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ABSTRACT

The Apollo Extension System (AES) has been proposed to carry out extended lunar surface missions and earth orbital missions during the 1968-1971 time period. This document is Part I of an eight part interim report and contains the Flight Mission Assignment Plan (FMAP) based on the present systems constraints and objectives. Supporting material for the FMAP is summarized here and is discussed in more detail in the separate parts of the interim report.

A discussion of the ground rules and guidelines is given to illustrate the constraints on the AES. Of these, the privision of modified spacecraft early in the AES program seems most critical. A summary of estimated hardware capability follows. Payload estimates for propulsion systems are given. It is suggested that a single modified Apollo CSM, suitable for about 45-day operation, may be adequate for all AES missions. LEM derivatives useful to extend volume and maneuverability in earth orbit and to extend the stay time on the moon are discussed. With the AES constraints assumed in this report, it appears that the payload available for experiments varies from about 2,000 lbs. for a S-IB to 83,000 lbs. for a Sa-V in earth orbit, and is about 3,000 lbs. for extended lunar surface missions.

Comments on the objectives and rationale of the proposed AES lunar program and earth orbital program are summarized. It appears that the AES can accomplish significant objectives in exploring the moon and near-earth space; however, the AES is an interim program in that much more will be left to be done by follow-on programs.

Finally, a Flight Mission Assignment Plan is given which appears to meet the present AES constraints. It should be apparent

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that the FMAP is based on many assumptions, some of which will undoubtedly be changed, and upon many estimates of performance and weight which will be better defined in the future. Therefore, this report must be considered solely as an interim assessment of the problem.

The complete report is divided into separate parts as follows:

INTERIM REPORT FOR AES FLIGHT MISSION ASSIGNMENT PLAN - January 29, 1965.

- Part I - Summary (U)(~~CONFIDENTIAL~~)
- Part II - Propulsion and Trajectory Capabilities
- Part III - Extended CSM Spacecraft (U)(~~CONFIDENTIAL~~)
- Part IV - LEM Derivatives (U)(~~CONFIDENTIAL~~)
- Part V - Lunar Mission Objectives and Rationale
- Part VI - Earth Orbital Mission Objectives and Rationale
- Part VII - Scheduling Constraints and Alternative Schedules (U)(~~CONFIDENTIAL~~)
- Part VIII - Launch Facilities and Equipment (U)(~~CONFIDENTIAL~~)

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TABLE OF CONTENTS

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TABLE OF CONTENTS

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Ref. No. 65-2012

SUBJECT: Interim Report for AES Flight Mission Assignment Plan - Part I: Summary (U) Case 218

DATE: January 29, 1965

FROM: T. L. Powers

TM - 65-1011-7

TECHNICAL MEMORANDUM

1.0 INTRODUCTION

The United States has set itself a goal of landing a man on the moon and returning him safely to earth during this decade. In accomplishing this goal through the Apollo Program, the resources and talents of the technical community will have developed a highly complex, expensive system of vehicles, spacecraft and facilities. An extension of the man-in-space program, exploring the earth space environment and detailing knowledge of the moon, is now a logical step. In the words of the President: "We expect to explore the moon, not just visit it or photograph it. We plan to explore and chart planets as well. We shall expand our earth laboratories into space laboratories and extend our national strength into the space dimension."*

The Apollo Extension System (AES) has been proposed to exploit the space capability of the United States in the years immediately following the first lunar landings. The specific objectives of the AES were stated to be**:

"...to provide a flexible capability for long-duration manned space flights, both in earth orbit and for lunar exploration beyond the scope of the Apollo manned lunar landing effort.

"...to demonstrate capabilities:

a. To conduct biomedical, scientific, operational and technological experiments in near earth space:

(1) to extend man's capabilities to operate effectively as an astronaut and as a scientist;

(2) to provide data and operational experience for later and more extensive earth orbital operations; and

(3) to qualify systems and crews for subsequent lunar missions.

* Report to the Congress from the President of the United States, United States Aeronautics and Space Activities 1964, January 27,1965.

** A proposal for the Development of Apollo Extension Systems (AES), OMSF November 1964 (U) (CONFIDENTIAL)

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b. To acquire scientific lunar data from a manned orbiting spacecraft using specialized cameras, non-photographic sensors and orbit-to-surface probes.

c. To conduct extensive geological and geophysical surveys of selected areas on the moon to provide a phased expansion of the data obtained from Ranger, Surveyor, Orbiter and earlier Apollo missions."

Studies are now under way to examine these objectives and determine how they can best be met.

The purpose of this interim report is to present a preliminary AES Flight Mission Assignment Plan (FMAP) which satisfies the present constraints. It should be clearly understood that the interim plan presented here is merely illustrative; further discussion of the AES objectives and constraints must be carried out before a more definitive FMAP can be presented.

This report, Part I of a series, contains the interim FMAP and a summary of factors which influence the FMAP. The other parts of the series contain more detailed information and are available separately. The series is listed below.

<u>Interim Report for AES Flight Mission Assignment Plan</u>

Part I Summary

II Propulsion and Trajectory Capabilities

III Extended CSM Spacecraft

IV LEM Derivatives

V Lunar Mission Objectives and Rationale

VI Earth Orbital Mission Objectives and Rationale

VII Scheduling Constraints and Alternative Schedules

VIII Launch Facilities and Equipment

Roman numeral references refer to other parts of this report.

2.0 AES CONSTRAINTS

The AES Flight Mission Assignment Plan will reflect the constraints on the program. The constraints to be considered here are the ground rules and guidelines, the mission types of interest, the hardware capabilities, and the launch support requirements.

2.1 AES GROUND RULES

A set of fundamental specifications for the AES has been proposed to be called "ground rules" because of their basic nature and broad scope.* These ground rules have not been critically reviewed but have been used for this study in order to show their effect on the AES program. The ones pertinent to a discussion of the FMAP are listed below.

2.1.1 The primary manned space flight objective is the Apollo mission.

2.1.1.1 There shall be no interference to Apollo from the AES.

2.1.1.2 Unmodified spacecraft (S/C) shall be available for Apollo until the first manned lunar landing has been assured.

2.1.2 There shall be maximum utilization of Apollo systems.

2.1.2.1 There shall be no uprating of propulsion systems except through normal improvement in the course of the basic program.

