUENCE OF MISSIONS.

9-26 LOCATION OF THIS MISSION ON OR ABOUT THE MOON. SPECIFY THE ACTUAL LOCATION.

27-28 NUMBER OF TIMES THIS LOCATION WILL HAVE BEEN VISITED COUNTING THIS MISSION.

31-35 NOMINAL MISSION START DATE. INPUT THE CALENDAR YEAR TO BE USED AS THE NOMINAL START DATE FOR THE MISSION. ALSO INDICATE WITH AN A OR B WHETHER THE START DATE IS IN THE FIRST OR SECOND HALF OF THE YEAR. FOR EXAMPLE,

1973A = FIRST HALF OF 1973
1973B = SECOND HALF OF 1973

THIS DATE IS USED BY THE COMPUTER AS THE STARTING POINT IN ITS ITERATIONS TO FIND THE MOST DESIRABLE START DATE.

39-40 RELATED MISSION NUMBER. INPUT HERE THE MISSION SEQUENCE NUMBER (SEE 7-8 ABOVE) OF THE MISSION UPON WHICH THE START OF THIS MISSION DEPENDS. FOR EXAMPLE, IF THIS IS MISSION 7 AND IT CANNOT START UNTIL MISSION 5 IS COMPLETED, THE NUMBER 5 IS INPUT HERE. IF THERE IS NO RELATED MISSION, LEAVE THESE SPACES BLANK.

NOTE- BE SURE TO PUT THE NUMBER OF THE RELATED MISSION IN COLUMNS 39-40 JUST AS IT APPEARS IN COLUMNS 7-8 OF THE IDENTIFIER FOR THAT MISSION.

CARD I.D. 3-01 PAGE 2 OF 2

MISSION INPUT - GENERAL (CONTINUED)

41-50	MINIMUM NUMBER OF 6-MONTH PERIODS THAT MUST ELAPSE BETWEEN THE LAST LAUNCH OF THE RELATED MISSION GIVEN IN 39-40 AND THE FIRST LAUNCH OF THE MISSION BEING IDENTIFIED WITH THIS CARD. INPUT 0 (ZERO) FOR 0-6 MONTHS, 1 FOR 7-12 MONTHS, ETC. THE INPUT NUMBER MAY BE PLACED ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT. IF COLUMNS 39-40 ARE BLANK, LEAVE THIS INPUT BLANK.
77-80	SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER- 3011

MISSION INPUT - BASE EXPERIMENT

THIS CARD IS USED TO IDENTIFY THOSE EXPERIMENTS FOR A MISSION WHICH ARE NOT DONE ON A TRAVERSE. THIS CARD SHOULD ALSO BE FILLED OUT FOR PROBE AND ORBITER MISSIONS. USE AS MANY CARDS AS THERE ARE NON-TRAVERSE EXPERIMENTS. UP TO 100 CARDS MAXIMUM MAY BE USED ON ANY ONE MISSION. IF ALL EXPERIMENTS ARE DONE ON TRAVERSE, DO NOT INPUT THIS CARD.

16-27 EXPERIMENT IDENTIFIER. INPUT HERE THE NUMBER WHICH UNIQUELY IDENTIFIES AN EXPERIMENT. IF POSSIBLE, USE THE NUMBER PROVIDED BY THE NORTH AMERICAN AVIATION STUDY OF LUNAR MISSIONS. EXPAND THEIR 8-DIGIT NUMBER INTO FIVE SECTIONS WITH DECIMAL POINTS AS FOLLOWS.

X.X.XX.XX.XX

BEGIN THIS 12-PLACE NUMBER IN COLUMN 16.

28 PHASE 1 CODE. INPUT HERE A CODE LETTER TO DESIGNATE THE UNITS OF THE NUMBER THAT FOLLOWS FOR THE FREQUENCY OF PHASE 1 (SETUP) OF THE GIVEN EXPERIMENT. USE ONE OF THESE LETTERS-

A = REPLICATIONS PER MISSION
D = REPLICATIONS PER MONTH

29-32 FREQUENCY OF PHASE 1. INPUT HERE THE NUMBER OF TIMES THE GIVEN EXPERIMENT MUST BE SET UP. BE SURE TO USE A NUMBER CONSISTENT WITH THE CODE IN COLUMN 28. SEE NOTE * ON PAGE 4 OF 4.

33 PHASE 2 CODE. INPUT HERE A CODE LETTER TO DESIGNATE THE UNITS OF THE NUMBER THAT FOLLOWS FOR THE FREQUENCY OF PHASE 2 (OPERATION) OF THE GIVEN EXPERIMENT. USE ONE OF THE LETTERS IDENTIFIED IN 28 ABOVE.

34-37 FREQUENCY OF PHASE 2. INPUT HERE THE NUMBER OF TIMES THE GIVEN EXPERIMENT IS PERFORMED. BE SURE TO USE A NUMBER CONSISTENT WITH THE CODE IN COLUMN 33. SEE NOTE * ON PAGE 4 OF 4.

38 PHASE 3 CODE. INPUT HERE A CODE LETTER TO DESIGNATE THE UNITS OF THE NUMBER THAT FOLLOWS FOR THE FREQUENCY OF PHASE 3 (ANALYSIS) OF THE GIVEN EXPERIMENT. USE ONE OF THE LETTERS IDENTIFIED IN 28 ABOVE.

39-42 FREQUENCY OF PHASE 3. INPUT HERE THE NUMBER OF TIMES THAT DATA OR SAMPLES TAKEN DURING THIS EXPERIMENT ARE ANALYZED. BE SURE TO USE A NUMBER CONSISTENT WITH THE CODE IN COLUMN 38. SEE NOTE * ON PAGE 4 OF 4.

MISSION INPUT - BASE EXPERIMENTS (CONTINUED)

43 PHASE 4 CODE. INPUT HERE A CODE LETTER TO DESIGNATE THE UNITS OF THE NUMBER THAT FOLLOWS FOR THE FREQUENCY OF PHASE 4 (TAKE DOWN) OF THE GIVEN EXPERIMENT. USE ONE OF THE LETTERS IDENTIFIED IN 28 ABOVE.

44-47 FREQUENCY OF PHASE 4. INPUT HERE THE NUMBER OF TIMES THAT THE EXPERIMENT EQUIPMENT MUST BE TAKEN DOWN. BE SURE TO USE A NUMBER CONSISTENT WITH THE CODE IN COLUMN 43. SEE NOTE * ON PAGE 4 OF 4.

48 LAUNCH PAYLOAD MASS CODE USE ONE OF THE FOLLOWING CODES TO DESIGNATE THE INPUT DESIRED FOR CALCULATION OF EQUIPMENT MASS LANDED ON THE MOON FOR THIS EXPERIMENT-

INPUT	MEANING
LEAVE BLANK	THIS EXPERIMENT USES MINOR SCIENTIFIC EQUIPMENT. USE THE NUMBER GIVEN WITH THE EXPERIMENT
A	THIS EXPERIMENT USES MAJOR SCIENTIFIC EQUIPMENT. USE THE NUMBER IN THE FOLLOWING 6 COLUMNS INSTEAD OF THAT GIVEN WITH THE EXPERIMENT.
B	THIS EXPERIMENT USES MINOR SCIENTIFIC EQUIPMENT. HOWEVER, USE THE NUMBER IN THE FOLLOWING 6 COLUMNS INSTEAD OF THAT GIVEN WITH THE EXPERIMENT

49-54 LAUNCH PAYLOAD MASS OVERRIDE. INPUT AS FOLLOWS DEPENDING ON INPUT IN COLUMN 48 (SEE NOTE* ON PAGE 4 OF 4) -

INPUT IN 48	INPUT HERE
NONE	NONE
A	MASS OVERRIDE, IN KG, IN PLACE OF MASS GIVEN WITH THE EXPERIMENT
B	MASS OVERRIDE, IN KG, IN PLACE OF MASS GIVEN WITH THE EXPERIMENT

MISSION INPUT - BASE EXPERIMENTS (CONTINUED)

55 NONRECURRING COST CODE. USE ONE OF THE CODES IN 48 ABOVE TO INDICATE THE INPUT THAT IS DESIRED FOR THE NONRECURRING COST OF THE SCIENTIFIC EQUIPMENT ASSOCIATED WITH THIS EXPERIMENT.

56-61 NONRECURRING COST OVERRIDE. INPUT AS FOLLOWS DEPENDING ON THE INPUT IN COLUMN 55 (SEE NOTE * PAGE 4 OF 4) -

INPUT IN 55	INPUT HERE
NONE	NONE
A	NONRECURRING COST, IN MILLIONS, FOR MINOR SCIENTIFIC EQUIPMENT ONLY. THIS COST IS TO BE USED IN PLACE OF THE COST GIVEN WITH THE EXPERIMENT.
B	NONRECURRING COST, IN MILLIONS, TO BE USED IN PLACE OF THE COST GIVEN WITH THE EXPERIMENT.

62 RECURRING COST CODE. USE ONE OF THE LETTER CODES GIVEN IN 48 ABOVE TO INDICATE THE INPUT THAT IS DESIRED FOR RECURRING HARDWARE PROCUREMENT OF THE SCIENTIFIC EQUIPMENT ASSOCIATED WITH THIS EXPERIMENT.

63-68 RECURRING COST OVERRIDE. INPUT AS FOLLOWS DEPENDING ON THE INPUT IN COLUMN 62 (SEE NOTE * PAGE 4 OF 4) -

INPUT IN 62	INPUT HERE
NONE	NONE
A	RECURRING COST, IN MILLIONS, FOR MINOR SCIENTIFIC EQUIPMENT ONLY. THIS COST IS TO BE USED IN PLACE OF THE COST GIVEN WITH THE EXPERIMENT.
B	RECURRING COST, IN MILLIONS, TO BE USED IN PLACE OF THE COST GIVEN WITH THE EXPERIMENT.

MISSION INPUT - BASE EXPERIMENTS (CONTINUED)

69-75 MINIMUM TIME FOR ALL MANNED REPLICATIONS. INPUT THE TIME, IN DAYS, THAT IS REQUIRED FOR THE CREW TO COMPLETE THE GIVEN EXPERIMENT. COUNT THE ENTIRE SPAN FROM START TO FINISH EVEN THOUGH LITTLE OR NO WORK MAY BE DONE ON SOME OF THE DAYS IN THE SPAN. IF THE EXPERIMENT IS PERFORMED WITHOUT CREW HELP, LEAVE THIS SPACE BLANK. SEE NOTE * BELOW.

NOTE * - PLACE THE INPUT NUMBER ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.

IMPORTANT - RECHECK THE INPUT OF THIS CARD. IF THE CODE LETTER A IS USED IN COLUMNS 48, 55, OR 62, IT MUST APPEAR IN ALL THREE COLUMNS.

CARD I.D. 3-03

MISSION INPUT - TRAVERSE DATA

THIS CARD IS USED TO INPUT CERTAIN DATA ASSOCIATED WITH EACH TRAVERSE TO BE ACCOMPLISHED DURING THE MISSION. FILL OUT ONE CARD FOR EACH TRAVERSE.

13-16 TRAVERSE IDENTIFIER. INPUT A SEQUENCE IDENTIFIER FOR THE TRAVERSE. THE FORM

R-XX OR F-XX

IS SUGGESTED WHERE

R = ROVING TRAVERSE

F = FLYING TRAVERSE

XX = NUMBERS IN SEQUENCE FOR EACH TYPE OF TRAVERSE

BE SURE TO START THE INPUT IN COLUMN 13.

31-40 TRAVERSE RANGE. INPUT THE TOTAL DISTANCE TRAVELED, IN KILOMETERS, FROM START TO FINISH OF THE TRAVERSE. SEE NOTE * BELOW

41-50 NUMBER OF STOPS. INPUT THE NUMBER OF MAJOR STOPS (1 HOUR OR LONGER FOR AN LRV OR ANY LEV LANDING) THAT OCCUR IN THE TRAVERSE. DO NOT COUNT THE FINAL STOP MADE AT THE END OF THE TRAVERSE. SEE NOTE * BELOW.

51-60 LEV VELOCITY INCREMENT. IF THIS IS A FLYING TRAVERSE, INPUT THE TOTAL DELTA V, IN METERS PER SECOND, EXPENDED BY AN LEV IN ACCOMPLISHING THE TRAVERSE. COUNT ALL VELOCITY INCREMENTS REQUIRED INCLUDING TAKEOFF, LANDING, FLIGHT, GRAVITY LOSSES, AND RESERVE (IF ANY). SEE NOTE * BELOW.

IF THIS CARD IS FOR A ROVING TRAVERSE, LEAVE THIS SPACE BLANK.

77-80 SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER- 303L

NOTE * - PLACE THE NUMBER ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.

MISSION INPUT - TRAVERSE EXPERIMENTS

THIS CARD IS USED TO IDENTIFY THOSE EXPERIMENTS PERFORMED ON EACH TRAVERSE IDENTIFIED BY A CARD I.D. NO. 3-03. USE AS MANY CARDS AS THERE ARE EXPERIMENTS FOR EACH TRAVERSE THAT IS IDENTIFIED. UP TO 50 CARDS MAY BE INPUT FOR ANY ONE TRAVERSE.

16-27 EXPERIMENT IDENTIFIER. INPUT HERE THE NUMBER WHICH UNIQUELY IDENTIFIES AN EXPERIMENT. IF POSSIBLE, USE THE NUMBER PROVIDED BY THE NORTH AMERICAN AVIATION STUDY OF LUNAR MISSIONS. EXPAND THEIR 8-DIGIT NUMBER INTO FIVE SECTIONS WITH DECIMAL POINTS AS FOLLOWS.

X.X.XX.XX.XX

BEGIN THIS 12-PLACE NUMBER IN COLUMN 16.

28 PHASE 1 CODE. INPUT HERE A CODE LETTER TO DESIGNATE THE UNITS OF THE NUMBER THAT FOLLOWS FOR THE FREQUENCY OF PHASE 1 (SETUP) OF THE GIVEN EXPERIMENT. USE ONE OF THESE LETTERS-

A = REPLICATIONS PER TRAVERSE
B = REPLICATIONS PER KILOMETER
C = REPLICATIONS PER STOP

29-32 FREQUENCY OF PHASE 1. INPUT HERE THE NUMBER OF TIMES THE GIVEN EXPERIMENT MUST BE SET UP. BE SURE TO USE A NUMBER CONSISTENT WITH THE CODE IN COLUMN 28. SEE NOTE * ON PAGE 4 OF 4.

33 PHASE 2 CODE. INPUT HERE A CODE LETTER TO DESIGNATE THE UNITS OF THE NUMBER THAT FOLLOWS FOR THE FREQUENCY OF PHASE 2 (OPERATION) OF THE GIVEN EXPERIMENT. USE ONE OF THE LETTERS IDENTIFIED IN 28 ABOVE.

34-37 FREQUENCY OF PHASE 2. INPUT HERE THE NUMBER OF TIMES THE GIVEN EXPERIMENT IS PERFORMED. BE SURE TO USE A NUMBER CONSISTENT WITH THE CODE IN COLUMN 33. SEE NOTE * ON PAGE 4 OF 4.

38 PHASE 3 CODE. INPUT HERE A CODE LETTER TO DESIGNATE THE UNITS OF THE NUMBER THAT FOLLOWS FOR THE FREQUENCY OF PHASE 3 (ANALYSIS) OF THE GIVEN EXPERIMENT. USE ONE OF THE LETTERS IDENTIFIED IN 28 ABOVE.

MISSION INPUT - TRAVERSE EXPERIMENTS (CONTINUED)

39-42 FREQUENCY OF PHASE 3. INPUT HERE THE NUMBER OF TIMES THAT DATA OR SAMPLES TAKEN DURING THIS EXPERIMENT ARE ANALYZED. BE SURE TO USE A NUMBER CONSISTENT WITH THE CODE IN COLUMN 38. SEE NOTE * ON PAGE 4 OF 4.

43 PHASE 4 CODE. INPUT HERE A CODE LETTER TO DESIGNATE THE UNITS OF THE NUMBER THAT FOLLOWS FOR THE FREQUENCY OF PHASE 4 (TAKE DOWN) OF THE GIVEN EXPERIMENT. USE ONE OF THE LETTERS IDENTIFIED IN 28 ABOVE.

44-47 FREQUENCY OF PHASE 4. INPUT HERE THE NUMBER OF TIMES THAT THE EXPERIMENT EQUIPMENT MUST BE TAKEN DOWN. BE SURE TO USE A NUMBER CONSISTENT WITH THE CODE IN COLUMN 43. SEE NOTE * ON PAGE 4 OF 4.

48 LAUNCH PAYLOAD MASS CODE USE ONE OF THE FOLLOWING CODES TO DESIGNATE THE INPUT DESIRED FOR CALCULATION OF EQUIPMENT MASS LANDED ON THE MOON FOR THIS EXPERIMENT-

INPUT	MEANING
LEAVE BLANK	THIS EXPERIMENT USES MINOR SCIENTIFIC EQUIPMENT. USE THE NUMBER GIVEN WITH THE EXPERIMENT
A	THIS EXPERIMENT USES MAJOR SCIENTIFIC EQUIPMENT. USE THE NUMBER IN THE FOLLOWING 6 COLUMNS INSTEAD OF THAT GIVEN WITH THE EXPERIMENT.
B	THIS EXPERIMENT USES MINOR SCIENTIFIC EQUIPMENT. HOWEVER, USE THE NUMBER IN THE FOLLOWING 6 COLUMNS INSTEAD OF THAT GIVEN WITH THE EXPERIMENT

NOTE- IF THE MASS OF ANY SCIENTIFIC EQUIPMENT USED ON THIS TRAVERSE HAS ALREADY BEEN ACCOUNTED FOR IN THE BASE EXPERIMENT INPUT (CARD I.D. 3-02), BE SURE TO INPUT A OR B (AS APPROPRIATE). IF NOT, THE COMPUTER WILL COUNT THE EQUIPMENT MASS TWICE.

MISSION INPUT - TRAVERSE EXPERIMENTS (CONTINUED)

49-54 LAUNCH PAYLOAD MASS OVERRIDE. INPUT AS FOLLOWS DEPENDING ON INPUT IN COLUMN 48 (SEE NOTE* ON PAGE 4 OF 4) -

INPUT IN 48	INPUT HERE
NONE	NONE
A	MASS OVERRIDE, IN KG, IN PLACE OF MASS GIVEN WITH THE EXPERIMENT
B	MASS OVERRIDE, IN KG, IN PLACE OF MASS GIVEN WITH THE EXPERIMENT

55 NONRECURRING COST CODE. USE ONE OF THE CODES IN 48 ABOVE TO INDICATE THE INPUT THAT IS DESIRED FOR THE NONRECURRING COST OF THE SCIENTIFIC EQUIPMENT ASSOCIATED WITH THIS EXPERIMENT.

56-61 NONRECURRING COST OVERRIDE. INPUT AS FOLLOWS DEPENDING ON THE INPUT IN COLUMN 55 (SEE NOTE * ON PAGE 4 OF 4) -

INPUT IN 55	INPUT HERE
NONE	NONE
A	NONRECURRING COST, IN MILLIONS, FOR MINOR SCIENTIFIC EQUIPMENT ONLY. THIS COST IS TO BE USED IN PLACE OF THE COST GIVEN WITH THE EXPERIMENT.
B	NONRECURRING COST, IN MILLIONS, TO BE USED IN PLACE OF THE COST GIVEN WITH THE EXPERIMENT.

62 RECURRING COST CODE. USE ONE OF THE LETTER CODES GIVEN IN 48 ABOVE TO INDICATE THE INPUT THAT IS DESIRED FOR RECURRING HARDWARE PROCUREMENT OF THE SCIENTIFIC EQUIPMENT ASSOCIATED WITH THIS EXPERIMENT.

MISSION INPUT - TRAVERSE EXPERIMENT (CONTINUED)

63-69 RECURRING COST OVERRIDE. INPUT AS FOLLOWS DEPENDING ON THE INPUT IN COLUMN 62 (SEE NOTE * ON PAGE 4 OF 4) -

INPUT IN 62	INPUT HERE
NONE	NONE
A	RECURRING COST, IN MILLIONS, FOR MINOR SCIENTIFIC EQUIPMENT ONLY. THIS COST IS TO BE USED IN PLACE OF THE COST GIVEN WITH THE EXPERIMENT.
B	RECURRING COST, IN MILLIONS, TO BE USED IN PLACE OF THE COST GIVEN WITH THE EXPERIMENT.

69 LRV OR LEV CARGO MASS CODE. USE ONE OF THE CODES IN 48 ABOVE TO DESIGNATE THE INPUT DESIRED FOR CALCULATION OF EQUIPMENT MASS TO BE CARRIED ON THE LRV OR LEV FOR THIS EXPERIMENT.

NOTE- IF TWO EXPERIMENTS ON THE TRAVERSE USE COMMON EQUIPMENT, BE SURE TO INPUT A OR B (AS APPROPRIATE) ON AT LEAST ONE OF THE EXPERIMENTS. OTHERWISE, THE COMPUTER MAY CALCULATE MORE CARGO MASS THAN IS DESIRED.

70-75 LRV OR LEV CARGO MASS OVERRIDE. INPUT AS FOLLOWS DEPENDING ON THE INPUT IN COLUMN 69 (SEE NOTE * BELOW) -

INPUT IN 69	INPUT HERE
NONE	NONE
A	MASS OVERRIDE, IN KG, IN PLACE OF MASS GIVEN WITH THE EXPERIMENT
B	MASS OVERRIDE, IN KG, IN PLACE OF MASS GIVEN WITH THE EXPERIMENT

THE COMPUTER WILL CALCULATE THE CARGO CARRIED BY THE LRV OR LEV ON THIS PARTICULAR TRAVERSE BASED ON THE INPUT HERE. HENCE, CARE SHOULD BE TAKEN WITH THIS INPUT.

NOTE * - PLACE THE INPUT NUMBER ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.

IMPORTANT - RECHECK THE INPUT OF THIS CARD. IF THE CODE LETTER A IS USED IN COLUMNS 48, 55, 62, OR 69, IT MUST APPEAR IN ALL FOUR COLUMNS.

Appendix C

DETAILED INSTRUCTIONS FOR PREPARING MODE INPUT CARDS

(Ref. Paragraph 10.5.2)

CARD I.D. 4-01

MODE INPUT - GENERAL

THIS CARD IS USED TO SUPPLY GENERAL INPUT DATA ON EACH MODE.

1-12	MODE IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. INCLUDE ALL DASHES. START THE IDENTIFIER IN COLUMN 1.
16-20	ACTIVE MODE CREW LEVEL. INPUT HERE THE NUMBER OF MEN WHO WILL ACTIVELY PERFORM THE MISSION EXPERIMENTS. FOR LUNAR SURFACE MISSIONS, COUNT ONLY THOSE MEN LANDED. SEE NOTE * BELOW.
21-25	TOTAL MODE CREW LEVEL. INPUT THE TOTAL CREW LEVEL SENT TO THE MOON. SEE NOTE * BELOW.
26-35	MODE STAY TIME. INPUT, IN DAYS, THE MAXIMUM TIME FOR ACCOMPLISHING SCIENTIFIC EXPERIMENTS PERMITTED BY THE MODE. FOR LUNAR SURFACE MISSIONS, THIS WILL BE THE TIME PERMITTED ON THE SURFACE. SEE NOTE * BELOW.
36-45	SAMPLE RETURN CAPABILITY. INPUT THE MAXIMUM MASS, IN KILOGRAMS, THAT CAN BE RETURNED TO EARTH BY THE MODE TRANSPORTATION SYSTEM. SEE NOTE * BELOW.
46-55	MINIMUM DECIMAL FRACTION TO CHECK FOR EXCESSIVE CAPABILITY. INPUT THE DECIMAL FRACTION OF THE MODE STAYTIME THAT MUST BE USED, AS A MINIMUM, DURING THE MISSION. THE COMPUTER WILL THEN CALCULATE THE STAYTIME REQUIRED FOR THE MISSION AND THEN CHECK TO SEE IF IT IS LESS THAN THIS FRACTION OF THE MODE STAYTIME CAPABILITY. IF THE REQUIREMENT CALCULATED IS TOO LOW, A SPECIAL MESSAGE WILL BE PRINTED OUT. SUGGESTED INPUT = 0.75 SEE NOTE * BELOW.
56-65	LAUNCH LEAD TIME FOR MINOR SCIENTIFIC EQUIPMENT. INPUT NUMBER OF 6-MONTH PERIODS PRIOR TO THE FIRST LAUNCH OF THE MODE THAT ALL MINOR SCIENTIFIC EQUIPMENT MUST BE DELIVERED FOR PAYLOAD INTEGRATION. INPUT 1 FOR 0-6 MONTHS, 2 FOR 7-12 MONTHS, ETC. SEE NOTE * BELOW. SUGGESTED INPUT = 2.0
72	FLAG FOR CONCURRENT SHELTERS. INPUT AS FOLLOWS. 0 (OR LEAVE BLANK) = NO CONCURRENT SHELTERS 1 = TWO OR MORE CONCURRENT SHELTERS
75	NUMBER OF PAYLOADS LAUNCHES IN THE MODE. IF MORE THAN 8, YOU ARE IN TROUBLE. THE COMPUTER WILL ACCEPT UP TO 8.
77-80	SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER- 401L

NOTE * - PLACE THE INPUT NUMBER ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.

CARD I.D. 4-02

MODE INPUT - OPERATIONS

THIS CARD IS USED TO INPUT CERTAIN OPERATIONAL DATA ON EACH MODE.

1-12 MODE IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. INCLUDE ALL DASHES. START THE IDENTIFIER IN COLUMN 1.

19-24 TOTAL TIME FOR BASE DEPLOYMENT. INPUT THE TIME, IN DAYS, REQUIRED FOR BASE DEPLOYMENT BY THE CREW. DO NOT COUNT TIME REQUIRED FOR DEPLOYMENT BEFORE THE CREW ARRIVES. USE INTEGER DAYS, NOT FRACTIONS. IF MORE THAN 1 HOUR OF DEPLOYMENT ACTIVITY IS NEEDED IN A DAY, COUNT THE ENTIRE DAY. SEE NOTE * BELOW.

25-30 SHIRTSLEEVE MAN-HOURS FOR SPECIAL OPERATIONS. COUNT ALL MAN-HOURS IN SHIRTSLEEVE ENVIRONMENT FOR DEPLOYMENT OF ALL SYSTEMS AND FOR ANY OTHER SPECIAL OPERATIONS. SEE NOTE * BELOW.

31-36 SPACESUIT MAN-HOURS FOR SPECIAL OPERATIONS. SEE NOTE * BELOW.

37-42 MAN-HOURS OF SPACESUIT LIFETIME. INPUT THE ESTIMATED NUMBER OF MAN-HOURS OF SPACESUIT USE BEFORE REPLACEMENT OF THE SUIT IS CONSIDERED TO BE REQUIRED. SEE NOTE * BELOW.
SUGGESTED INPUT (MAN-HOURS) = 240.0 (HARD SUIT)

43-48 MAN-HOURS OF BACKPACK LIFETIME. INPUT ESTIMATED LIFETIME OF NON-EXPENDABLE ELEMENTS OF THE SPACESUIT BACKPACK. SEE NOTE * BELOW.
SUGGESTED INPUT (MAN-HOURS) = 100.0

49-54 MASS OF SUIT REPLACEMENT. INPUT MASS, IN KILOGRAMS, OF REPLACEMENT SPACESUIT. MASS INCLUDES ALL GARMENTS, BOOTS, AND HELMET. SEE NOTE * BELOW.
SUGGESTED INPUT (KG) = 33.0 (HARD SUIT)

55-60 MASS OF BACKPACK REPLACEMENT. INPUT MASS, IN KILOGRAMS, OF BACKPACK REPLACEMENT. COUNT ALL MASS ITEMS EXCEPT EXPENDABLES. SEE NOTE * BELOW.
SUGGESTED INPUT (KG) = 10.0

77-80 SEQUENCE NUMBER. INSERT THE FOLLOWING NUMBER- 402L

NOTE * - PLACE INPUT NUMBER ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.

COST CURVE - GENERAL

THIS STANDARD CARD IS USED TO INPUT ALL NONRECURRING AND RECURRING COSTS REQUIRED FOR THE COMPUTER PROGRAM. THE IDENTIFIER (SPACES 1-12) AND SEQUENCE NUMBER (SPACES 77-80) ESTABLISH EXACTLY WHICH COST CURVE IS BEING GIVEN. EACH COST CURVE WILL BE GIVEN BY A SET OF THESE CARDS. EACH SET MAY CONTAIN UP TO THREE CARDS. AS EACH CARD PERMITS ENTRY OF COSTS FOR FIVE 6-MONTH TIME PERIODS, USE OF THREE CARDS ALLOWS INPUT OF COSTS FOR UP TO 7.5 YEARS. IF IT IS NOT DESIRED TO INPUT A COST CURVE, FILL OUT COLUMNS 1-12 AND 77-80 ONLY.

AT LEAST ONE OF THESE CARDS MUST BE INPUT FOR EVERY COST CATEGORY REQUIRED FOR EACH MODE.

1-12 MODE IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. INCLUDE ALL DASHES. START THE IDENTIFIER IN COLUMN 1.

21-25 ZERO POINT. INSERT HERE THE NUMBER OF 6-MONTH TIME PERIODS THAT OCCUR FROM THE FIRST NON-ZERO ENTRY IN THE COST CURVE UP TO AND INCLUDING THE 6-MONTH TIME PERIOD OF A SPECIFIC DEADLINE DATE. THE FOLLOWING DEADLINES SHOULD BE USED -

COST INPUT	DEADLINE
MODE NONRECURRING	DATE OF FIRST LAUNCH
MODE RECURRING	DATE OF FIRST LAUNCH

NOTE- THIS ZERO POINT ENTRY NEED ONLY BE PUT ON FIRST CARD OF THE SET THAT WILL DECRIBE EACH COST CURVE. THE INPUT NUMBER MAY BE PUT ANYWHERE IN THE FIVE SPACES PROVIDED. SHOW A DECIMAL POINT WITH EACH ENTRY.

26-35 COST ENTRY, IN MILLIONS OF DOLLARS, FOR 6-MONTH FUNDING PERIOD. THE INPUT NUMBER MAY BE PUT ANYWHERE WITHIN THE 10 SPACES PROVIDED. SHOW LOCATION OF DECIMAL POINT.

36-45 SAME AS ABOVE.

46-55 SAME AS ABOVE.

56-65 SAME AS ABOVE.

66-75 SAME AS ABOVE.

COST CURVE - GENERAL (CONTINUED)

77-80 SEQUENCE NUMBER. INPUT NUMBER AS SHOWN BELOW. NOTE THAT THE SYMBOL * HAS SPECIAL SIGNIFICANCE.

COST CURVE	INPUT
NONRECURRING R AND D COST - MODE LEVEL	403*
NONRECURRING COST OF FACILITIES - MODE LEVEL	404*
RECURRING HARDWARE PROCUREMENT COST - MODE LEVEL	405*
RECURRING OPERATIONS SUPPORT COST - MODE LEVEL	406*

* = LAST DIGIT OF SEQUENCE NUMBER. USE AS FOLLOWS-
L - IF LAST CARD IN SEQUENCE OF ANY SIZE
1 - IF FIRST CARD IN SEQUENCE OF 2 OR 3 CARDS
2 - IF SECOND CARD IN SEQUENCE OF 3 CARDS

CARD I.D. 4-07

MODE INPUT - PAYLOAD LAUNCH IDENTIFICATION

THIS CARD IS USED TO INPUT CERTAIN GENERAL DATA ON EACH PAYLOAD LAUNCH OF A MODE. THE COMPUTER MEMORY ALLOCATION IS LIMITED TO EIGHT PAYLOADS PER MODE. THUS, UP TO EIGHT OF THESE CARDS MAY BE INPUT.