2.1.2.2 AES missions should use basic Apollo spacecraft suitably modified.

2.1.2.3 No major facility modifications should be required.

2.1.3 Modifications of Apollo spacecraft and integration of experiments will be accomplished at a modification facility following production of standard Apollo spacecraft systems by the Apollo prime contractors.

2.1.4 Launches shall be based on a production capability of six Sa-IB, six Sa-V, and eight S/C per year for the 1969-71 time period.

Of these ground rules, the most critical appear to be the requirements that unmodified S/C be available for Apollo until the first manned lunar landing is assured, and that only modified Apollo S/C be used for AES. The first requirement has been interpreted to mean that no S/C modifications for AES can be started until the first manned lunar landing has been accomplished. Because of this interpretation and the lead time necessary for modifications, it appears that no extensive AES missions can be flown until about one year after the first manned lunar landing, with two exceptions (VII-Ap.1).

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*AES Program Specification Ground Rules, preliminary draft, MT-1, December, 1964.

The second critical ground rule is interpreted to mean that no new S/C can be developed for AES. It now appears that the provision of an auxiliary module to be used for orbital experimentation with the CSM and for a lunar surface shelter could lead to a significant increase in the capability of the AES. This module would be of particular aid in the early period of the AES when it is assumed that no modified Apollo S/C are available.

It should also be noted that the production capability of six Sa-IB, six Sa-V, and eight S/C per year implies that at least four unmanned launches be made each year. Tentative assignments have been assumed for four unmanned Sa-IB/Centaur vehicles for Voyager Mars windows. However, these and other unmanned missions will not be discussed in this report.

2.2 GUIDE LINES

Several other guide lines have been used in developing the AES FMAP. These are considered to be not as firm as the ground rules stated before. Again, the guidelines have not been specifically reviewed but have been used to illustrate their effect on the AES program. In some cases it may be desirable to depart from them. These guidelines are listed next.

2.2.1 All Saturn V launches should be manned.

2.2.2 There should be two extended lunar surface missions per year starting about one year after the first manned lunar landing.

2.2.3 There should be two Saturn V earth orbital missions per year, in a combination of synchronous and polar orbits.

The first guideline means that at least four Sa-V and four S/C per year would be devoted to the lunar program since an extended mission now requires a dual launch. The remaining Sa-V can best be used in earth orbit by placing payloads into either synchronous or polar orbits, either of which require the Sa-V capability.

In addition to these guide lines, some more or less obvious sequencing guidelines have been assumed (VII):

2.2.4 There should be a gradual evolution of mission capability by qualifying difficult missions on earlier flights if possible, although no flights have been uniquely assigned for qualification.

2.2.5 Missions should be scheduled so that time is available to use data from one flight to optimize the next flight in a mission class.

2.3 MISSION TYPES

The mission types listed below have been assumed for the AES. Specific data are presented here for convenience. The derivation of the data is discussed in other sections of this paper and in other parts of this report.

2.3.1 Earth Orbital

Inclinations: 0° to 90°

Altitude: About 200 n mi or synchronous

Duration: up to 45 days

Objectives: Experiments concerning biomedical/behavioral aspects of man, observations of zero-g effects, earth oriented applications, astronomy, space operations and technology, and advanced subsystems development.

Hardware: Modified CSM and LEM (LEM-Lab)
Saturn IB or Saturn V

2.3.2 Lunar Orbital

Inclinations: 0° to 90°

Altitude: 80 n mi or lower

Duration: up to 28 days plus transit time

Objectives: Multispectral mapping and survey of the moon

Hardware: Modified CSM and LEM (LEM-Lab)
LEM descent stage for extra propulsion
Saturn V

2.3.3 Lunar Surface

Locations: Apollo region of interest

Duration: Up to 14 days

Objectives: Extended exploration of lunar surface

Hardware: Modified CSM and LEMs (LEM-Taxi, LEM-Shelter)
LEM descent stage
Saturn V.

2.4 LAUNCH VEHICLE AND SPACECRAFT CAPABILITIES

Launch vehicle and S/C hardware used for AES is planned to be derived from basic Apollo hardware in accordance with 2.1.2.

2.4.1 Propulsion and Trajectory Capability

The propulsion and trajectory capabilities of the SM, and the Sa-IB and Sa-V launch vehicles are discussed in Part II of this report. In that discussion the following estimates are especially significant:

2.4.1.1 Ortital altitudes for earth orbital missions must be about 200 n mi for AES satellite lifetime of at least 45 days.

2.4.1.2 The Sa-IB has the capability to insert about 31,100 lbs. of payload (not including the LEM adapter) into 200 n mi low inclination orbit with two burns of the SM. This capability sets the lower limit for AES missions, and is felt to be a conservative estimate.

2.4.1.3 The structural properties of the S-IVB stage limit the payload capability of the Sa-V in low inclination earth orbit to the stack limit of 110,000 lbs. A two-stage Sa-V without the S-IVB could conceivably insert 240,000 lbs. into low inclination earth orbit; however, the use of this configuration would require the development of an adapter for the payload.

2.4.1.4 The capability of the Sa-V in synchronous earth orbit is about 63,000 lbs. at 28° and 55,000 lbs. at 0° inclination.

2.4.1.5 The capability of the Sa-V in polar earth orbit depends critically on the launch profile. A minimum weight of 40,000 lbs. seems possible and weights up to the 110,000 lb. stack limit may be possible by modifying present range safety limits and/or maneuvering constraints during launch.

2.4.2 Extended CSM (XCSM)

The AES as presently conceived requires the modification of the Apollo CSM II to provide for extended duration missions. The modifications, primarily in the SM, are most extensive in the electrical power system (EPS) where the addition of two or three fuel cells and associated cryogenics may be necessary. Also, a preliminary study by NAA of a long duration lunar mapping mission indicates a need to supply a great deal more reactants for attitude stabilization. All the necessary modifications appear to be extensions of present systems with no major new development required. These modifications are discussed in Part III of this report.

The extended CSM discussed in this interim report is conceived to be a general purpose module capable of use for any AES mission. It is therefore sized by the longest and/or most difficult mission to be accomplished. Such a module leads directly to the flexibility desired in the AES without incurring excessive penalties for any particular mission. In addition, the provision of only one modified version of the Apollo CSM should simplify the management of the program.