1-12	MODE IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. INCLUDE ALL DASHES. START THE IDENTIFIER IN COLUMN 1.
19	PAYLOAD LAUNCH IDENTIFIER. INPUT THE NUMBER OF THIS LAUNCH IN THE SEQUENCE OF LAUNCHES IN THE MODE.
25	PAYLOAD LAUNCH IDENTIFIER OF RELATED LAUNCH. INPUT THE LAUNCH IDENTIFIER OF THE NEAREST PREVIOUS LAUNCH UPON WHICH THE CURRENT LAUNCH DEPENDS. FOR EXAMPLE, LAUNCH 2 WILL USUALLY DEPEND UPON COMPLETION OF LAUNCH 1, OR A CREW ROTATION LAUNCH MAY DEPEND ON COMPLETION OF A PREVIOUS CREW DELIVERY. IF NO LAUNCH DEPENDENCY EXISTS, LEAVE SPACE BLANK.
31-40	MINIMUM NUMBER OF 6-MONTH TIME PERIODS THAT MUST ELAPSE BETWEEN THE TWO LAUNCHES GIVEN ABOVE. IF LESS THAN SIX MONTHS IS ACCEPTABLE, INPUT 0. SEE NOTE * BELOW. IF COLUMN 25 IS BLANK, LEAVE THIS SPACE BLANK.
41-50	MAXIMUM NUMBER OF 6-MONTH TIME PERIODS THAT MAY ELAPSE BETWEEN THE TWO LAUNCHES GIVEN ABOVE. IF LESS THAN 6-MONTHS IS REQUIRED, INPUT 0. SEE NOTE * BELOW. IF COLUMN 25 IS BLANK, LEAVE THIS SPACE BLANK.
51-60	MASS MARGIN AVAILABLE. INPUT THE MASS MARGIN, IN KILOGRAMS, THAT IS AVAILABLE WITH THIS LAUNCH FOR CARRYING MINOR SCIENTIFIC EQUIPMENT, EXTRA EXPENDABLES, AND SPACESUIT AND BACKPACK REPLACEMENTS. THE MASS MARGIN WILL GENERALLY BE FOUND BY SUBTRACTING THE MASS OF ALL SYSTEMS AND CREW ARRIVING AT THE FINAL DESTINATION OF THE LAUNCH (EXCEPT TRANSPORTATION EQUIPMENT USED IN THE OUTBOUND TRIP) FROM THE PAYLOAD DELIVERY CAPABILITY OF THE TRANSPORTATION SYSTEM. SEE NOTE * BELOW.
77-80	SEQUENCE NUMBER. INPUT 407X WHERE X = 1, 2, ETC UP TO THE LAST LAUNCH = L FOR THE LAST LAUNCH

NOTE * - PLACE INPUT NUMBER ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.

MODE INPUT - SYSTEMS ON EACH PAYLOAD

THIS CARD IS USED TO IDENTIFY EACH SYSTEM MAKING UP EACH PAYLOAD LAUNCH. THE COMPUTER MEMORY ALLOCATION ALLOWS FOR UP TO 15 SYSTEMS ON EACH LAUNCH. THUS, UP TO 15 OF THESE CARDS CAN BE USED TO FORM A SET FOR A GIVEN LAUNCH. UP TO 8 LAUNCHES (HENCE, 8 SETS OF CARDS) ARE ALLOWED PER MODE. THUS, FOR THE MAXIMUM CASE, 120 OF THESE CARDS WOULD BE NEEDED.

FOR THE GIVEN MODE, FILL OUT AS MANY CARDS TO FORM A SET AS THERE ARE SYSTEMS ON THE LAUNCH. FORM AS MANY SETS AS THERE ARE LAUNCHES IN THE MODE. BE SURE ALL SYSTEMS ARE INCLUDED EXCEPT THOSE SYSTEMS MAKING UP THE TRANSPORTATION SYSTEM. WHEN THE TRANSPORTATION SYSTEM IS SPECIFIED, THE COMPUTER WILL AUTOMATICALLY FIND THE LIST OF REQUIRED FLIGHT SYSTEMS AND LAUNCH VEHICLE. THESE SYSTEMS ARE COUNTED TOWARD THE 15 MAXIMUM.

1-12	MODE IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. INCLUDE ALL DASHES. START THE IDENTIFIER IN COLUMN 1.
15	PAYLOAD LAUNCH IDENTIFIER. INPUT THE NUMBER OF THIS LAUNCH IN THE SEQUENCE OF LAUNCHES IN THE MODE.
22-27	SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS. START THE NUMBER IN COLUMN 22.
31-40	NUMBER OF MEN SUPPORTED BY THIS SYSTEM. FOR TRANSPORTATION SYSTEMS, LEAVE THIS SPACE BLANK. SEE NOTE * BELOW.
41-50	LAUNCH LEAD TIME FOR SYSTEM. INPUT NUMBER OF 6-MONTH PERIODS PRECEDING THE LAUNCH DATE WHEN DELIVERY OF THE FLIGHT-QUALIFIED SYSTEM IS REQUIRED. INPUT 1 FOR 0-6 MONTHS, 2 FOR 7-12 MONTHS, ETC. SEE NOTE * BELOW. FOR TRANSPORTATION SYSTEMS, LEAVE THIS SPACE BLANK.
51-60	EXPENDABLES REQUIRED FOR SPECIAL OPERATIONS. INPUT THE MASS FOR EXPENDABLES, IN KILOGRAMS, REQUIRED FOR ANY SPECIAL OPERATIONS. THESE SPECIAL OPERATIONS INCLUDE DEPLOYMENT, CREW ARRIVAL AND DEPARTURE, AND SUCH OTHER OPERATIONS AS REQUIRED. COUNT ALL EXPENDABLES NEEDED WHETHER THEY ARE DUMPED OVERBOARD OR NOT. SEE NOTE * BELOW. FOR TRANSPORTATION SYSTEMS, LEAVE THIS SPACE BLANK.

MODE INPUT - SYSTEMS ON EACH PAYLOAD (CONT)

77-80 SEQUENCE NUMBER. INPUT 41AB WHERE
A = PAYLOAD LAUNCH IDENTIFIER
B = NUMBER OF THE CARD IN THE SET FOR THIS LAUNCH. FOR NUMBERS 10-15, USE ONLY LAST DIGIT. BE SURE TO INPUT THE LETTER L IN COLUMN 80 ON THE LAST CARD OF THE SET.

NOTE * - PLACE THE NUMBER ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.

CARD I.D. NO. 4-20

MODE INPUT - EMERGENCY MODES

THIS CARD IS USED TO IDENTIFY THE EMERGENCY MODES ASSOCIATED WITH AN EXPLORATION CONCEPT MODE. ONLY ONE CARD IS REQUIRED.

1-12	MODE IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. INCLUDE ALL DASHES. START THE IDENTIFIER IN COLUMN 1.
25-36	IDENTIFIER FOR CREW RESCUE EMERGENCY MODE. START THE NUMBER IN COLUMN 25. IF NO RESCUE MODE IS NEEDED, LEAVE THE SPACE BLANK.
49-60	IDENTIFIER FOR LOGISTICS EMERGENCY MODE. START THE NUMBER IN COLUMN 49. IF NO RESCUE MODE IS NEEDED, LEAVE THE SPACE BLANK.
77-80	SEQUENCE NUMBER. INPUT 420L

Appendix D

DETAILED INSTRUCTIONS FOR PREPARING EMERGENCY MODE INPUT CARDS

(Ref. Paragraph 10.5.3)

CARD I.D. 7-01

EMERGENCY MODE INPUT - GENERAL

THIS CARD IS USED TO SUPPLY GENERAL INPUT DATA ON EACH EMERGENCY MODE.

1-12 EMERGENCY MODE IDENTIFIER. START THE IDENTIFIER IN COLUMN 1.

77-80 SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER - 701L

COST CURVE - GENERAL

THIS STANDARD CARD IS USED TO INPUT ALL NONRECURRING AND RECURRING COSTS REQUIRED FOR THE COMPUTER PROGRAM. THE IDENTIFIER (SPACES 1-12) AND SEQUENCE NUMBER (SPACES 77-80) ESTABLISH EXACTLY WHICH COST CURVE IS BEING GIVEN. EACH COST CURVE WILL BE GIVEN BY A SET OF THESE CARDS. EACH SET MAY CONTAIN UP TO THREE CARDS. AS EACH CARD PERMITS ENTRY OF COSTS FOR FIVE 6-MONTH TIME PERIODS, USE OF THREE CARDS ALLOWS INPUT OF COSTS FOR UP TO 7.5 YEARS.

AT LEAST ONE OF THESE CARDS MUST BE INPUT FOR EVERY COST CATEGORY REQUIRED FOR EACH MODE. IF IT IS NOT DESIRED TO INPUT A COST CURVE, FILL OUT COLUMNS 1-12 AND 77-80 ONLY.

1-12 MODE IDENTIFIER. USE THE NUMBER INPUT WITH THE 7-01 CARD.

21-25 ZERO POINT. INSERT HERE THE NUMBER OF 6-MONTH TIME PERIODS THAT OCCUR FROM THE FIRST NON-ZERO ENTRY IN THE COST CURVE UP TO AND INCLUDING THE 6-MONTH TIME PERIOD OF A SPECIFIC DEADLINE DATE. THE FOLLOWING DEADLINES SHOULD BE USED -

COST INPUT	DEADLINE
MODE NONRECURRING	DATE OF FIRST LAUNCH
MODE RECURRING	DATE OF FIRST LAUNCH

NOTE- THIS ZERO POINT ENTRY NEED ONLY BE PUT ON FIRST CARD OF THE SET THAT WILL DESCRIBE EACH COST CURVE. THE INPUT NUMBER MAY BE PUT ANYWHERE IN THE FIVE SPACES PROVIDED. SHOW A DECIMAL POINT WITH EACH ENTRY.

26-35 COST ENTRY, IN MILLIONS OF DOLLARS, FOR 6-MONTH FUNDING PERIOD. THE INPUT NUMBER MAY BE PUT ANYWHERE WITHIN THE 10 SPACES PROVIDED. SHOW LOCATION OF DECIMAL POINT.

36-45 SAME AS ABOVE.

46-55 SAME AS ABOVE.

56-65 SAME AS ABOVE.

66-75 SAME AS ABOVE.

COST CURVE - GENERAL (CONTINUED)

77-80 SEQUENCE NUMBER. INPUT NUMBER AS SHOWN BELOW. NOTE THAT THE SYMBOL * HAS SPECIAL SIGNIFICANCE.

COST CURVE	INPUT
NONRECURRING R AND D COST - MODE LEVEL	703*
NONRECURRING FACILITIES COST - MODE LEVEL	704*
RECURRING HARDWARE PROCUREMENT COST - MODE LEVEL	705*
RECURRING OPERATIONS SUPPORT COST - MODE LEVEL	706*

* = LAST DIGIT OF SEQUENCE NUMBER. USE AS FOLLOWS-
L - IF LAST CARD IN SEQUENCE OF ANY SIZE
1 - IF FIRST CARD IN SEQUENCE OF 2 OR 3 CARDS
2 - IF SECOND CARD IN SEQUENCE OF 3 CARDS

CARD I.D. 7-07

EMERGENCY MODE INPUT - PAYLOAD LAUNCH IDENTIFICATION

THIS CARD IS USED TO INPUT CERTAIN GENERAL DATA ON THE PAYLOAD LAUNCH OF THE EMERGENCY MODE.

1-12	MODE IDENTIFIER. USE THE NUMBER INPUT WITH THE 7-01 CARD.
19	PAYLOAD LAUNCH IDENTIFIER. INPUT THE NUMBER 1.
77-80	SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER - 707L.

CARD I.D. 7-11

EMERGENCY MODE INPUT - SYSTEMS ON THE PAYLOAD

THIS CARD IS USED TO IDENTIFY EACH SYSTEM MAKING UP THE PAYLOAD LAUNCH. THE COMPUTER MEMORY ALLOCATION ALLOWS FOR UP TO 15 SYSTEMS ON THE LAUNCH. THUS, UP TO 15 OF THESE CARDS CAN BE USED.

FOR THE GIVEN MODE, FILL OUT AS MANY CARDS TO FORM A SET AS THERE ARE SYSTEMS ON THE LAUNCH. BE SURE ALL SYSTEMS ARE INCLUDED EXCEPT THOSE SYSTEMS MAKING UP THE TRANSPORTATION SYSTEM. WHEN THE TRANSPORTATION SYSTEM IS SPECIFIED, THE COMPUTER WILL AUTOMATICALLY FIND THE LIST OF REQUIRED FLIGHT SYSTEMS AND LAUNCH VEHICLE. THESE SYSTEMS MUST BE COUNTED TOWARD THE 15 MAXIMUM.

1-12	MODE IDENTIFIER. USE THE NUMBER INPUT WITH THE 7-01 CARD.
15	PAYLOAD LAUNCH IDENTIFIER. INPUT THE NUMBER 1.
22-27	SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS. START THE NUMBER IN COLUMN 22.
31-40	NUMBER OF MEN SUPPORTED BY THIS SYSTEM. FOR TRANSPORTATION SYSTEMS, LEAVE THIS SPACE BLANK. SEE NOTE * BELOW.
41-50	LAUNCH LEAD TIME FOR SYSTEM. INPUT NUMBER OF 6-MONTH PERIODS PRECEDING THE LAUNCH DATE WHEN DELIVERY OF THE FLIGHT-QUALIFIED SYSTEM IS REQUIRED. INPUT 1 FOR 0-6 MONTHS, 2 FOR 7-12 MONTHS, ETC. SEE NOTE * BELOW. FOR TRANSPORTATION SYSTEMS, LEAVE THIS SPACE BLANK.
77-80	SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER - 711X WHERE X = 1, 2, ETC UP TO THE LAST SYSTEM = L FOR THE LAST SYSTEM

NOTE * - PLACE THE NUMBER ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.

Appendix E

DETAILED INSTRUCTIONS FOR PREPARING SYSTEM INPUT CARDS

(Ref. Paragraph 10.6.1)

CARD I.D. NO. 5-01

SYSTEM INPUT - GENERAL

ONE OF THESE CARDS MUST BE SUPPLIED FOR EVERY SYSTEM.

1-6 SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.

7-30 SYSTEM NAME. NAME MUST NOT EXCEED 24 UNITS COUNTING ALL LETTERS, NUMBERS, SPACES, AND PUNCTUATION. PLACE THE NAME IN THE CENTER OF THE 24 SPACES PROVIDED.

31-40 PROCUREMENT QUANTITY UNIT. PLACE HERE THE NUMBER OF THE SYSTEMS THAT CAN BE PROCURED BEFORE A BACKUP SYSTEM MUST BE PROCURED. THE COMPUTER WILL THEN SHOW PROCUREMENT OF BACKUP SYSTEMS WHEN MULTIPLES OF THIS NUMBER ARE COUNTED DURING THE PROGRAM ANALYSIS. SEE NOTE * BELOW.

SUGGESTED INPUT = 10.0

41-50 MAXIMUM MASS PERMITTED FOR ALL EXPENDABLES. INSERT MAXIMUM MASS, IN KILOGRAMS, PERMITTED FOR ALL EXPENDABLES BY THE CONCEPT DESIGN. THIS INCLUDES LS AND ECS EXPENDABLES, FUEL FOR POWER, WATER, LEV REACTION CONTROL GAS, ETC. DO NOT INCLUDE LEV PROPELLANT. SEE NOTE * BELOW.

NOTE - LEAVE THIS SPACE BLANK FOR ALL TRANSPORTATION EQUIPMENT. FOR LRV TRAILERS, INPUT THE SUM OF THE EXPENDABLES IN THE TRAILER AND IN THE APPROPRIATE LRV.