A preliminary estimate of the changes to the CSM II necessary for AES indicate a total weight increase of about 6000 lbs., as shown in the following table. This increase in weight would result in a module capable of supporting a 3-man crew up to about 45 days in earth orbit or for a 35-day lunar mapping mission. Significant weight capability of the propulsion systems remains for inclusion of experiments.

EXTENDED CSM FOR AES

APOLLO CSM modified for extended duration missions

Basic Apollo CSM II			
CM			11,000 lbs
SM			10,000
SPS Propellant			40,000
Duration			
Assumed lifetime of 12 days			
Provision for 38 man days			
Extended CSM (XCSM)			
Weight required beyond Apollo CSM II			5,890
Environmental Control System		660	
LiOH	300		
Oxygen	360		
Electrical Power System		2530	
Two fuel cells	500		
Reactants	1540		
Tankage	490		
Miscellaneous		500	
		3690	
Reaction Control for Mapping*		2200	
Reactants	1600		
Tankage	600		

*Critically dependent on mission profile.

The 2200 lbs needed for reaction control for mapping depends on the specific profile of the mapping mission. It is felt that adequate mapping could be done with less weight. An arbitrary assumption has been made that 1100 lbs would be sufficient. Using these estimated numbers, a standard 45 day AES XCSM would weigh:

Basic CSM	21,000
Modifications	4,790
SM Fuel for retro	1,000
	26,790

2.4.3 Lem Derivatives

The proposed AES requires the provision of additional pressurized volume for orbital experiments and of spacecraft capable of extended operations on the lunar surface. At this time it has been suggested that the Apollo LEM be modified for these missions. Details of the modifications are discussed in Part IV of this report.

2.4.3.1 LEM-Lab

The LEM-Lab is conceived to be a LEM ascent stage modified for use as a laboratory for orbital experiments. The lab would be completely dependent on the CSM to support the crew. A summary of the types of modifications and pertinent weights now estimated is given below and a discussion follows:

LEM-Lab for AES

LEM Ascent Stage Modified to Provide Volume for Orbital Experiments.

Basic Apollo LEM Ascent Stage		10,000	lbs.
Structure	1000		
Fuel	5200		
Expendables	800		
Other Systems	3000		
Duration			
Idle time - 10 days			
Active time (2 men) - 2 days			
Minimum Modification LEM-Lab		4,000	180 ft^3
Offload fuel and expendables	6000		
Maximum Modification LEM-Lab*		1,200	240
Structure plus minimum wiring, lighting (Does not include adapter mounting)			
LEM-Shelter Used as LEM-Lab		4,500	180
Designed for lunar surface use			

*Used for AES planning

LEM-Lab for AES (Continued)

LEM Ascent Stage Modified to Provide Volume for Orbital Experiments

LEM Descent Stage Used for Extra Propulsion

Dry weight	4000
Propellant	16000

Ground rule 2.1.3 means that spacecraft would be modified after production as standard Apollo spacecraft. Therefore a minimum modification would be merely to offload the tanks. Such a Lab would weigh about 4000 lbs., have a volume of about 180 ft^3, and could be useful during the early AES period if provided with easy integration of an experimental package.

A maximum modification in the sense of the ground rule would be to strip completely the LEM ascent stage, providing only the basic structure and minimum wiring, lighting, etc. Actually, during the later stages of the AES it might be preferable simply to pull such a structure off the production line before it is cluttered up with Apollo subsystems. In this case, the "modifications" would be minimal. This modification provides the maximum laboratory volume (about 240 ft^3) with a minimum weight of about 1200 lbs. In future discussion, this shall be identified as the LEM-Lab. This lab, added to the XCSM, results in a basic AES spacecraft weighing about 28,000 lbs. suitable for orbital use up to about 45 days.

An additional concept is to use the LEM-Shelter, which is discussed in the next section, as a lab in order to minimize the number of LEM derivatives. The Shelter is heavy but could provide for about 14 days of life support for the crew. In this case a less extensive modification of the CSM might be required for long duration missions; or, extended times could be spent separated from the CSM. These concepts are indicative of the types of flexible use possible with the basic Apollo modules. Further study is necessary to determine the full range of capability.

Finally, for missions which require extra propulsion, the LEM descent stage can be used. This unit has a throttleable engine and fuel capacity capable of providing significant maneuvering for a separated LEM or for the entire AES spacecraft. It is likely that this capability would be necessary to provide an extra margin for abort during an extended lunar orbital mission.

2.4.3.2 LEM-Shelter

An objective of the AES is to extend the duration and capability of lunar surface missions. At this time it has been proposed that this extension be done through the use of two Sa-V launches to the moon, one carrying a Shelter with life support and experimental equipment, and one bringing a crew. The second mission will be discussed in the next section. The Shelter now under study is a modification of the Apollo LEM.

The LEM-Shelter is intended to be delivered into lunar orbit as in a normal Apollo mission, then to be landed unmanned on the lunar surface. The Shelter must remain in a stored condition until the crew arrives a few weeks or months later. At this time the crew is intended to transfer to the Shelter for periods up to about 14 days. The Shelter also would contain equipment necessary for the lunar operations. A summary is given below of the modifications which now appear necessary to convert an Apollo LEM into a Shelter.

LEM-SHELTER FOR AES

Modified LEM for unmanned delivery from lunar orbit and 14-day support of two men delivered by LEM-Taxi.

LEM Descent Stage is Unmodified.

LEM Ascent Stage is Modified for:

Unmanned landing
Pre-usage storage
Support of two men for 14 days
Delivery of experimental equipment

Modifications

REMOVE		7000
Ascent propulsion	5700	
Other items	1300	
ADD		3800
Structure	700	
Crew provisions	150	
ECS and EPS*	2150	
Pre-usage storage*	800	
PAYLOAD FOR EXPERIMENTS		3200

*Assume closed cycle system and redesign of hydrogen tanks

Removal of the ascent propulsion provides for a significant amount of weight for modifications and experiments. At this time, the provision for unmanned landing is under study by MIT and does not appear to be extremely difficult if the lunar surface is suitable for an Apollo landing.

The provision of expendables for the crew for a period of about 14 days does not appear to be a major problem if the environmental control system of the LEM is modified to make use of water generated by the fuel cells in the electrical power system. Such a closed cycle system is used in the CSM. The numbers in the preceding table assume that this modification will be made. There are two problems yet to be resolved. One concerns storage of hydrogen for EPS and ECS. If a closed cycle EPS-ECS system is installed, a pre-usage storage time of 3-6 months could be provided for about 800 lbs penalty if the hydrogen tanks were also redesigned. If no tank redesign is done, a storage time of about 45 days appears to be possible within an 800 lb penalty by adding one additional hydrogen tank of the present design and more insulation.

The second problem is that of radiation shielding for the crew. If no additional shielding is provided, there is about a 28% chance of an abort being required due to radiation during a 14 day surface stay time. Means of reducing this probability must be investigated. It is possible that additional weight would be necessary for this purpose. Therefore, preliminary estimates of modifications and weights indicate that about 3000 lbs. will be available for lunar surface experiments. This is more than an order of magnitude increase in experimental weight over that available with Apollo.

It is possible that minor modifications could be incorporated into the Apollo LEM to increase the surface stay time moderately, e.g., 3 or 4 days. However, no substantial increase in time or in experimental weight can be achieved without uprating the LEM descent propulsion. The capability of this propulsion system fixes the amount of weight which can be delivered to the surface irrespective of other improvements in the launch vehicle or CSM performance.

It is also worth noting that the development of techniques for unmanned landing and pre-usage storage for the Shelter could lead to even greater lunar surface payloads with the LEM-Truck, which is simply an automated LEM descent stage. The major problems in design of the LEM-Truck must be solved for a Shelter modification. However, provision of the LEM-Truck should be accompanied with design of payloads which make optimum use of its capability, and therefore are slightly beyond present AES planning.

2.4.3.3 LEM-Taxi

The LEM-Taxi has been proposed to deliver the crew to the LEM-Shelter for extended lunar surface missions. The Taxi must wait in a quiescent mode until the crew is ready to return and then transport them into orbit for rendezvous with the XCSM. The modifications to the LEM now thought to be necessary are summarized in the following table.

LEM-TAXI FOR AES

Modified LEM for delivery of two men near LEM-Shelter on Lunar surface, quiescent storage for 14 days, and return of crew to XCSM.

Modifications

REMOVE		260 lbs.
Scientific equipment,TV		
ADD		300
Expendables	25	
Meteoroid shielding and insulation	70	
Water	205	

Assumes two fuel cells can be shut down and restarted, one idles.

If all fuel cells must idle, then require additional reactants, cooling water, tankage estimated at 400 to 1000 lbs.

These numbers are based on the assumption that two of the fuel cells in the LEM-Taxi can be shut down and restarted when needed. Preliminary study indicates that this should not be a problem if the Apollo requirements for fuel cells are successfully met.

From a philosophical point of view, the LEM-Taxi mission may be the one which could be most improved by some upgrading of the LEM descent propulsion system. The LEM-Taxi must do everything the Apollo LEM does plus remain on the surface for 14 days. The only weight tradeoff now contemplated involves removal of experimental equipment. This does not yield a large weight reserve and also makes the usefulness of the mission completely dependent on the LEM-Shelter. However, it also may be likely that experience with the Apollo LEM will reveal areas in which weight can be reallocated while maintaining adequate mission safety probabilities. An example of this is the weight required for hover fuel in the Apollo LEM.

A fundamental problem remains in determining the area of the lunar surface which is accessible for extended missions. A discussion of this problem is contained in Part II of this report. It seems that AES planning should be based on missions in the nominal Apollo landing zone until more information is available.

2.4.4 Summary of Weights

The following table summarizes the launch vehicle performance and spacecraft weights being used for AES planning. It should be understood that these numbers depend on many assumptions concerning operations and mission profiles and may therefore change as more definitive information becomes available. The experimental payload weights are felt to be conservative. Larger experimental payloads could be obtained for shorter duration missions or for missions with no mapping.

SUMMARY OF WEIGHTS

Mission	Launch Vehicle Performance	Spacecraft	Experimental Payload
EARTH ORBIT			
Saturn IB			
Low Inclination	31,100	28,000	3,100
Saturn V			
Low Inclination	110,000	28,000	78,500
Synchronous	55,000	43,000*	8,500
Polar	40,000 min	28,000	8,500 min
LUNAR MISSIONS			
Saturn V			
Orbital	95,000	87,000	8,000
Surface	95,000	95,000	-
Shelter			3,200
Taxi			zero

Spacecraft includes XCSM and LEM-Lab with provisions for 45 days for orbital missions. Lunar orbital mission includes fully fueled SM and LEM descent stage for extra propulsion.

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*Includes 16,000 lbs. SM propellant for retro.

2.5 LAUNCH FACILITIES AND EQUIPMENT

Launch operations and facilities for the AES are discussed in Part VIII of this report. It is planned that no extensive modifications to the Apollo facilities will be required for the AES except possibly for more checkout crews to support the suggested launch rate. Also provisions must be made for checkout of the AES experiments. An exception to the modification conclusion is that pads 34 and 37B must both be reconfigured for S-IB/Centaur if closely spaced (∿ 1/month) launches of these unmanned vehicles are desired.

The estimated limits on successive launches are summarized below:

For Saturn-IB or Saturn-IB/Centaur:

3 month pad turn-around time for Sa-IB
1 additional month to reconfigure from Sa-IB to Sa-IB/Centaur or vice versa.

For Saturn V:

4 month pad turn-around time nominal
2 month pad turn-around time for short intervals

These constraints have been used as guides in scheduling AES missions in the Flight Missions Assignment Plan.

2.6 OTHER SYSTEMS CONSTRAINTS

There are many other constraints which must be eventually determined for AES planning. Cursory looks have been taken into several areas, but time has not allowed a thorough examination. Some areas which must be examined are:

1. Mission control -- the possibility of controling multiple missions must be determined.

2. Communications -- the need for additional communications capability must be determined.

3. Recovery procedures -- recovery of S/C at the rate of 8 a year must be studied.

4. Abort procedures -- the problem of abort procedures may have significant implications for AES missions.

3.0 AES MISSIONS

Missions for the AES have been discussed in two general categories:

Lunar: Part V of this report

Earth Orbital: Part VI of this report

In the respective parts the objectives and rationale for lunar and earth orbital missions are discussed in more detail. Some of the more pertinent conclusions are summarized here and the proposed sequence of flights for these programs is illustrated.