51-60 MAXIMUM MASS OF USABLE LEV PROPELLANT. INSERT THE MAXIMUM MASS, IN KILOGRAMS, PERMITTED FOR USABLE LEV PROPELLANT BY THE TANK SIZES IN THE CONCEPT DESIGN. SEE NOTE * BELOW.

NOTE - LEAVE THIS SPACE BLANK FOR ALL SYSTEMS EXCEPT LEV CONCEPTS AND THOSE SYSTEMS CARRYING REFUEL PROPELLANT.

77-80 SEQUENCE NUMBER. INSERT THE FOLLOWING NUMBER- 5011

NOTE * - PLACE THE INPUT NUMBER ANYWHERE IN THE 10 SPACES PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.

CARD I.D. NO. 5-02

SYSTEM INPUT - IDENTIFICATION OF REQUIRED STATE-OF-THE-ART ADVANCES

THIS CARD IS USED TO IDENTIFY WHICH OF THE SUBSYSTEM CONCEPTS USED ON THE SYSTEM WILL REQUIRE AN ADVANCE IN THE STATE-OF-THE-ART (SOTA). AT LEAST ONE CARD MUST BE INPUT FOR EACH SYSTEM. IF NO SOTA ADVANCE IS REQUIRED, SPACES 13-72 ARE LEFT BLANK. FOR EACH SOTA ADVANCE GIVEN, OTHER INPUT CARDS, DETAILING NON-RECURRING COSTS ASSOCIATED WITH THAT SOTA ADVANCE MUST BE SUPPLIED.

1-6	SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.
13-18	SUBSYSTEM IDENTIFIER. SUPPLY THE I.D. NUMBER USED TO IDENTIFY THE SUBSYSTEM CONCEPT. USE THE NUMBER SUPPLIED IN THE DATA BOOK. ALWAYS PUT FIRST DIGIT OF I.D. NUMBER AT FAR LEFT OF THE 6 SPACES PROVIDED. USE ONLY THE SIX DIGITS SUPPLIED. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.
19-24	FIRST ITEM DELIVERY DATE. INSERT THE NUMBER OF 6-MONTH TIME PERIODS PRECEDING REQUIRED SYSTEM DELIVERY THAT THE NEW SUB-SYSTEM SOTA ADVANCE MUST BE COMPLETED. PLACE THE INPUT NUMBER ANYWHERE IN THE 6 SPACES PROVIDED. SHOW A DECIMAL POINT AFTER THE LAST DIGIT OF THE NUMBER.

REPEAT THIS PROCESS FOR EACH IDENTIFIABLE STATE-OF-THE-ART ADVANCE. USE UP TO 3 CARDS (OR 15 SUBSYSTEM ENTRIES). FILL OUT EACH SUBSEQUENT DATA SET AS FOLLOWS-

25-30	SAME AS 13-18 ABOVE
31-36	SAME AS 19-24 ABOVE
37-42	SAME AS 13-18 ABOVE
43-48	SAME AS 19-24 ABOVE
49-54	SAME AS 13-18 ABOVE
55-60	SAME AS 19-24 ABOVE
61-66	SAME AS 13-18 ABOVE
67-72	SAME AS 19-24 ABOVE
77-80	SEQUENCE NUMBER. INSERT ONE OF THE FOLLOWING NUMBERS 5021 IF THIS IS THE LAST CARD OF A SET OF 1, 2, OR 3 CARDS 5021 IF THIS IS THE FIRST CARD OF A SET OF 1 OR 2 CARDS 5022 IF THIS IS THE SECOND CARD OF A 3-CARD SET

SYSTEM COST CURVE

THIS STANDARD CARD IS USED TO INPUT ALL NONRECURRING AND RECURRING COSTS REQUIRED FOR THE COMPUTER PROGRAM. THE IDENTIFIER (SPACES 1-6) AND SEQUENCE NUMBER (SPACES 77-80) ESTABLISH EXACTLY WHICH COST CURVE IS BEING GIVEN. EACH COST CURVE WILL BE GIVEN BY A SET OF THESE CARDS. EACH SET MAY CONTAIN UP TO THREE CARDS. AS EACH CARD PERMITS ENTRY OF COSTS FOR FIVE 6-MONTH TIME PERIODS, USE OF THREE CARDS ALLOWS INPUT OF COSTS FOR UP TO 7.5 YEARS.

AT LEAST ONE OF THESE CARDS MUST BE INPUT FOR EVERY COST CATEGORY REQUIRED FOR EACH SYSTEM. IF IT IS NOT DESIRED TO INPUT A COST CURVE, INPUT COLUMNS 1-6 AND 77-80 ONLY.

1-6 SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.

21-25 ZERO POINT. INSERT HERE THE NUMBER OF 6-MONTH TIME PERIODS THAT OCCUR FROM THE FIRST NON-ZERO ENTRY IN THE COST CURVE UP TO AND INCLUDING THE 6-MONTH TIME PERIOD OF A SPECIFIC DEADLINE DATE. THE FOLLOWING DEADLINES SHOULD BE USED -

COST INPUT	DEADLINE
SYSTEM NONRECURRING	DELIVERY DATE OF FIRST FLIGHT QUALIFIED SYSTEM TO PAYLOAD INTEGRATOR
SYSTEM RECURRING	DELIVERY DATE OF SYSTEM TO PAYLOAD INTEGRATOR

NOTE- THIS ZERO POINT ENTRY NEED ONLY BE PUT ON FIRST CARD OF THE SET THAT WILL DECRIBE EACH COST CURVE. THE INPUT NUMBER MAY BE PUT ANYWHERE IN THE FIVE SPACES PROVIDED. SHOW A DECIMAL POINT WITH EACH ENTRY.

26-35 COST ENTRY, IN MILLIONS OF DOLLARS, FOR 6-MONTH FUNDING PERIOD. THE INPUT NUMBER MAY BE PUT ANYWHERE WITHIN THE 10 SPACES PROVIDED. SHOW LOCATION OF DECIMAL POINT.

36-45 SAME AS ABOVE.

46-55 SAME AS ABOVE.

56-65 SAME AS ABOVE.

66-75 SAME AS ABOVE.

CARD I.D. NOS. 5-03, 5-04, 5-05, 5-06 PAGE 2 OF 2

SYSTEM COST CURVE (CONTINUED)

77-80 SEQUENCE NUMBER. INPUT NUMBER AS SHOWN BELOW. NOTE THAT THE SYMBOL * HAS SPECIAL SIGNIFICANCE.

COST CURVE	INPUT
NONRECURRING R AND D COST - SYSTEM LEVEL	503*
NONRECURRING FACILITIES COST - SYSTEM LEVEL	504*
RECURRING HARDWARE PROCUREMENT COST - SYSTEM LEVEL	505*
RECURRING OPERATIONS SUPPORT - SYSTEM LEVEL	506*

* = LAST DIGIT OF SEQUENCE NUMBER. USE AS FOLLOWS-
L - IF LAST CARD IN SEQUENCE OF ANY SIZE
1 - IF FIRST CARD IN SEQUENCE OF 2 OR 3 CARDS
2 - IF SECOND CARD IN SEQUENCE OF 3 CARDS

TABLE OF HARDWARE COST REDUCTION FOR ADDITIONAL COPIES

THIS CARD IS USED TO INPUT AN APPROXIMATION OF THE COST REDUCTION IN HARDWARE PROCUREMENT THAT OCCURS WITH THE PROCUREMENT OF VARIOUS NUMBER OF COPIES. THE TOTAL NUMBER OF COPIES EXPECTED TO BE PROCURED ARE DIVIDED INTO NO MORE THAN 10 GROUPS. THE COST OF EVERY ARTICLE IN EACH GROUP IS THEN GIVEN AS A DECIMAL FRACTION OF THE FIRST ARTICLE PROCUREMENT COST.

THE COMPUTER, AFTER IDENTIFYING A SYSTEM DESIRED FOR A MISSION, DETERMINES HOW MANY COPIES OF THAT SYSTEM HAVE BEEN PROCURED. IT THEN CONSULTS THIS COST REDUCTION TABLE AND DETERMINES THE APPROPRIATE COST REDUCTION FACTOR. IT THEN MULTIPLIES EACH ENTRY OF THE COST CURVE FOR RECURRING SYSTEM HARDWARE PROCUREMENT COSTS BY THE REDUCTION FACTOR.

IT IS POSSIBLE TO ENTER THE DECIMAL FRACTION COST OF 5 GROUPS ON ONE CARD. THUS, NO MORE THAN TWO CARDS ARE NEEDED. IN ANY EVENT, AT LEAST ONE CARD MUST BE INPUT FOR EACH SYSTEM.

1-6	SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.
13-18	THE NUMBER OF THE LAST ARTICLE IN THE GROUP. IF THIS IS THE FIRST GROUP, IT MUST CONTAIN THE NUMBER OF ARTICLES THAT COST THE SAME AS THE FIRST ARTICLE. FOR EXAMPLE, IF THE FIRST FOUR ARTICLES COST THE SAME, THE NUMBER 4. WOULD BE ENTERED HERE. PLACE THE NUMBER ANYWHERE IN THE 6 SPACES PROVIDED. BE SURE TO ENTER THE DECIMAL POINT.
19-24	DECIMAL FRACTION OF FIRST ARTICLE COST FOR EACH MEMBER OF THE ABOVE GROUP. IF THIS IS THE FIRST GROUP, THE NUMBER 1.0 WOULD BE ENTERED HERE. PLACE THE NUMBER ANYWHERE IN THE 6 SPACES PROVIDED. BE SURE TO ENTER THE DECIMAL POINT.
25-30	THE NUMBER OF THE LAST ARTICLE IN THE NEXT GROUP. PLACE THE NUMBER ANYWHERE IN THE 6 SPACES PROVIDED. BE SURE TO ENTER THE DECIMAL POINT.
31-36	DECIMAL FRACTION OF FIRST ARTICLE PROCUREMENT COST FOR EACH MEMBER OF THE ABOVE GROUP. PLACE THE NUMBER ANYWHERE IN THE 6 SPACES PROVIDED. BE SURE TO ENTER THE DECIMAL POINT.
37-42	SEE 25-30 ABOVE.
43-48	SEE 31-36 ABOVE.

CARD I.D. NO. 5-07 PAGE 2 OF 2

TABLE OF HARDWARE COST REDUCTION (CONTINUED)

49-54	SEE 25-30 ABOVE.
55-60	SEE 31-36 ABOVE.
61-66	SEE 25-30 ABOVE.
67-72	SEE 31-36 ABOVE.
77-80	SEQUENCE NUMBER. INPUT NUMBERS AS SHOWN BELOW FOR EACH SYSTEM.
	5071 IF THIS IS FIRST OF TWO CARDS.
	507L IF THIS IS THE ONLY CARD OR IF THIS IS SECOND CARD OF A PAIR.

R AND D FLIGHT TABLE

THIS CARD IS USED TO IDENTIFY THOSE NON-MISSION LAUNCHES REQUIRED TO COMPLETE THE R AND D OF A GIVEN SYSTEM. THE NUMBER OF FLIGHTS PER 6-MONTH TIME PERIOD IS RECORDED. UP TO TWO CARDS ARE PERMITTED PER SYSTEM. AS THERE IS SPACE ON A CARD FOR DATA ON FIVE 6-MONTH TIME PERIODS, DATA FOR 5 YEARS CAN BE INPUT INTO THE COMPUTER. FILL OUT DATA ON ONLY THOSE 6-MONTH TIME PERIODS IN WHICH FLIGHTS ARE REQUIRED, EXCEPT WHERE A 6-MONTH PERIOD WITH NO FLIGHTS IS IN BETWEEN TWO PERIODS THAT HAVE FLIGHTS. IN THAT CASE, THE INPUT SPACES ON THE CARD FOR THAT 6-MONTH PERIOD MUST BE LEFT BLANK.

IF NO R AND D TEST FLIGHTS ARE REQUIRED FOR THE SYSTEM CONCEPT BEING INPUT, FILL IN SPACES 1-6 AND 77-80 ONLY.

1-6	SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.
7-12	ZERO POINT. INPUT HERE THE NUMBER OF 6-MONTH TIME PERIODS AFTER THE START OF FLIGHT TESTING THAT OCCUR BEFORE THE FIRST FLIGHT QUALIFIED SYSTEM IS DELIVERED TO THE PAYLOAD INTEGRATOR. SEE NOTE * BELOW.
13-18	NUMBER OF R AND D TEST FLIGHTS IN THE FIRST OR THE SIXTH 6-MONTH TIME PERIOD (DEPENDING ON WHETHER THIS IS THE FIRST OR SECOND CARD OF THE TWO INPUT CARDS PERMITTED). SEE NOTE * BELOW.
19-24	TRANSPORTATION SYSTEM USED FOR THE LAUNCHES IN THE GIVEN 6-MONTH TIME PERIOD. NOTE THAT THIS IMPLIES ONLY ONE TRANSPORTATION SYSTEM CONCEPT IS USED PER 6-MONTH PERIOD. IF TWO OR MORE DIFFERENT TRANSPORTATION SYSTEMS ARE USED, SCHEDULE THE LAUNCHES OF THESE SYSTEMS INTO DIFFERENT 6-MONTH PERIODS. INPUT THE SYSTEM IDENTIFIER REQUIRED. START THE NUMBER TO THE LEFT OF THE SPACE PROVIDED.
25-30	NUMBER OF FLIGHTS IN SUBSEQUENT 6-MONTH TIME PERIOD. SEE NOTE * BELOW.
31-36	SEE 19-24 ABOVE.
37-42	SEE 25-30 ABOVE.
43-48	SEE 19-24 ABOVE.

NOTE * - PLACE THE INPUT NUMBER ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.

R AND D FLIGHT TABLE (CONTINUED)

49-54	SEE 25-30 ABOVE.
55-60	SEE 19-24 ABOVE.
61-66	SEE 25-30 ABOVE.
67-72	SEE 19-24 ABOVE.
77-80	SEQUENCE NUMBER. INPUT THE NUMBER 5081 ONLY IF THIS IS THE FIRST OF TWO CARDS. IN ALL OTHER CASES, INPUT THE NUMBER 508L.

SYSTEM EXPENDABLES

THIS CARD IS USED TO IDENTIFY THE RATE OF USAGE THAT IS ESTIMATED FOR A GIVEN SYSTEM WITH A SPECIFIC CREW LEVEL. BECAUSE A SYSTEM CONCEPT MAY HAVE TO OPERATE AT VARIOUS CREW LEVELS, SEVERAL OF THESE CARDS MAY BE NEEDED. SPACE IS PROVIDED IN THE COMPUTER TO PRESENT DATA ON FIVE DIFFERENT CREW LEVELS. THE CARDS MUST BE FILLED OUT IN THE DESCENDING ORDER OF CREW SIZE.

FOR TRANSPORTATION SYSTEMS AND FLIGHT SYSTEMS (NOT LEV CONCEPTS), FILL IN SPACES 1-6 AND 77-80 ONLY.

1-6 SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.

13-15 CREW LEVEL FOR WHICH THE DATA ON THIS CARD APPLIES. SEE NOTE * BELOW. START FIRST CARD WITH LARGEST CREW SIZE.
NOTE - FOR LRV TRAILERS, INPUT THE CREW LEVELS ASSOCIATED WITH THE APPROPRIATE LRV AS INDICATED IN THE MIMOSA DATA BOOK.

16-25 TOTAL EXPENDABLES, IN KILOGRAMS, EXPENDED PER DAY AT THE ABOVE CREW LEVEL. THIS RATE INCLUDES ALL POWER SYSTEM FUEL, LS AND ECS EXPENDABLES, WATER, ATMOSPHERE LOSS, ETC. COUNT ALL EXPENDABLES WHETHER DUMPED OVERBOARD OR NOT EXCEPT THOSE REQUIRED FOR SPACESUIT OPERATION. SEE NOTE * BELOW.

26-35 TOTAL EXPENDABLES, IN KILOGRAMS PER KW-HR, THAT MUST BE USED OVER AND ABOVE NORMAL NONSCIENTIFIC SYSTEM OPERATION TO POWER AN EXPERIMENT SUPPORTED BY THE SYSTEM. FOR MAJOR SCIENTIFIC EQUIPMENT, INPUT ONLY THE KG/KW-HR SUPPLIED BY THE EQUIPMENT CONCEPT ITSELF. IF POWER IS SUPPLIED TO THE EQUIPMENT FROM A BASE POWER SUPPLY, SHELTER, LRV, OR LEV, THEN LEAVE THIS INPUT SPACE BLANK. SEE NOTE * BELOW.

36-45 TOTAL EXPENDABLES, IN KILOGRAMS PER KILOMETER, REQUIRED TO PROVIDE MOBILITY FOR A LUNAR ROVING VEHICLE. LEAVE THIS SPACE BLANK FOR ALL OTHER SYSTEMS. FOR TRAILERS (WHEN USED WITH THE LRV), COUNT THE SUM OF BOTH THE LRV AND THE TRAILER USAGE RATE. IF INPUT IS DESIRED, SEE NOTE * BELOW.

46-55 TOTAL EXPENDABLES, IN KILOGRAMS PER STOP, REQUIRED FOR ANY ACTIVATION OR DEACTIVATION OF A ROVING OR FLYING VEHICLE. DO NOT COUNT SPACESUIT EXPENDABLES. LEAVE THIS SPACE BLANK FOR SYSTEMS OTHER THAN LRV AND LEV CONCEPTS. IF INPUT IS DESIRED, SEE NOTE * BELOW.

NOTE * - THE INPUT NUMBER MAY BE PLACED ANYWHERE IN THE SPACE PROVIDED BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.

CARD I.D. NO. 5-09 PAGE 2 OF 2

SYSTEM EXPENDABLES (CONTINUED)

56-65	TOTAL EXPENDABLES, IN KILOGRAMS PER SPACESUIT MAN-HOUR, THAT EXCEED THE EXPENDABLES PER SHIRTSLEEVE MAN-HOUR. IF SYSTEM IS OPERATED SOLELY BY SPACESUIT, IT IS SUGGESTED THAT THE TOTAL SPACESUIT EXPENDABLE RATE BE INPUT. SEE NOTE * BELOW.
66-75	TOTAL EXPENDABLES, IN KILOGRAMS, THAT ARE NOT USABLE BY THE SYSTEM THROUGHOUT ITS USE. THIS INCLUDES UNUSABLE BOILOFF DURING THE MISSION AND PRE-MISSION STORAGE, ULLAGE, REFUELING LOSSES, RESERVES, ETC. DO NOT COUNT USABLE LEV PROPELLANT. FOR LRV TRAILERS (WHEN USED WITH THE LRV) COUNT BOTH TRAILER AND LRV BOILOFF. IF INPUT IS DESIRED, SEE NOTE * BELOW.
77-80	SEQUENCE NUMBER. INPUT THE NUMBER 5099 IF THIS IS LAST CARD IN ANY SEQUENCE. INPUT 5091, 5092, 5093, 5094, AS APPROPRIATE, IF THIS IS FIRST THROUGH FOURTH CARD OF A SEQUENCE.

NOTE * - THE INPUT NUMBER MAY BE PLACED ANYWHERE IN THE SPACE PROVIDED BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.

SYSTEM MAN-HOUR REQUIREMENTS FOR NONSCIENTIFIC OPERATIONS

THIS CARD IS USED TO IDENTIFY THE NONSCIENTIFIC SPACESUIT AND SHIRTSLEEV MAN-HOURS REQUIRED TO SUPPORT EACH SYSTEM CONCEPT FOR A GIVEN CREW LEVEL BECAUSE A SYSTEM CONCEPT MAY HAVE TO OPERATE AT VARIOUS CREW LEVELS, SEVERAL OF THESE CARDS MAY BE NEEDED. SPACE IS PROVIDED IN THE COMPUTER TO PRESENT DATA ON FIVE DIFFERENT CREW LEVELS. THE CREW LEVELS USED MUS BE THE SAME AS THOSE IDENTIFIED ON THE SYSTEM EXPENDABLE CARD (CARD I.D. 5-05). FURTHERMORE, THE CREW LEVELS MUST BE IN THE SAME DESCENDING ORDER.

FOR TRANSPORTATION SYSTEMS AND FLIGHT SYSTEMS, INPUT COLUMNS 1-6 AND 77-80 ONLY.

1-6	SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.
13-15	CREW LEVEL FOR WHICH THE DATA ON THIS CARD APPLIES. SEE NOTE * BELOW.
16-25	SHIRTSLEEVE MAN-HOURS FOR ACTIVATION AND DEACTIVATION OF SYSTEM CONCEPT AT THE ABOVE CREW LEVEL. THIS IS MEANT TO INCLUDE ALL OPERATIONS TO ACTIVATE AND DEACTIVATE CONCEPT, BUT IS NOT MEAN TO INCLUDE DEPLOYMENT. SEE NOTE * BELOW.
26-35	SPACESUIT MAN-HOURS FOR ACTIVATION AND DEACTIVATION AS DESCRIBED ABOVE. SEE NOTE * BELOW.
36-45	SHIRTSLEEVE MAN-HOURS PER DAY FOR NONSCIENTIFIC OPERATIONS. THIS INCLUDES MAN-HOURS PER DAY FOR MAINTENANCE, REPAIRS, STATION-KEEPING, AIRLOCK OPERATIONS, AND PERSONAL OPERATIONS. SEE NOTE * BELOW.
46-55	SPACESUIT MAN-HOURS PER DAY FOR NONSCIENTIFIC OPERATIONS AS DESCRIBED ABOVE. SEE NOTE * BELOW.
56-65	SHIRTSLEEVE MAN-HOURS PER STOP ON A TRAVERSE FOR NONSCIENTIFIC OPERATIONS. THIS INCLUDES OPERATIONS FOR VEHICLE SHUTDOWN, CHECKOUT, AND RESTART AT EACH STOP. IT DOES NOT COUNT ACTIVATION AND DEACTIVATION AT THE BEGINNING AND THE END OF THE TRAVERSE. FOR ALL SYSTEMS OTHER THAN LRV AND LEV CONCEPTS, LEAVE THIS SPACE BLANK. IF INPUT IS DESIRED, SEE NOTE * BELOW
66-75	SPACESUIT MAN-HOURS PER STOP ON A TRAVERSE AS DESCRIBED ABOVE. IF INPUT IS DESIRED, SEE NOTE * BELOW.

NOTE * - THE INPUT NUMBER MAY BE PLACED ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW LOCATION OF THE DECIMAL POINT.

SYSTEM MAN-HOUR REQUIREMENTS (CONTINUED)

77-80	SEQUENCE NUMBER. INPUT THE NUMBER 510L IF THIS CARD IS FOR A TRANSPORTATION SYSTEM, FLIGHT SYSTEM, OR UNMANNED SYSTEM, OR IF THIS IS THE LAST CARD IN ANY SEQUENCE. INPUT 5101, 5102, 5103, OR 5104, AS APPROPRIATE, IF THIS IS THE FIRST THROUGH THE FOURTH CARD OF A SEQUENCE.

CARD I.D. NO. 5-11

SYSTEM INPUT - PERSONNEL SHELTER ONLY

THIS CARD IS USED TO RELATE SHELTER STAYTIME TO ALTERNATE SHELTER CREW LEVELS. THE CREW LEVELS USED MUST BE THE SAME AS THOSE USED IN CARDS 5-09 AND 5-10. FOR DATA INPUT ON SYSTEMS OTHER THAN SHELTERS, IGNORE THIS CARD.

1-6	SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.
7-12	MAXIMUM CREW LEVEL. INPUT THE LARGEST CREW SIZE USED FOR INPUT CARDS 5-09 (SYSTEM EXPENDABLES) AND 5-10 (SYSTEM MAN-HOUR REQUIREMENTS). SEE NOTE * BELOW.
13-18	MAXIMUM ALLOWABLE STAYTIME, IN DAYS, AT THE GIVEN CREW LEVEL. THIS STAYTIME INPUT IGNORES THE POSSIBILITY THAT PART OF THE CREW MAY SPEND SOME TIME AWAY FROM THE SHELTER. SEE NOTE * BELOW.
19-24	NEXT LARGEST CREW LEVEL CONSIDERED IN CARDS 5-09 AND 5-10. SEE NOTE * BELOW.
25-30	SEE 13-18 ABOVE.
31-36	SEE 19-24 ABOVE.
37-42	SEE 13-18 ABOVE.
43-48	SEE 19-24 ABOVE.
49-54	SEE 13-18 ABOVE.
55-60	SEE 19-24 ABOVE.
61-66	SEE 13-18 ABOVE.
77-80	SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER - 511L

NOTE * - THE INPUT NUMBER MAY BE PLACED ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW LOCATION OF THE DECIMAL POINT.

CARD I.D. NO. 5-12 PAGE 1 OF 2

SYSTEM INPUT - LRV ONLY

THIS CARD IS USED TO SUPPLY CERTAIN INPUT DATA FOR LRV CONCEPTS WHICH MAY BE SENSITIVE TO CREW LEVEL. IT IS PERMITTED TO INPUT FIVE CARDS FOR FIVE DIFFERENT CREW LEVELS. THE CREW LEVELS USED HERE MUST BE THE SAME AS THOSE USED IN CARDS 5-09 AND 5-10. IN ADDITION, THEY MUST BE IN THE SAME DESCENDING ORDER IN SIZE.

FOR THE PURPOSES OF THIS CARD, A TRAILER, WHEN USED WITH AN LRV, WILL REQUIRE INPUT HERE OF VALUES FOR THE TWO ACTING AS A SINGLE UNIT. FOR DATA INPUT ON SYSTEMS OTHER THAN LRV CONCEPTS, IGNORE THIS CARD.

1-6	SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.
11-20	CREW LEVEL. ON THE FIRST CARD, INPUT THE LARGEST CREW SIZE USED FOR INPUT CARDS 5-09 (SYSTEM EXPENDABLES) AND 5-10 (SYSTEM MAN-HOUR REQUIREMENTS). THE INPUT ON SUBSEQUENT CARDS IN SERIES MUST COVER THE OTHER CREW LEVELS IN 5-09 AND 5-10 IN THE SAME DESCENDING ORDER. SEE NOTE * BELOW.
21-30	NOMINAL SINGLE EXCURSION STAYTIME, IN DAYS, PERMITTED FOR THE GIVEN CREW LEVEL. ALL INDIVIDUAL TRAVERSES WITH WHICH THIS CONCEPT IS COMPARED SHOULD HAVE TOTAL TRAVERSE TIMES OF ABOUT THE VALUE INPUT HERE. SEE NOTE * BELOW.
31-40	NOMINAL SINGLE EXCURSION RANGE, IN KILOMETERS, PERMITTED FOR THE GIVEN CREW LEVEL. THIS IS THE NOMINAL RANGE FOR ANY TRAVERSE WITHOUT VEHICLE REFUELING. SEE NOTE * BELOW.
41-50	AVERAGE VEHICLE SPEED, IN KILOMETERS PER HOUR. TRAVERSE RANGE WILL BE DIVIDED BY THIS INPUT TO ESTIMATE THE HOURS REQUIRED FOR TRAVELING. SEE NOTE * BELOW.
51-60	MAXIMUM PAYLOAD (OR CARGO) MASS CAPABILITY, IN KILOGRAMS. THIS IS THE MAXIMUM MASS FOR PAYLOAD, SUCH AS SCIENTIFIC EQUIPMENT, PERMITTED BY THE VEHICLE DESIGN FOR THE GIVEN CREW LEVEL. SEE NOTE * BELOW.
72	SPACESUIT USAGE FLAG. INPUT 0 (ZERO) OR LEAVE THE SPACE BLANK IF SPACESUIT EXPENDABLES ARE USED DURING TRAVELING. INPUT 1 (ONE) IF TRAVELING IS DONE IN SHIRTSLEEVES.

NOTE * - THE INPUT NUMBER MAY BE PLACED ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW LOCATION OF THE DECIMAL POINT.

SYSTEM INPUT - LRV ONLY (CONTINUED)

77-80 SEQUENCE NUMBER. INPUT ONE OF THE FOLLOWING NUMBERS.

5121 IF THIS IS THE ONLY CARD REQUIRED OR IF THIS IS THE LAST CARD OF A SERIES.

5121 IF THIS IS FIRST CARD OF A SERIES.

5122 IF THIS IS SECOND CARD OF A SERIES.

5123 IF THIS IS THIRD CARD OF A SERIES.

5124 IF THIS IS FOURTH CARD OF A SERIES.

CARD I.D. NO. 5-13

SYSTEM INPUT - LEV ONLY

THIS CARD IS USED TO SUPPLY CERTAIN INPUT DATA FOR LEV CONCEPTS WHICH MAY BE SENSITIVE TO CREW LEVEL. IT IS PERMITTED TO INPUT FIVE CARDS FOR FIVE DIFFERENT CREW LEVELS. THE CREW LEVELS USED HERE MUST BE THE SAME AS THOSE USED IN CARDS 5-09 AND 5-10. IN ADDITION, THEY MUST BE IN THE SAME DESCENDING ORDER IN SIZE.

FOR DATA INPUT ON SYSTEMS OTHER THAN LEV CONCEPTS, IGNORE THIS CARD.

1-6	SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.
11-20	CREW LEVEL. ON THE FIRST CARD, INPUT THE LARGEST CREW SIZE THAT WAS USED FOR INPUT CARDS 5-09 (SYSTEM EXPENDABLES) AND 5-10 (SYSTEM MAN-HOUR REQUIREMENTS). THE INPUT ON SUBSEQUENT CARDS IN A SERIES MUST COVER THE OTHER CREW LEVELS IN 5-09 AND 5-10 IN THE SAME DESCENDING ORDER. SEE NOTE * BELOW.
21-30	MAXIMUM SINGLE EXCURSION TIME, IN HOURS, PERMITTED FOR GIVEN CREW LEVEL. ALL INDIVIDUAL TRAVERSES WITH WHICH THIS CONCEPT IS COMPARED MUST HAVE TOTAL TRAVERSE TIMES LESS THAN THE VALUE INPUT HERE. SEE NOTE * BELOW.
31-40	SPECIFIC IMPULSE, IN METERS PER SECOND, FOR THE LEV PROPULSION SUBSYSTEM. IF VALUES ARE NOT AVAILABLE FOR THE CONCEPT DESIGN, USE A NOMINAL VACUUM ISP FOR THE DESIRED PROPELLANTS. SEE NOTE * BELOW.
41-50	INERT MASS OF LEV IN KILOGRAMS. THE INERT MASS IS GIVEN AS THE SUM OF THE TOTAL NONEXPENDABLES IN THE CONCEPT DESIGN PLUS THE UNUSABLE LEV PROPELLANT. IT DOES NOT INCLUDE THE CREW, THEIR SPACESUITS AND BACKPACKS, USABLE LEV PROPELLANT, AND ALL OTHER EXPENDABLES. SEE NOTE * BELOW.
72	SPACESUIT USAGE FLAG. INPUT 0 (ZERO) OR LEAVE THE SPACE BLANK IF SPACESUIT EXPENDABLES ARE USED DURING TRAVELING. INPUT 1 (ONE) IF TRAVELING IS DONE IN SHIRTSLEEVES.
77-80	SEQUENCE NUMBER. INPUT ONE OF THE FOLLOWING. 5131 IF THIS IS THE FIRST CARD OF A SERIES. 5132 IF THIS IS THE SECOND CARD OF A SERIES. 5133 IF THIS IS THE THIRD CARD OF A SERIES. 5134 IF THIS IS THE FOURTH CARD OF A SERIES. 5135 IF THIS IS THE ONLY CARD REQUIRED OR IF THIS IS THE LAST CARD OF A SERIES

NOTE * - THE INPUT NUMBER MAY BE PLACED ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW LOCATION OF THE DECIMAL POINT.