3.1 LUNAR PROGRAM

One of the objectives of the AES is to explore the moon in order to illuminate scientific questions concerning its origin, evolution, and inherent properties as well as to investigate its relationship to other bodies in the solar system. In addition, a gradual buildup of technology is sought to provide for orderly extension of space exploration activities during follow-on programs, if such programs are shown to be desirable.

To obtain a significant scientific return from the lunar program, it appears to be desirable to carry out large area surveys from lunar orbit as well as extended lunar surface missions.

3.1.1 Lunar Orbital Missions

The objective of lunar orbital missions is to survey large areas of the moon which are inaccessible to surface missions (either manned or unmanned), which are potential sites for extended surface missions, or which offer interesting possibilities for surface checks but don't appear worthy of a manned surface mission. Obviously any such large area coverage would serve to extrapolate knowledge from surface missions to other similar areas. The desired information could be obtained through the use of remote sensors (cameras, radar, etc.) and orbit-to-surface probes, such as Surveyor derivatives. An example of a typical orbital survey payload is given in the following table.

LUNAR ORBITAL SURVEY PAYLOADS ∿8,000 lbs.

Remote Sensors ∿2,000 lbs., 2 kw, 80 ft^3

Photography - geology
Multispectral photography - geology, composition
Radar - geology
UV - Mineralogy
IR - Mineralogy, geology, thermal structure
γ-Ray - elemental composition
X-Ray - elemental composition
Gravity - geology, selenodesy
Passive Microwave - thermal structure
VHF Reflectivity - surface electrical properties

Probes 2-6 Surveyor derivaties, ∿200-300 lbs. payload

Surface Composition - x-ray, neutron activation, TV, etc.
Lunar Environment - seismology, particles and fields,etc.

It would be desirable to alternate orbital missions and lunar surface missions in order to correlate both types of data to enable proper planning of each succeeding mission. The orbital missions are planned to increase in difficulty during the course of the program by progressing from moderate duration missions with moderate orbital inclinations (thereby simplifying the abort problem) to long duration, polar orbital missions. A summary of the characteristics of orbital mission classes is given below.

LUNAR ORBITAL SURVEY MISSION CLASSES

Class I. Equatorial (0° inclination)

- Pass over each equatorial point every two hours
- See each equatorial point at all lunar phases in 1.1° intervals

Class II. Inclined (>0°, <90°)

- Pass over band of moon bounded in north and south latitude by orbital inclination
- Pass over each area in band twice in 28 days, with 0 to 14 day separation
- Consecutive orbital path separation variable from $\gtrsim 0$ to $\lesssim 33$ km.

Class III. Polar (90° inclination)

- Pass over lunar poles every two hours
- Pass over entire moon twice in 28 days with 14-day separation
- Consecutive orbital path separation varies from 33 km at equator to 0 at poles
- See entire moon at 2 phase angles ($\pm 14°$)

As presently conceived, the orbital program requires the allocation of a group of unique flights with experiments mounted in a Laboratory module. It should be pointed out that a significant amount of time in orbit occurs during other AES and Apollo missions. Therefore, some of the objectives of the orbital program could be achieved during these missions if the sensors could be easily integrated with the spacecraft. However, it is unlikely that polar orbital or probe delivery missions could be carried out in conjunction with other missions.

3.1.2 Lunar Surface Missions

The lunar surface missions proposed for the AES are intended to provide a significant increase in scientific return from the moon by:

(1) Increasing the surface stay time

(2) Increasing the scientific instrumentation

(3) Increasing astronaut mobility.

Through the use of the LEM-Shelter and the LEM-Taxi, astronauts would be able to work on the moon for about two weeks compared with one day for Apollo. Their work should also be more efficient through proper design of the shelter and experimental equipment, and it should cover a larger area through the provision of a mobility aid such as a small roving vehicle. During an AES lunar surface mission, the crew would be able to conduct geological and geophysical experiments, survey an immediate area, sample the lunar material with a core drill, and set up an unmanned emplaced scientific station which will remain to operate for long periods of time. An example of a weight allocation for a typical mission is shown below:

SAMPLE 14-DAY LUNAR SURFACE MISSION

3,200 lb.	Scientific Payload Available in LEM-Shelter
1,500 lb.	vehicle, 300 km range, 10 km radius of operation
400 lb.	emplaced scientific station
300 lb.	drilling equipment
300 lb.	geophysical and geological equipment

The LEM-Shelter serves both as living quarters for the crew and also as a laboratory where preliminary sample analyses, preparation and packing can be done. The instruments in the laboratory could possibly be derived from advanced Surveyor experiments. Several hours per day could be spent monitoring data gathered by the emplaced scientific station. This station would require one or two days to set up and would then operate unattended for perhaps a year. An example of possible experiments for the emplaced scientific station is:

Gravimeters	Radiation Detectors
Seismometers	Solid Particle Detectors
Mass Spectrometer	Television
Magnetometer	Bore-Hole Probes

An experiment of major importance is the lunar drill. Recent data indicate the possibility of the moon's being covered with a rather uniform layer of "gardened" material. If this is the case, it will be necessary to drill under it to observe the basic structural material. In any case, core drilling, analysis of the sample, and logging of the drill hole will provide extremely interesting information.

The roving vehicle envisaged for the extended lunar mission should be able to carry an astronaut in his space suit throughout an immediate area of approximately six miles in radius and also carry some scientific equipment. The range of the rover is limited by weight and also by safety considerations in that it seems reasonable to restrict the range to the distance which a man can walk in a space suit with his backpack. If the moon is homogeneous over large areas, e.g., is "gardened", the rover may not greatly increase the amount of scientific return.

At the present time it appears that a great deal of time can be spent by the astronauts in carrying out extensive geological and geophysical surveys over relatively small areas. The information can then be extrapolated to larger areas through the use of orbital reconnaissance.

3.1.3 Preliminary Flight Allocations

A preliminary list of flight allocations for the lunar program is given below, with some remarks. The orbital and surface missions alternate. Specific sequence data are discussed later in section 4.7. Note that only three orbital missions and only three surface missions have been assigned. It is likely that this will be insufficient to meet the objectives of lunar exploration. If this were the case, the lunar program could be expanded by allocating more missions. However, an alternative means would be to increase the capability of successive surface missions through propulsion uprating and/or the inclusion of LEM-Truck payloads. Orbital survey missions could be improved in duration and in type and number of probes available.