CARD I.D. NO. 5-14

SYSTEM INPUT - LFV STOPS VS RANGE TABLE

THIS CARD IS USED TO SPECIFY THE RELATIONSHIP BETWEEN THE MAXIMUM SINGLE EXCURSION RANGE OF AN LFV ON A TRAVERSE AND THE NUMBER OF STOPS ON THAT TRAVERSE. THE CARD PROVIDES FOR INPUT OF FIVE ORDERED PAIRS. UP TO TWO CARDS MAY BE USED.

FOR SYSTEMS OTHER THAN LFV CONCEPTS, IGNORE THIS CARD.

1-6	SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.
13-18	NUMBER OF STOPS. SPECIFY A VALUE FOR NUMBER OF STOPS BY THE LFV IN ONE TRAVERSE. DO NOT COUNT THE START OR THE FINISH POINT OF THE POSSIBLE TRAVERSE. BEGIN WITH THE NUMBER ZERO AND ON SUCCEEDING ENTRIES, INPUT 1, 2, 3, ETC. IN INCREASING ORDER. SEE NOTE * BELOW.
19-24	MAXIMUM SINGLE EXCURSION RANGE OF THE LFV, IN KILOMETERS, FOR THE NUMBER OF STOPS JUST GIVEN. GENERALLY, THIS WILL BE THE RANGE ACHIEVED WITH ZERO PAYLOAD. SEE NOTE * BELOW.
25-30	SEE 13-18 ABOVE.
31-36	SEE 19-24 ABOVE.
37-42	SEE 13-18 ABOVE.
43-48	SEE 19-24 ABOVE.
49-54	SEE 13-18 ABOVE.
55-60	SEE 19-24 ABOVE.
61-66	SEE 13-18 ABOVE.
67-72	SEE 19-24 ABOVE.
77-80	SEQUENCE NUMBER. INPUT THE NUMBER 514L IN ALL CASES EXCEPT IF THIS IS THE FIRST OF TWO CARDS. IN THAT CASE, INPUT THE NUMBER 5141.

NOTE * - THE INPUT NUMBER MAY BE PLACED ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW LOCATION OF THE DECIMAL POINT.

CARD I.D. NO 5-15

SYSTEM INPUT - MAJOR SCIENTIFIC EQUIPMENT ONLY

THIS CARD IS USED TO IDENTIFY THOSE EXPERIMENTS PERFORMED BY A MAJOR SCIENTIFIC EQUIPMENT SYSTEM. UP TO FIVE EXPERIMENT IDENTIFIERS CAN BE INPUT ON ONE CARD. UP TO FIVE CARDS MAY BE USED. NOT ALL OF THE 25 POSSIBLE EXPERIMENTS NEED BE PERFORMED ON ANY ONE MISSION.

FOR SYSTEMS OTHER THAN MAJOR SCIENTIFIC EQUIPMENT, IGNORE THIS CARD.

1-6 SYSTEM IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.

7-18 EXPERIMENT IDENTIFIER. INPUT THE EXPERIMENT IDENTIFIER OF AN EXPERIMENT PERFORMED WITH THE USE OF THE GIVEN MAJOR SCIENTIFIC EQUIPMENT CONCEPT. USE THE NUMBER PROVIDED BY THE NORTH AMERICAN AVIATION STUDY OF LUNAR MISSIONS. EXPAND THEIR 8-DIGIT NUMBER INTO FIVE SECTIONS WITH DECIMAL POINTS AS FOLLOWS.

X.X.XX.XX.XX

BEGIN THIS 12-PLACE NUMBER AT THE LEFT OF THE SPACE PROVIDED.

19-30 SEE 6-18 ABOVE.

31-42 SEE 6-18 ABOVE.

43-54 SEE 6-18 ABOVE.

55-66 SEE 6-18 ABOVE.

77-80 SEQUENCE NUMBER. INPUT ONE OF THE FOLLOWING.

5151 IF THIS IS THE ONLY CARD REQUIRED OR IF THIS IS THE LAST OF A SERIES.
5151 IF THIS IS THE FIRST OF A SERIES.
5152 IF THIS IS THE SECOND OF A SERIES.
5153 IF THIS IS THE THIRD OF A SERIES.
5154 IF THIS IS THE FOURTH OF A SERIES.

CARD I.D. NO. 5-16

SYSTEM INPUT - TRANSPORTATION SYSTEMS ONLY

THIS CARD IS USED TO IDENTIFY THE FLIGHT SYSTEMS MAKING UP THE TRANSPORTATION SYSTEM. IT ALSO INDICATES THE LAUNCH LEAD TIME REQUIRED FOR THE DELIVERY OF EACH FLIGHT SYSTEM.

ONE OF THESE CARDS MUST BE INPUT WITH EACH TRANSPORTATION SYSTEM.

1-6	SYSTEM IDENTIFIER. INPUT THE TRANSPORTATION SYSTEM IDENTIFICATION NUMBER SUPPLIED IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT USE THE DASH SEPARATING THE DIGITS.
11-16	FLIGHT SYSTEM IDENTIFIER. INPUT THE SYSTEM IDENTIFIER FOR A FLIGHT SYSTEM USED TO MAKE UP THE TRANSPORTATION SYSTEM. INPUT THE NUMBER SUPPLIED IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT USE THE DASH SEPARATING THE DIGITS.
17-20	LAUNCH LEAD TIME FOR THE GIVEN FLIGHT SYSTEM. INPUT THE NUMBER OF 6-MONTH TIME PERIODS PRECEDING THE LAUNCH DATE WHEN DELIVERY OF THE FLIGHT-QUALIFIED SYSTEM IS REQUIRED. INPUT 1 FOR 0-6 MONTHS, 2 FOR 7-12 MONTHS, ETC. PLACE THE NUMBER ANYWHERE IN THE FOUR SPACES PROVIDED. BE SURE TO SHOW LOCATION OF THE DECIMAL POINT.
21-26	SEE 11-16 ABOVE.
27-30	SEE 17-20 ABOVE.
31-36	SEE 11-16 ABOVE.
37-40	SEE 17-20 ABOVE.
41-46	SEE 11-16 ABOVE.
47-50	SEE 17-20 ABOVE.
51-56	SEE 11-16 ABOVE.
57-60	SEE 17-20 ABOVE.
61-66	SEE 11-16 ABOVE.
67-70	SEE 17-20 ABOVE.
77-80	SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER- 5161

Appendix F

DETAILED INSTRUCTIONS FOR PREPARING SUBSYSTEM SOTA ADVANCE INPUT CARDS

(Ref. Paragraph 10.6.2)

CARD I.D. 6-01 .

SUBSYSTEM SOTA ADVANCE - GENERAL

ONE OF THESE CARDS IS REQUIRED FOR EVERY SUBSYSTEM SOTA ADVANCE.

1-6	SUBSYSTEM IDENTIFIER. START IDENTIFIER IN COLUMN 1.
7-30	SUBSYSTEM NAME FIRST LINE. CENTER THE NAME WITHIN THE SPACE PROVIDED. THIS INPUT WILL APPEAR ON FIRST LINE OF PRINTOUT.
31-54	SUBSYSTEM NAME SECOND LINE. CENTER THE REST OF THE NAME WITHIN THE SPACE PROVIDED. THIS INPUT WILL APPEAR ON SECOND LINE OF PRINTOUT.
77-80	SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER - 6011

CARD I.D. 6-02 AND 6-03

COST CURVE - GENERAL

THIS STANDARD CARD IS USED TO INPUT ALL NONRECURRING COSTS REQUIRED FOR THE COMPUTER PROGRAM. THE IDENTIFIER (SPACES 1-6) AND SEQUENCE NUMBER (SPACES 77-80) ESTABLISH EXACTLY WHICH COST CURVE IS BEING GIVEN. EACH COST CURVE WILL BE GIVEN BY A SET OF THESE CARDS. EACH SET MAY CONTAIN UP TO THREE CARDS. AS EACH CARD PERMITS ENTRY OF COSTS FOR FIVE 6-MONTH TIME PERIODS, USE OF THREE CARDS ALLOWS INPUT OF COSTS FOR UP TO 7.5 YEARS.

AT LEAST ONE OF THESE CARDS MUST BE INPUT FOR EVERY COST CATEGORY REQUIRED FOR EACH SUBSYSTEM SOTA ADVANCE. IF IT IS NOT DESIRED TO INPUT A COST CURVE, FILL OUT COLUMNS 1-12 AND 77-80 ONLY.

1-6	SUBSYSTEM IDENTIFIER. USE THE NUMBER INPUT WITH THE 6-01 CARD.
21-25	ZERO POINT. INSERT HERE THE NUMBER OF 6-MONTH TIME PERIODS THAT OCCUR FROM START OF FUNDING UP TO AND INCLUDING THE 6-MONTH TIME PERIOD OF THE DELIVERY DATE OF FIRST FLIGHT QUALIFIED SUBSYSTEM TO SYSTEM INTEGRATOR. NOTE- THIS ZERO POINT ENTRY NEED ONLY BE PUT ON FIRST CARD OF THE SET THAT WILL DESCRIBE EACH COST CURVE. THE INPUT NUMBER MAY BE PUT ANYWHERE IN THE FIVE SPACES PROVIDED. SHOW A DECIMAL POINT WITH EACH ENTRY.
26-35	COST ENTRY, IN MILLIONS OF DOLLARS, FOR 6-MONTH FUNDING PERIOD. THE INPUT NUMBER MAY BE PUT ANYWHERE WITHIN THE 10 SPACES PROVIDED. SHOW LOCATION OF DECIMAL POINT.
36-45	SAME AS ABOVE.
46-55	SAME AS ABOVE.
56-65	SAME AS ABOVE.
66-75	SAME AS ABOVE.
77-80	SEQUENCE NUMBER. INPUT NUMBER AS SHOWN BELOW. NOTE THAT THE SYMBOL * HAS SPECIAL SIGNIFICANCE.

COST CURVE	INPUT
NONRECURRING R AND D COST - SUBSYSTEM LEVEL	602*
NONRECURRING FACILITIES COST - SUBSYSTEM LEVEL	603*

* = LAST DIGIT OF SEQUENCE NUMBER. USE AS FOLLOWS-
- 1 - IF LAST CARD IN SEQUENCE OF ANY SIZE
- 1 - IF FIRST CARD IN SEQUENCE OF 2 OR 3 CARDS
- 2 - IF SECOND CARD IN SEQUENCE OF 3 CARDS

Appendix G

DETAILED INSTRUCTIONS FOR PREPARING EXPERIMENT INPUT CARDS

(Ref. Paragraph 10.6.3)

CARD I.D. NO. 8-01 PAGE 1 OF 2

EXPERIMENT INPUT - TYPE 1 CARD

THIS CARD IS USED TO INPUT SUMMARY DATA FOR EACH EXPERIMENT.

1	CARD TYPE. INPUT NUMBER 1.
4-11	EXPERIMENT NUMBER. INPUT AN EIGHT DIGIT NUMBER WHICH UNIQUELY IDENTIFIES THIS EXPERIMENT.
12-31	ABBREVIATED TITLE OF EXPERIMENT.
42	NUMBER OF MEN. MINIMUM NUMBER OF CREW PERSONNEL REQUIRED TO PERFORM THE CRITICAL OPERATIONS RELATED TO THIS EXPERIMENT.
45-48	EQUIPMENT MASS. INPUT TOTAL MASS, IN KILOGRAMS, NOT INCLUDING PACKAGING, STORAGE, OR TRANSPORTATION FACTORS. THE FOUR DIGIT CODE USES THE FIRST TWO DIGITS FOR THE SIGNIFICANT FIGURES, AND THE LAST TWO DIGITS FOR THE EXPONENT TO THE BASE 10. FOR NEGATIVE EXPONENTS ADD 50 TO THE ABSOLUTE VALUE.
	EXAMPLE - $2001 = 2.0 \times (10)^{1} = 20KG$
	$2051 = 2.0 \times (10)^{-1} = 0.2KG$
49-52	EQUIPMENT VOLUME. INPUT TOTAL VOLUME, IN CUBIC METERS, OF OUTSIDE ENVELOPE OF EQUIPMENT PACKAGE, NOT INCLUDING SPECIAL CONTAINER REQUIREMENTS. USE FOUR DIGIT CODE AS PREVIOUSLY DESCRIBED.
53-56	TOTAL EQUIPMENT ENERGY. INPUT, IN WATT-HRS, PRODUCT OF AVERAGE POWER DEMAND AND TOTAL OPERATING TIME. USE FOUR DIGIT CODE AS PREVIOUSLY DESCRIBED.
57-60	PEAK POWER. INPUT MAX POWER DEMAND, IN WATTS, FOR PERFORMING SPECIAL FUNCTIONS.
70	DEVELOPMENT TIME. INPUT THE NUMBER OF YEARS REQUIRED TO DEVELOP THE OPERATIONAL PIECE OF EQUIPMENT WHICH IS PACING FOR THE EXPERIMENT.
71-72	YEAR OF EARLIEST AVAILABILITY. LAST TWO DIGITS OF CALENDAR YEAR PACING EQUIPMENT COULD BE AVAILABLE, INCLUDING PAST IF ALREADY AVAILABLE.

EXPERIMENT INPUT - TYPE 1 CARD (CONTINUED)

73-74	NONRECURRING COST. A TWO-DIGIT CODE FOR COST TO DEVELOP ITEM(S) SUITABLE FOR SPACE USE. FIRST DIGIT IS SIGNIFICANT FIGURE, SECOND DIGIT IS FOR EXPONENT.
75-76	FIRST ITEM COST. A TWO-DIGIT CODE FOR THE ESTIMATED COST OF THE FIRST ITEM INTENDED FOR OPERATIONAL USE. USE CODING PROCEDURE AS PREVIOUSLY DESCRIBED.
77-80	TOTAL EARTH RETURNED MASS. INPUT MASS, IN KILOGRAMS, OF ALL SAMPLES, EMULSIONS, AND OTHER MATERIALS INCLUDING SUITABLE STORAGE CONTAINERS NOT INTEGRAL WITH THE SPACECRAFT. USE FOUR-DIGIT CODE PREVIOUSLY DESCRIBED.

CARD I.D. NO. 8-02 PAGE 1 OF 2

EXPERIMENT INPUT - TYPE 3 CARD

THIS CARD IS USED TO INPUT LABOR OPERATION MANHOURS FOR EACH EXPERIMENT.

1	CARD TYPE. INPUT NUMBER 3
4-11	EXPERIMENT NUMBER. INPUT AN EIGHT DIGIT NUMBER WHICH UNIQUELY IDENTIFIES THIS EXPERIMENT. USE SAME NUMBER AS ON 8-01 CARD.

THE NEXT EIGHT INPUTS ARE FOR TRAVERSE OPERATIONS ONLY.

12-15	SHIRTSLEEVE SETUP (PHASE 1). INPUT THE NUMBER OF MANHOURS TO SETUP THE EXPERIMENT IN A SHIRTSLEEVE ENVIRONMENT. THE FOUR DIGIT CODE USES THE FIRST TWO DIGITS FOR THE SIGNIFICANT FIGURES, AND THE LAST TWO DIGITS FOR THE EXPONENT TO THE BASE 10. FOR NEGATIVE EXPONENTS ADD 50 TO THE ABSOLUTE VALUE.
	EXAMPLE - $2001 = 2.0 \times (10)^{1} = 20$ MAN-HOURS
	$2051 = 2.0 \times (10)^{-1} = 0.2$ MAN-HOURS
16-19	SHIRTSLEEVE OPERATE (PHASE 2). INPUT THE NUMBER OF MANHOURS TO OPERATE THE EXPERIMENT IN A SHIRTSLEEVE ENVIRONMENT. USE THE FOUR DIGIT CODE DESCRIBED ABOVE.
20-23	SHIRTSLEEVE ANALYSIS (PHASE 3). INPUT THE NUMBER OF MANHOURS TO ANALYZE THE EXPERIMENT IN A SHIRTSLEEVE ENVIRONMENT USE THE FOUR DIGIT CODE DESCRIBED ABOVE.
24-27	SHIRTSLEEVE TEARDOWN (PHASE 4). INPUT THE NUMBER OF MANHOURS TO TEARDOWN THE EXPERIMENT IN A SHIRTSLEEVE ENVIRONMENT USE THE FOUR DIGIT CODE DESCRIBED ABOVE.
28-31	SPACESUIT SETUP (PHASE 1). SAME AS 12-15 ONLY IN SPACESUIT.
32-35	SPACESUIT OPERATE (PHASE 2). SAME AS 16-19 ONLY IN SPACESUIT.
36-39	SPACESUIT ANALYSIS (PHASE 3). SAME AS 20-23 ONLY IN SPACESUIT.
40-43	SPACESUIT TEARDOWN (PHASE 4). SAME AS 24-27 ONLY IN SPACESUIT.