PRELIMINARY AES LUNAR PROGRAM

Flight	Spacecraft	Remarks
511	XCSM & LEM-Lab & LDS	Lunar orbital survey, system qual.
514	CSM & LEM-Shelter	Shelter delivery for 1st extended mission
515	XCSM & LEM-Taxi	Surface rendezvous with 514
517	XCSM & LEM-Lab & LDS	Extended area orbital survey, probes
519	CSM & LEM-Shelter	2nd extended LS mission with 520
520	XCSM & LEM-Taxi	Surface rendezvous with 519
522	XCSM & LEM-Lab & LDS	Synoptic orbital coverage, probes
524	CSM & LEM-Shelter	3rd extended LS mission with 525
525	XCSM & LEM-Taxi	Surface rendezvous with 524

3.2 EARTH ORBITAL PROGRAM

An objective of the AES is to carry out missions in earth orbit to:

(1) Evaluate and extend man's capabilities to operate in space effectively as an astronaut and as a scientist .

(2) Conduct observations of earth, extra-terrestrial phenomena, and experiments dependent on the space environment.

(3) Qualify systems and crews for subsequent long-duration space missions.

Progress toward these objectives will yield both scientific and practical benefits as well as prepare in an orderly manner for more ambitious future missions.

The earth orbital program is intended to capitalize on the unique abilities of a trained observer to evaluate and investigate as well as to select and manipulate experimental equipment. This flexibility would be utilized by providing a variety of experimental equipment on each flight. Man's discrimination ability is particularly important in selecting the most useful data to record and return.

As an organizational step to translate the general earth orbital objectives to the Flight Mission Assignment Plan, four mission classes have been defined:

(1) Earth oriented applications

(2) Astronomy

(3) Biomedical/behavioral

(4) Space operations/technology

Each class will be briefly discussed in the following sections and the assignment of flights in the preliminary AES FMAP will be given. It should be noted that, because of the flexibility of experiments, many types of observations may be carried out on each flight. However, each flight has been assigned to a mission class to indicate the first priority observations for that flight. Another way of indicating the major purpose of a flight is to associate with it a skilled crew member, such as a medical crewman for biomedical/behavioral flights, etc. A matrix will be shown in section 3.2.5 to indicate the combinations of observations on various flights.

It should also be noted that there are other types of missions which have not been included, such as communications. As the AES studies progress, other missions may be added and/or other mission classes created. Therefore, this listing is not meant to be totally inclusive but is representative of earth orbital missions suitable for AES.

3.2.1 Earth Oriented Applications Missions

With the capability of the AES program, man could observe a great variety of features both on and above the earth's surface. Missions of this class should yield data concerning these features which will be of important scientific interest and may be of vast practical interest as well. The catalog of suggested areas of investigation is expanding almost daily. A few of the more important disciplines involved are meteorology, oceanography, geology, geography, hydrology, agriculture, forestry, and upper atmospheric physics. In many cases a common experimental package will serve a variety of disciplines.

Of the various disciplinary areas, that of meteorology can be used as an example of the type of AES mission envisaged. The experimental payload might involve the use of instruments to measure the external factors which affect the weather, such as solar radiation, and to describe the weather that results in terms of its nature and extent. Remote sensor measurements might be supplemented by the delivery of probes from orbit or from the earth to establish the "atmospheric truth" sampled by the sensors. These measurements could then be correlated with ground-based data such as barometric pressure, temperature, wind velocity, etc., which are impractical to measure from orbit. The goal of the meteorology missions would be to understand the weather system sufficiently well to predict the weather, lead to the design of an economical operational weather satellite system (manned or unmanned), and perhaps progress toward eventual control of the weather. Satisfaction of any of these goals would result in tremendous practical benefits for mankind.

Missions of this class could be most useful through the provision of a trained observer with a flexible complement of instruments. There is an enormous amount of data which could be recorded; only a small percentage will be of critical importance. The discirimination of a man can be used to determine what to look at, how to observe it, and of what importance the results are. Such a "data filter" can make optimum use of the weight available to return data to earth, and can avoid the pile-up of relatively uninteresting data on earth. In the course of making such decisions the observer would define those measurements which are of most value and therefore affect the payloads of future missions.

The flights listed next have been tentatively assigned to the Earth Oriented Applications class.

AES PRELIMARY EARTH ORIENTED APPLICATIONS CLASS

Flt.	Orbit nm/incl.	Duration Days	Spacecraft	Exp'l Wt.,Lbs.	Remarks
507	S or P	10-14	Unmod.CSM&LEM AS	10,500	Alternate to Apollo
215	200/low	10-14	Unmod.CSM&LEM AS	5,100	c/o of remote sensors
221	200/low	30-45	XCSM&LEM-Lab	3,100	Meteorology, oceanography, agriculture
518	200/P	30-45	XCSM&LEM-Lab	8,500	Meteorology, geophysical
521	Synch	30-45	XCSM&LEM-Lab	8,500	Meteorology, oceanography

3.2.2 Astronomy Missions

Astronomy is the major part of a class of missions intended for investigation of extra-terrestrial phenomena. Such studies contribute to our scientific knowledge and may have practical applications in fields such as celestial navigation and deep space communications. The goal of the astronomy program would be to record appropriate position, image, and spectral information for both optical and radio sources. The fact that the instruments would be above most of the earth's atmosphere extends the range of measurements and improves their accuracy.

The payload for the astronomy missions would be composed of an optical telescope with suitable filters, cameras, etc., to operate in both an imaging and spectrophotometric mode; a radio telescope to measure radio wave flux and spectral properties at wavelengths of 1 cm or less; a low frequency antenna for measurements at wavelengths of 30 m or greater; and a space radiation telescope to measure cosmic ray and gamma ray flux and energy spectra. A trained observer should accompany the mission to make maximum use of the equipment.

So far as the actual time of the mission is concerned, there are many events in the 1969-1970 time period which will be of interest. Examples are: the sun, at the peak of the current sunspot cycle; the solar corona, during the total eclipse of March 7, 1970; and the planets, such as Mars and Venus, during inferior conjunction.

A list follows which exhibits the flights tentatively assigned to the astronomy class.

AES PRELIMINARY ASTRONOMY CLASS

Flt.	Orbit nm/incl.	Duration Days	Spacecraft	Exp'l. Wt.,Lbs.	Remarks
516	Synch	30-45	XCSM&LEM-Lab	8,500	Telescope qual., observations
523	200/low	30	XCSM&LEM-Lab	78,500*	Telescope up, observations
229	200/low	30	XCSM&LEM-Lab	3,100	Rendezvous with 523, cont. astronomy, begin biomed./behavioral observations
230*	200/low	30-45	XCSM&LEM-Lab	3,100	Rendezvous with 229, cont. astronomy & biomedical/behavioral observations

*Also listed under biomedical/behavioral.

3.2.3 Biomedical/Behavioral Missions

These missions continue the observations of the biomedical and behavioral responses of man in space which began in rudimentary form with the Mercury program. The AES can extend these investigations, not only in terms of time, number of observations and specimens but also by providing trained medical observers and

and possible means of therapy. The ultimate goal of these missions is the prediction of the effects on man of prolonged spaceflight and the development of techniques to counteract any adverse effects. Such investigations are a necessary step in preparing for extensive use of man in space.

Two of the major areas of interest are the effects of weightlessness on the cardiovascular and musculoskeletal systems. Short-time experience with Mercury indicated potential problems such as blood pooling in the legs, dizziness, and a loss of calcium from the system. However, such symptoms could result from several causes; therefore a well-controlled series of experiments must be carried out to determine the causes and effects.

With the capability of the AES, it should also be possible to investigate various means of therapy for undesirable space effects. Such therapy may be relatively simple, such as exercise, or might involve the creation of an artificial gravity environment. The need for either method would have extensive effects on plans for future AES missions and for extended duration missions, such as planetary missions. Therefore it is important that at least one long duration mission occur early in the program.

In addition to biomedical/behavioral experiments, it should be possible to carry out on these flights a number of fundamental experiments to observe the effect of the absence of gravitational forces on physical, chemical, and life processes. Examples of some of these experiments are as follows:

(a) Physics - measurement of extremely small physical effects on test bodies, such as light pressure and recoil reaction during radioactive decay.

(b) Physics - observation of relativistic precession of a gyroscope during spacecraft orbit.

(c) Chemistry - effect of zero gravity and reduced pressure on exothermic chemical reactions.

(d) Bioscience - investigation of healing process under zero gravity conditions.

(e) Bioscience - effect of zero gravity on plant growth.

This is a very flexible group of experiments which could be done at any time in the AES program. However, it may occur that a sufficient number and variety of interesting experiments are suggested that at least one flight should be allocated primarily as a zero-gravity laboratory. In this interim report, those experiments will be considered as part of the biomedical/behavorial class.

The following flights have been assigned to this class of missions in the preliminary AES FMAP. The durations indicated are based on estimated spacecraft capability as discussed in Part III of this report. Extended durations may be possible through different modifications of the Apollo systems or through use of a new module of some type. In either case, the use of rendezvous missions, as indicated below, may still be desirable to provide for appreciable time in orbit.

AES PRELIMINARY BIOMEDICAL/BEHAVIORAL CLASS

Flt.	Orbit nm/incl.	Duration Days	Spacecraft	Exp'l. Wt.,Lbs.	Remarks
211	200/low	30-45	XCSM&LEM-Lab	3,100	1st long-duration mission; lunar survey qual.
218	200/low	30-45	XCSM&LEM-Lab	3,100	Biomedical/behavioral, zero-g lab.
219	200/low	30-45	XCSM&LEM-Lab	3,100	Rendezvous with 218, continue observations
230*	200/low	30-45	XCSM&LEM-Lab	3,100	Rendezvous with 229, Long-duration biomed/behavioral effects in conjunction with astronomy

*Also listed under astronomy

3.2.4 Space Operations/Technology Missions

The objectives of this class of missions would be, first of all, to demonstrate man's ability to perform useful tasks in space, and to take steps to improve his capabilities. Secondly, experiments on these missions would be designed to make the spacecraft and its subsystems more compatible with extended periods of flight. The development of advanced subsystems is a necessary precursor to more extensive operations in space.

Space operations include the general areas of astronaut and spacecraft maneuvering and the performance of functional tasks such as:

(a) extravehicular mobility

(b) rendezvous and inspection of satellites

(c) assembly in space of equipment such as antennae

Technological experiments are aimed toward evaluation and improvement of spacecraft subsystems and materials such as:

(a) environmental control systems

(b) fire and blast protection

(c) exposure effects on materials.

The evaluation of operational techniques would be particularly suitable for early AES missions with unmodified spacecraft because lengthy time in orbit is not required. A second reason for performing these experiments early in the program would be to evaluate maneuvers planned for later missions and provide for tests of sybsystems which may be useful for extended duration missions later in the AES program.

The following flights have been tentatively assigned to the space operations/technology class.