THE NEXT EIGHT INPUTS ARE FOR BASE OPERATIONS ONLY.

44-47	SHIRTSLEEVE SETUP (PHASE 1). SAME AS 12-15 ONLY AT BASE.
48-51	SHIRTSLEEVE OPERATE (PHASE 2). SAME AS 16-19 ONLY AT BASE.
52-55	SHIRTSLEEVE ANALYSIS (PHASE 3). SAME AS 20-23 ONLY AT BASE.

EXPERIMENT INPUT - TYPE 3 CARD (CONTINUED)

56-59	SHIRTSLEEVE TEARDOWN (PHASE 4). SAME AS 24-27 ONLY AT BASE.
60-63	SPACESUIT SETUP (PHASE 1). SAME AS 28-31 ONLY AT BASE.
64-67	SPACESUIT OPERATE (PHASE 2). SAME AS 32-35 ONLY AT BASE.
68-71	SPACESUIT ANALYSIS (PHASE 3). SAME AS 36-39 ONLY AT BASE.
72-75	SPACESUIT TEARDOWN (PHASE 4). SAME AS 40-43 ONLY AT BASE.

Appendix H

DETAILED INSTRUCTIONS FOR PREPARING COMPUTER DATA UPDATE CARDS

(Ref. Paragraph 10.8)

CARD I.D. NO. 2-02

COMPUTER CONTROL - TAPE RECORD IDENTIFIER

THIS CARD IS USED BY THE COMPUTER TO FIND A SPECIFIC DATA RECORD WHICH WILL BE OPERATED UPON BY THE INPUT AND UPDATE COMPUTER ROUTINE. THE IDENTIFIER OF THAT DATA RECORD IS INPUT HERE. THIS MUST BE DONE IN ORDER TO

1. UPDATE THE EXISTING DATA RECORD
2. DELETE THE ENTIRE DATA RECORD
3. COPY THE ENTIRE DATA RECORD ONTO ANOTHER TAPE

1-12 DATA RECORD IDENTIFIER. INPUT THE IDENTIFIER FOR THE SPECIFIC DATA RECORD REQUIRED. INPUT AS FOLLOWS-

DATA RECORD CATEGORY	COLUMNS
MISSION	1-8
MODE	1-12
EMERGENCY MODE	1-12
SYSTEM	1-6
SUBSYSTEM S.O.T.A. ADVANCE	1-6
EXPERIMENT	1-12

77-80 SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER- 202L

CARD I.D. NO. 2-03

COMPUTER CONTROL - A-FORMAT CHANGES

THIS CARD IS USED TO REVISE ANY DATA RECORD WORD THAT IS WRITTEN IN A-FORMAT ONLY.

1-12	DATA RECORD IDENTIFIER. INPUT IDENTIFIER OF SPECIFIC DATA RECORD FOR WHICH AN A-FORMAT CHANGE IS REQUIRED. USE SAME IDENTIFIER AS INPUT ON 2-02 CARD.
16-18	DATA ADDRESS. INPUT THE ADDRESS OF THE FIRST A-FORMAT DATA WORD TO BE CHANGED. THIS ADDRESS CAN BE FOUND IN THE ACCOMPANYING TABLE FOR THE DESIRED DATA RECORD CATEGORY. BE SURE TO RIGHT-ADJUST THE INPUT NUMBER. THAT IS, BE SURE THAT THE LAST DIGIT OF THE INPUT APPEARS IN COLUMN 18.
24	NUMBER OF CONSECUTIVE ENTRIES (ALL A-FORMAT) TO BE REVISED STARTING WITH THE ENTRY WHOSE ADDRESS APPEARS IN COLUMNS 16-18 ABOVE. ONLY A MAXIMUM OF 8 CONSECUTIVE ENTRIES CAN BE CHANGED WITH ONE 2-03 CARD.
26-31	NEW A-FORMAT WORD DESIRED IN FIRST DATA ADDRESS. INPUT THE WORD EXACTLY AS YOU WISH IT TO APPEAR. START THE INPUT IN COLUMN 26.
32-37	NEW A-FORMAT WORD DESIRED IN THE NEXT DATA ADDRESS. INPUT THE WORD EXACTLY AS YOU WISH IT TO APPEAR. START THE INPUT TO THE LEFT OF THE SPACE PROVIDED.
38-43	SEE ABOVE.
44-49	SEE ABOVE.
50-55	SEE ABOVE.
56-61	SEE ABOVE.
62-67	SEE ABOVE.
68-73	SEE ABOVE.
77-80	SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER- 203L

CARD I.D. NO. 2-04

COMPUTER CONTROL - E-FORMAT CHANGES

THIS CARD IS USED TO REVISE ANY NUMBER IN THE DATA RECORD THAT IS WRITTEN IN E-FORMAT (FLOATING DECIMAL POINT).

1-12	DATA RECORD IDENTIFIER. INPUT IDENTIFIER OF SPECIFIC DATA RECORD FOR WHICH AN E-FORMAT CHANGE IS REQUIRED. USE SAME IDENTIFIER AS INPUT ON 2-02 CARD.
16-19	DATA ADDRESS. INPUT THE ADDRESS OF THE FIRST E-FORMAT DATA NUMBER TO BE CHANGED. THIS ADDRESS CAN BE FOUND IN THE ACCOMPANYING TABLE FOR THE DESIRED DATA RECORD CATEGORY. BE SURE TO RIGHT-ADJUST THE INPUT NUMBER. THAT IS, BE SURE THAT THE LAST DIGIT OF THE INPUT APPEARS IN COLUMN 19.
24	NUMBER OF CONSECUTIVE ENTRIES (ALL E-FORMAT) TO BE REVISED STARTING WITH THE ENTRY WHOSE ADDRESS APPEARS IN COLUMNS 16-19 ABOVE. ONLY A MAXIMUM OF 5 CONSECUTIVE ENTRIES CAN BE CHANGED WITH ONE 2-04 CARD.
26-35	NEW E-FORMAT NUMBER DESIRED IN FIRST DATA ADDRESS. INPUT THE NUMBER EXACTLY AS YOU WISH IT TO APPEAR. INPUT THE NUMBER ANYWHERE IN THE 10 SPACES PROVIDED. BE SURE TO SHOW LOCATION OF DECIMAL POINT. A BLANK ENTRY IN THE 10 SPACES WILL BE READ AS A ZERO BY THE COMPUTER.
36-45	NEW E-FORMAT NUMBER DESIRED IN THE NEXT DATA ADDRESS. SAME INPUT RULES APPLY AS GIVEN IN 26-35 ABOVE.
46-55	SEE ABOVE.
56-65	SEE ABOVE.
66-75	SEE ABOVE.
77-80	SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER- 204L

Table H-1

LOCATION OF DATA ON MODE FIXED LENGTH RECORD

Address	Variable Name	Format	Original Input Card Name
3	Active Mode Crew Level	F	
4	Total Mode Crew Level	F	
5	Mode Staytime	F	
6	Sample Return Capability	F	Mode Input-General
7	Min. Decimal Fraction	F	
8	Deliv. Date-Minor Sci. Equip.	F	
9	Flag		
10	No. of Payloads	F	
11	Total Time for Base Deploy.	F	
12	Deploy. mhr – Shirtsleeve	F	
13	Deploy. mhr – Spacesuit	F	
14	Mhr of Suit Lifetime	F	Mod Input-Operations
15	Mhr of Backpack Lifetime	F	
16	Mass of Suit Replacement	F	
17	Mass of Backpack Replacement	F	
18–33	Nonrecur., Eng., Mfg., Test, Sup.	F	
34–49	Nonrecur., Facilities	F	Mode
50–65	Recurring; Eng., Mfg., Test	F	Cost Curve
66–81	Recurring; Oper. Support	F	
82	1st Payload Launch ID	F	
83	Related Launch ID	F	
84	Min. 6-mo Periods	F	
85	Max. 6-mo Periods	F	
86	Mass Margin Available	F	
87–91	2nd Payload		Mode Input Payload
92–96	3rd Payload		Launch Identification
97–101	4th Payload		
102–106	5th Payload		

Table H-1 (Cont.)

Address	Variable Name	Format	Original Input Card Name
107-111	6th Payload		
112-116	7th Payload		
117-121	8th Payload Launch ID	F	Mode Input Payload Launch Identification
	1st Payload, 1st System		
122	System Iden.	A	
123	No. Men Supported	F	
124	Delivery Date	F	
125	Expend -Special Oper.	F	
126-129	1st Payload, 2nd System		
.	.		
.	.		
.	.		
178-181	1st Payload, 15th System		Mode Input-Systems on Each Launch
182-185	2nd Payload, 1st System		
.	.		
.	.		
.	.		
238-241	2nd Payload, 15th System		
242-301	3rd Payload		
302-361	4th Payload		
362-421	5th Payload		
422-481	6th Payload		
482-541	7th Payload		
542-601	8th Payload		
602-603	Identifier for Crew Rescue Emergency Mode	A	
604-605	Identifier for Logistics Emergency Mode	A	Mode Input-Emergency

Table H-2

LOCATION OF DATA FOR EMERGENCY MODE FIXED LENGTH RECORD

Address	Variable Name	Format	Original Input Card Name
11-26	Nonrecurring R&D	F	
27-42	Nonrecurring Cost of Facilities	F	Emergency Mode Cost
43-58	Recurring Hardware Procurement	F	Cost Curve
59-74	Operations Support	F	
	Only Payload, 1st System		
75	System Identifier	A	
76	No. Men Supported	F	
77	Launch Lead Time	F	
78	Expendables - Spec. Oper.	F	Systems on the Payload
79-82	Only Payload, 2nd System	A, F, F, F	
.	.		
.	.		
.	.		
131-134	Only Payload, 15th System	A, F, F, F	

Table H-3

LOCATION OF DATA FOR SYSTEM FIXED LENGTH RECORD

Address	Variable Name	Format	Original Input Card Name
2-5	System Name	A	
6	Procurement Quantity Unit	F	System Input-General
7	Max. Mass for all Expend.	F	
8	Max. Mass for LFV Propellant	F	
9-38	Subsys. Ids., Deliv. Date - Pairs	A, F	System Input-Subsystem S.O.T.A. Iden.
39-54	Nonrecurring Cost	F	
55-70	Nonrecurring Facilities Cost	F	Cost System Curve
71-86	Recurring Cost	F	
87-102	Recurring Operations Support	F	
103-122	(Copies Nbrd., Dec. Frac.) - Pairs	(F, F)	Table of Hardware Cost Reduction for Add. Copies
123	Zero Pt. for Flight Table	F	R&D Flight Table
124-143	(No. Flights, Veh. Used) -Pairs	(F, A)	
144-150	1st Crew Level → Boiloff	F	
151-157	2nd Crew Level → Boiloff	F	System Expendables
158-164	3rd Crew Level → Boiloff	F	
165-171	4th Crew Level → Boiloff	F	
172-178	5th Crew Level → Boiloff		
179-185	1st Crew Level → Non-Sci. Oper./Stop (Spacesuit)	F	
186-192	2nd Crew Level → Non-Sci. Oper./Stop (Spacesuit)	F	System Man-Hour Requirements for Nonscientific Operations
193-199	.	.	
200-206	.	.	
207-213	5th Crew Level → Non-Sci. Oper./Stop (Spacesuit)		

Table H-3 (Cont.)

Address	Variable Name	Format	Original Input Card Name
214-223	(Crew Level, Max. Staytimes)—Pairs	(F,F)	System Input-Per. Shelter Only
224-229	1st Crew Level → Flag	F	
230-235	2nd Crew Level → Flag	F	
236-241	3rd Crew Level → Flag	F	System Input-LRV Only
242-247	4th Crew Level → Flag	F	
248-253	5th Crew Level → Flag	F	
254-258	1st Crew Level → Flag	F	
259-263	2nd Crew Level → Flag	F	
264-268	3rd Crew Level → Flag	F	System Input-LFV Only
269-273	4th Crew Level → Flag	F	
274-278	5th Crew Level → Flag	F	
279-298	(No. Stops, Max. Single Excursion Range)— Pairs	(F,F)	System Input-LFV Stops vs. Range Table
299-348	Experiment Iden.	A	System Input-Major Scien. Equip. Only
349-360	(Flight System, Lead Time)—Pairs	(A,F)	System Input-Transportation System Only

Table H-4

LOCATION OF DATA FOR SUBSYSTEM SOTA
ADVANCE FIXED LENGTH RECORD

Address	Variable Name	Format	Original Input Card Name
2-5	Subsystem Name (1st line)	A	Subsystem SOTA
6-9	Subsystem Name (2nd line)	A	Advance-General
10-25	Nonrucurring R&D	F	Subsystem Cost Curve
26-41	Nonrecurring Cost of Facilities	F	

Note: A total of 211 word locations have been set aside for subsystems, but only 41 are currently allocated.

Table H-5

LOCATION OF DATA FOR EXPERIMENT FIXED LENGTH RECORD

Address	Variable Name	Format	Original Input Card Name
3-6	Experiment Title	A	
7	Number Men Required	A	
8	Crew Skill	A	
9	Total Equipment Mass	A	
10	Total Equipment Volume	A	
11	Total Equipment Energy	A	
12	Peak Power	A	Experiment Input-Type 1 Card
13	Dev. Time	A	
14	Year of Earliest Availability	A	
15	Nonrecurring Cost	A	
16	Est. 1st Item Cost	A	
17	Total Earth Return Mass	A	
18	Setup Shirtsleeve Traverse	A	
19	Operate Shirtsleeve Traverse	A	
20	Analysis Shirtsleeve Traverse	A	
21	Take Down Shirtsleeve Traverse	A	
22	Setup Spacecuit Traverse	A	
23	Operate Spacesuit Traverse	A	
24	Analysis Spacesuit Traverse	A	
25	Take Down Spacesuit Traverse	A	Experiments Input-Type 3 Card
26	Setup Shirtsleeve Base	A	
27	Operate Shirtsleeve Base	A	
28	Analysis Shirtsleeve Base	A	
29	Take Down Shirtsleeve Base	A	
30	Setup Spacesuit Base	A	
31	Operate Spacesuit Base	A	
32	Analysis Spacesuit Base	A	
33	Take Down Spacesuit Base	A	

Appendix I

DETAILED INSTRUCTIONS FOR PREPARING MISSION-MODE COMPARISON CONTROL CARDS

(Ref. Paragraph 10.9)

CARD I.D. 2-11

PROGRAM LEVEL INPUT - MISSION-MODE IDENTIFICATION

THIS CARD IS USED TO INPUT THE REQUIRED IDENTIFIERS FOR EACH MISSION AND MODE MATCH THAT IS TO BE VERIFIED BY THE COMPUTER. THERE IS NO LIMIT TO THE NUMBER OF SUCH MATCHES THAT CAN BE VERIFIED IN ONE RUN.

1-12 EXPLORATION PROGRAM IDENTIFIER. START THE IDENTIFIER IN COLUMN 1.

13-20 MISSION IDENTIFIER. INPUT AN IDENTIFIER IN THE EIGHT COLUMNS SPECIFIED THAT WILL UNIQUELY LABEL THE MISSION BEING CONSIDERED. THE FOLLOWING INPUT FORMAT WILL BEST MATCH THE COMPUTER INTERNAL LOGIC AND OUTPUT PRINT ROUTINE.

13-15 SCIENTIFIC PROGRAM IDENTIFIER. USE ANY COMBINATION OF LETTERS AND NUMBERS TO LABEL THE SCIENTIFIC PROGRAM UNDER CONSIDERATION. START THE INPUT IN COLUMN 13.

17-18 MISSION MIX IDENTIFIER. IDENTIFY THE GROUP OF MISSIONS BEING DERIVED TO ACCOMPLISH THE SCIENTIFIC PROGRAM GIVEN ABOVE.

19-20 NUMBER OF THIS MISSION IN THE SEQUENCE OF MISSIONS.

25-36 MODE IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. START THE NUMBER IN THE FIRST SPACE PROVIDED.

50-55 SHIRTSLEEVE MAN-HOUR MULTIPLIER. THE MAN-HOUR DATA FOR EXPERIMENTS GIVEN BY NORTH AMERICAN DOES NOT ACCOUNT FOR ANY DIFFERENCE IN GRAVITY BETWEEN EARTH AND MOON. INPUT HERE THE FACTOR BY WHICH EXPERIMENT SHIRTSLEEVE MAN-HOURS WILL BE MULTIPLIED TO ACCOUNT FOR THIS DIFFERENCE. PLACE THE NUMBER ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW LOCATION OF DECIMAL POINT.

60-65 SPACESUIT MAN-HOUR MULTIPLIER. THE MAN-HOUR DATA FOR EXPERIMENTS GIVEN BY NORTH AMERICAN IS FOR 1 G SHIRTSLEEVE EFFORT. INPUT HERE THE FACTOR BY WHICH EXPERIMENT SPACESUIT MAN-HOURS WILL BE MULTIPLIED TO ACCOUNT FOR SPACESUIT EFFORT ON THE MOON. PLACE THE NUMBER ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW LOCATION OF DECIMAL POINT.

77-80 SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER- 2111

CARD I.D. 2-12

PROGRAM LEVEL INPUT - TRAVERSE-VEHICLE IDENTIFICATION

THIS CARD IS USED TO IDENTIFY THE TRAVERSES PERFORMED BY EACH FLYING AND ROVING VEHICLE IN THE MODE IDENTIFIED IN CARD I.D. 2-11. INPUT OF UP TO 24 TRAVERSES PER VEHICLE IS PERMITTED. AS THERE IS SPACE FOR IDENTIFYING 6 TRAVERSES PER CARD, A MAXIMUM OF 4 CARDS IS ALLOWED PER VEHICLE.

START WITH FLYING VEHICLES FIRST. IF THERE ARE NO FLYING OR ROVING VEHICLES USED IN THE MISSION, INPUT ONLY COLUMNS 1-12 AND 77-80.

1-12 MODE IDENTIFIER. USE THE NUMBER INPUT IN COLUMNS 25-36 OF THE 2-11 CARD.

13-18 TRAVERSE VEHICLE IDENTIFIER. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.

19-24 IF THE VEHICLE IN COLUMNS 13-18 IS A TRAILER USED IN COMBINATION WITH AN LRV, INPUT THE LRV IDENTIFIER HERE. USE THE NUMBER SHOWN IN THE MIMOSA DATA BOOK. USE ONLY THE SIX DIGITS. DO NOT INCLUDE THE DASH SEPARATING THE DIGITS.

25-30 CREW LEVEL. INPUT THE NUMBER OF CREWMEN PARTICIPATING IN THE FOLLOWING LIST OF TRAVERSES. SHOW LOCATION OF DECIMAL POINT.

31-34 TRAVERSE IDENTIFIER. INPUT IDENTIFIER OF TRAVERSE PERFORMED BY ABOVE VEHICLE AT THE SPECIFIED CREW LEVEL. THIS IDENTIFIER SHOULD TAKE THE FORM

F-XX OR R-XX

WHERE F = FLYING TRAVERSE
R = ROVING TRAVERSE
XX = SEQUENCE NUMBER (01, 02, 03, ETC.) IN INCREASING ORDER

MAKE SURE THE IDENTIFIER GIVEN HERE CONFORMS TO DATA INPUT WITH MISSION, PARTICULARLY CARDS 3-03 AND 3-04.

7-40 SEE ABOVE.

43-46 SEE ABOVE.

49-52 SEE ABOVE.

55-58 SEE ABOVE.

61-64 SEE ABOVE.

77-80 SEQUENCE NUMBER. INPUT THE NUMBER 212X WHERE
X = 1, 2,..., L DEPENDING ON THE NUMBER OF CARDS USED. THE LETTER L MUST BE USED ON THE LAST 2-12 CARD FOR EACH MISSION.

Appendix J

DETAILED INSTRUCTIONS FOR PREPARING INTEGRATION AND COST CONTROL CARDS

(Ref. Paragraph 10.10)

CARD I. D. 2-20

INTEGRATION AND COSTING - GENERAL INPUT

THIS CARD IS USED TO SUPPLY GENERAL CONTROL INFORMATION FOR THE INTEGRATION AND COSTING ROUTINE OF THE MIMOSA COMPUTER PROGRAM.

1-36	EXPLORATION PROGRAM NAME. START INPUT IN COLUMN 1.
41-50	NUMBER OF SATURN 5 LAUNCHES PERMITTED PER CALENDAR YEAR BY EXISTING LAUNCH FACILITIES WITHOUT REQUIRING LAUNCH RATE IMPROVMENT COSTING. INPUT THE NUMBER ANYWHERE IN THE 10 SPACES PROVIDED. BE SURE TO SHOW LOCATION OF THE DECIMAL POINT.
55	EMERGENCY MODE USAGE FLAG. INPUT AS FOLLOWS- 0 (OR BLANK) = EMERGENCY MODES ARE NOT TO BE CONSIDERED 1 = EMERGENCY MODES ARE TO BE CONSIDERED
60	BACKUP SYSTEMS FLAG. INPUT AS FOLLOWS- 0 (OR BLANK) = BACKUP SYSTEMS ARE NOT TO BE PROCURED 1 = BACKUP SYSTEMS ARE TO BE PROCURED
65	EXCEED LAUNCH RATE FLAG. INPUT AS FOLLOWS- 0 (OR BLANK) = LAUNCH RATE VS. CALENDAR YEAR (2-21 CARDS) MAY NOT BE EXCEEDED 1 = LAUNCH RATE VS. CALENDAR YEAR (2-21 CARDS) MAY BE EXCEEDED
77-80	SEQUENCE NUMBER. INPUT THE FOLLOWING NUMBER- 220L

CARD I. D. 2-21 PAGE 1 OF 2

LAUNCH RATE LIMIT VS CALENDAR YEAR

LOCKHEED HAS DEVELOPED TWO VERSIONS OF THE INTEGRATION AND COST ROUTINE. EACH VERSION ALLOWS CALCULATION OF COSTS FOR 21 CONSECUTIVE CALENDAR YEARS. ONE VERSION IS GOOD FOR 1967 THROUGH 1987, THE OTHER VERSION WORKS FOR 1980 THROUGH 1990.

THIS CARD IS USED TO TELL THE COMPUTER THE MAXIMUM NUMBER OF SATURN 5 LAUNCHES DESIRED IN EACH OF THE 21 YEARS FOR WHICH COSTS ARE CALCULATED. THE YEAR THAT IS INTENDED FOR EACH INPUT VALUE IS DETERMINED BY THE POSITION OF THE INPUT NUMBER ON THE CARD. THEREFORE CARE MUST BE TAKEN TO MAKE SURE THE INPUT ON THIS CARD AND THE DESIRED VERSION OF THE COST ROUTINE INSTRUCTIONS ARE COMPATIBLE.

DEPENDING ON THE VERSION OF THE INTEGRATION AND COST ROUTINE TO BE USED, INPUT AS FOLLOWS. INSERT A NUMBER ON THE CARD IN THE SPECIFIED COLUMNS FOR THE MAXIMUM NUMBER OF SATURN 5 (AND UPRATED SATURN 5) LAUNCHES DESIRED FOR THE CALENDAR YEAR GIVEN IN THE TABLE ON THE FOLLOWING PAGE. PLACE EACH NUMBER ANYWHERE IN THE 6-COLUMN SPACE PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT. DO NOT INPUT THE NUMBER OF THE YEAR (E.G., 1970) ITSELF. INPUT ONLY THE LAUNCH LIMIT.

BOTH CARDS MUST BE FILLED OUT. A BLANK IN ANY 6-COLUMN SPACE IS INTERPRETED AS A ZERO BY THE COMPUTER.

INSERT THE FOLLOWING SEQUENCE NUMBERS IN COLUMNS 77-80

CARD 1 - 2211
CARD 2 - 221L

LAUNCH RATE LIMIT VS CALENDAR YEAR (CONTINUED)

POSITION OF LAUNCH RATE LIMIT VALUES ON EACH REQUIRED CARD

COLUMN NUMBERS OF FIELD	APPLICABLE YEARS-- 1967 - 1987 VERSION		APPLICABLE YEARS-- 1970 - 1980 VERSION	
	CARD 1	CARD 2	CARD 1	CARD 2
1 - 6	1967	1978	1970	1981
7 - 12	1968	1979	1971	1982
13 - 18	1969	1980	1972	1983
19 - 24	1970	1981	1973	1984
25 - 30	1971	1982	1974	1985
31 - 36	1972	1983	1975	1986
37 - 42	1973	1984	1976	1987
43 - 48	1974	1985	1977	1988
49 - 54	1975	1986	1978	1989
55 - 60	1976	1987	1979	1990
61 - 66	1977		1980	

CARD I. D. 2-22

MISSION-MODE COMBINATIONS

THIS CARD IS USED TO INPUT THE REQUIRED IDENTIFIERS FOR EACH MISSION-MODE COMBINATION TO BE INTEGRATED AND COSTED IN ONE EXPLORATION PROGRAM. UP TO 50 COMBINATIONS MAY BE INPUT AT ONE TIME. AS THERE ARE 3 COMBINATIONS INPUT PER CARD, UP TO 17 CARDS MAY BE USED. COMBINATIONS MAY BE INPUT IN ANY ORDER PROVIDED THE SCHEDULING OF ONE MISSION DOES NOT DEPEND ON THE SCHEDULING OF ANOTHER MISSION (SEE 3-01 CARD).

CAUTION-- TWO INSTRUCTION TAPES ARE AVAILABLE FOR COST CALCULATIONS. ONE WILL CALCULATE COSTS FROM 1967A THROUGH 1987B. THE OTHER WILL CALCULATE COSTS FROM 1970A THROUGH 1990B. BE SURE TO NOTE WHICH TAPE YOU ARE USING AND MAKE SURE THAT NO MISSION LAUNCHES ARE SCHEDULED OUTSIDE THE PERMITTED RANGE OF DATES. IF LAUNCHES OCCUR OUTSIDE THE PERMITTED RANGE, THE COMPUTER RUN WILL BE ABORTED AUTOMATICALLY.

1-8	MISSION IDENTIFIER. INPUT THE IDENTIFIER OF A DESIRED MISSION EXACTLY AS IT APPEARS IN COLS. 1-8 OF THE 3-01 CARD.
9-20	MODE IDENTIFIER. INPUT THE MODE WHICH IS TO BE COSTED WITH THE MISSION OF 1-8. MAKE SURE IT IS INPUT EXACTLY AS IT APPEARS IN COLS. 1-12 OF THE 4-01 CARD.
21-25	MISSION START DATE OVERRIDE. IF YOU DESIRE TO CHANGE THE MISSION START DATE FOR THIS COSTING ROUTINE FROM WHAT IS SHOWN IN COLS. 31-35 OF THE 3-01 CARD, INPUT A NEW DATE HERE. IF NO INPUT IS MADE THEN THE DATE SHOWN ON THE 3-01 CARD WILL BE USED BY THE COMPUTER.
26-33	SEE 1-8 ABOVE EXCEPT NEXT MISSION IN THE PROGRAM.
34-45	SEE 9-20 ABOVE EXCEPT NEXT MODE IN THE PROGRAM.
46-50	SEE 21-25 ABOVE.
51-58	SAME AS 26-33 ABOVE.
59-70	SAME AS 34-45 ABOVE.
71-75	SEE 21-25 ABOVE.
77-80	SEQUENCE NUMBER. INPUT THE NUMBER 222A WHERE A = NUMBER OF THE CARD IN THE SET. FOR CARDS 10-16, USE ONLY THE LAST DIGIT. BE SURE TO INPUT THE LETTER L IN COLUMN 80 OF THE LAST CARD IN THE SET.

LAUNCH RATE IMPROVEMENT COST CURVE

TWO COST CURVES FOR FACILITY LAUNCH RATE IMPROVEMENT ARE INPUT FOR EACH INCREMENTAL STEP IN LAUNCH RATE IMPROVEMENT. EACH COST CURVE MAY COVER A PERIOD OF UP TO 7.5 YEARS. EACH CARD HAS PROVISIONS FOR FIVE COST ENTRIES OF 6 MONTHS DURATION EACH. THUS, A MAXIMUM OF 3 CARDS (15 ENTRIES OR 7.5 YEARS) MAY BE INPUT FOR EACH COST CURVE. UP TO 10 INCREMENTAL STEPS IN LAUNCH RATE IMPROVEMENT MAY BE INPUT. HENCE, THIS SET MAY COMPRISE A MAXIMUM OF 60 CARDS.

13-16 ANNUAL LAUNCH RATE BEFORE IMPROVEMENT IS MADE. SEE NOTE * BELOW.

17-20 ANNUAL LAUNCH RATE AFTER IMPROVEMENT IS MADE. SEE NOTE * BELOW.

21-25 ZERO POINT. INSERT HERE THE NUMBER OF 6-MONTH TIME PERIODS THAT OCCUR FROM START OF FUNDING UP TO AND INCLUDING THE 6-MONTH TIME PERIOD WHEN THE LAUNCH FACILITY FIRST OPERATES AT THE NEW LAUNCH RATE SHOWN IN COLUMNS 17-20 ABOVE.

NOTE- THIS ZERO POINT ENTRY NEED ONLY BE PUT ON THE FIRST CARD OF THE SET THAT WILL DESCRIBE EACH COST CURVE. SEE NOTE * BELOW.

26-35 COST ENTRY, IN MILLIONS OF DOLLARS, FOR 6-MONTH FUNDING PERIOD. SEE NOTE * BELOW.

36-45 SAME AS ABOVE.

46-55 SAME AS ABOVE.

56-65 SAME AS ABOVE.

66-75 SAME AS ABOVE.

LAUNCH RATE IMPROVEMENT COST CURVE (CONTINUED)

77-80	SEQUENCE NUMBER. INPUT NUMBER AS SHOWN BELOW.	
	NONRECURRING R AND D COST OF 1ST STEP IN LAUNCH RATE	223X
	NONRECURRING FACILITIES COST OF 1ST STEP IN LAUNCH RATE	224X
	NONRECURRING R AND D COST OF 2ND STEP IN LAUNCH RATE	225X
	NONRECURRING FACILITIES COST OF 2ND STEP IN LAUNCH RATE	226X
	.	
	.	
	.	
	NONRECURRING R AND D COST OF 10TH STEP IN LAUNCH RATE	241X
	NONRECURRING FACILITIES COST OF 10TH STEP IN LAUNCH RATE	242X

WHERE X = LAST DIGIT OF SEQUENCE NUMBER. USE AS FOLLOWS-
L - IF LAST CARD IN SEQUENCE OF ANY SIZE.
1 - IF FIRST CARD IN SEQUENCE OF 2 OR 3 CARDS.
2 - IF SECOND CARD IN SEQUENCE OF 3 CARDS.

NOTE * - PLACE THE INPUT NUMBER ANYWHERE IN THE SPACE PROVIDED. BE SURE TO SHOW THE LOCATION OF THE DECIMAL POINT.