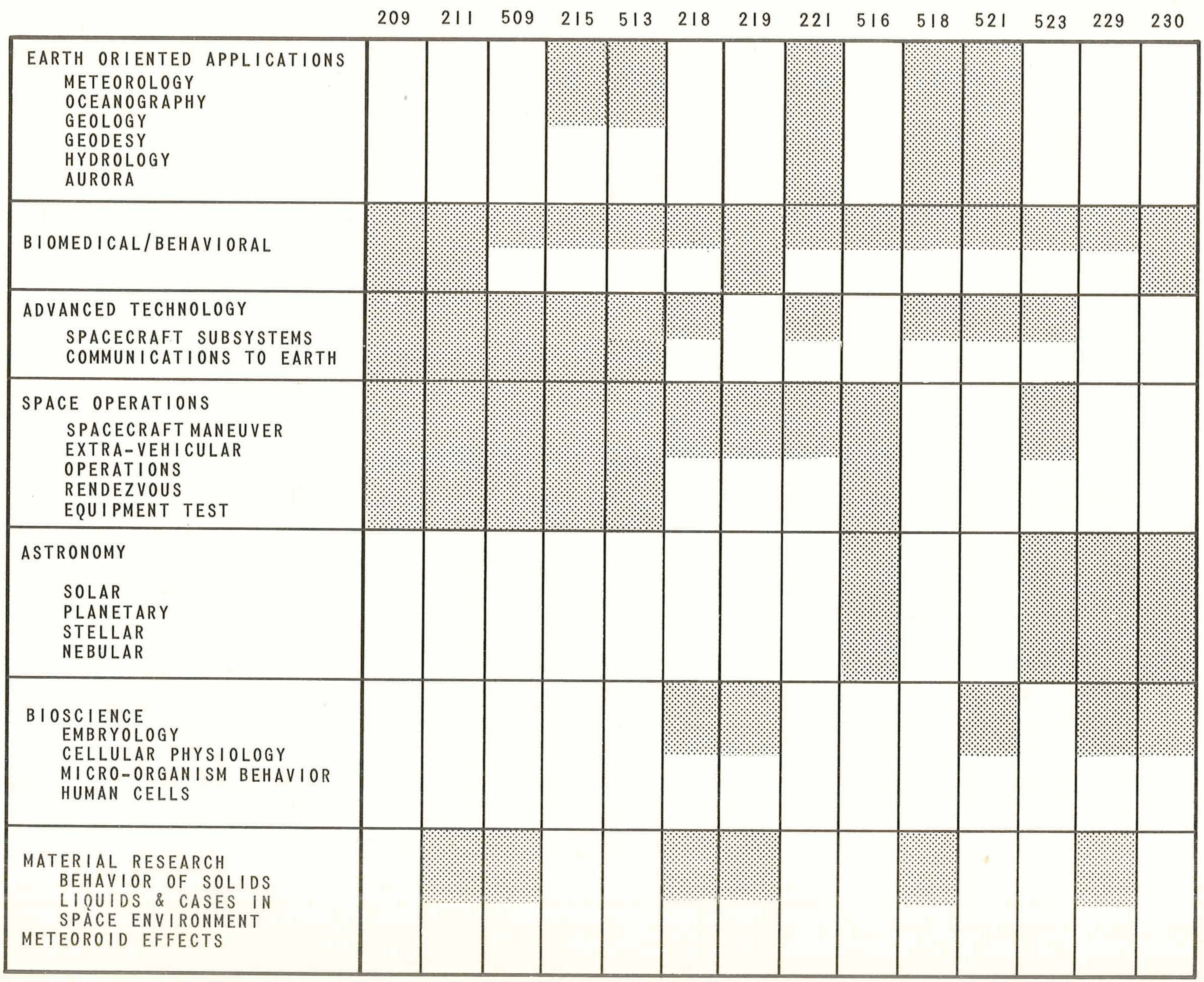
AES PRELIMINARY SPACE OPERATIONS/TECHNOLOGY CLASS

Flt.	Orbit nm/incl.	Duration Days	Spacecraft	Exp'l. Wt.,Lbs.	Remarks
209	200/low	10-14	Unmod.CSM&LEM AS	5,100	Maneuvering,extra-vehicular activity
509	Synch	10-14	Unmod.CSM&LEM AS	10,500	Maneuvering, sub-systems development
513	200/polar	10-14	Unmod.CSM&LEM AS	10,500	Maneuvering, sub-systems development

3.2.5 Activity-Flight Matrix

A characteristic of the proposed earth orbital program is flexibility -- that is, the ability to make measurements of many types on each mission. Because of this it has been difficult to assign some missions to any one class and in doing so, it may seem that some experiments have not received proper emphasis. In order to clarify this feature of the program, a matrix has been constructed which illustrates the types of measurements carried out on each mission now assigned to the earth orbital program. It is likely that many changes in specific measurements will be suggested in the future; therefore, at this time only general types of measurements are mentioned.

REPRESENTATIVE EXPERIMENT & TASK ASSIGNMENT FOR EARTH ORBITAL MISSIONS



3.3 UNMANNED PROGRAM

Unmanned missions have not been specifically considered in this report. However, for AES planning, it is necessary to make some assumptions concerning unmanned missions. The following list shows the assumptions which have been made. Note that two SA-IB/Centaurs are allocated for each Mars window. Use of these vehicles depends on planning by other NASA offices.

In addition to these missions, there are missions which are now unassigned but which must be flown unmanned because of a lack of spacecraft. These will be discussed in the FMAP section.

208*	Cislunar Pegasus
210	Voyager Mars qualification
212	Cislunar Pegasus
213	Mars window
214	Mars window
227	Mars window
228	Mars window

*May be re-assigned to manned lunar landing program.

4.0 FLIGHT MISSION ASSIGNMENT PLAN FOR AES

The objectives of the AES and the constraints used during this study have been discussed earlier in this paper. A summary of the more specific objectives of the lunar and earth orbital programs has been given along with lists of tentative mission assignments. In this section these mission assignments are integrated to form a tentative Flight Mission Assignment Plan for AES planning purposes. It should be pointed out that this FMAP has been molded by all the constraints discussed before. It is very likely that many of these constraints will change; in that case, the FMAP must be evaluated to determine its continuing suitability for AES planning. In addition, many factors have probably been overlooked or not fully appreciated. It is hoped that these factors may be brought to light in the process of examining the present AES program plans.

Fig. 1 is the FMAP in terms of Saturn launches and Fig. 2 has the form of a schedule of the sub-programs. A discussion of this schedule and some possible alternates is given in Part VII of this report. Figure 3 is a chronological listing of flights with monthly launch dates. Specific data for each flight is found in the appendix. The following comments refer primarily to Figure 2 and may serve to amplify the FMAP.

4.1 PAD ASSIGNMENTS

Pad assignments have been made in accordance with the requirements discussed in Part VIII of this report. An effort was made to minimize the number of reconfigurations of pads 34 and 37B from S-IB to S-IB/Centaur and back. At this time 11 reconfigurations are required. This could be reduced to 9 if only one unmanned S-IB/Centaur is flown at the 1969 Mars opportunity. Further definition of pad assignments must await more information on the unmanned program to be considered.

4.2 SPACECRAFT ASSIGNMENTS

Spacecraft assignments to launch vehicles have been made in accordance with the latest (unofficial) data available to us. These assignments will most likely change as a result of changes in the Apollo program.

4.3 MODIFIED SPACECRAFT AVAILABILITY

The FMAP shown here is based on the assumption that there will be one modified (103m) S/C in 1968, one (108m) in 1969, and then 8 per year in 1970 and later. If the modification ground rules as discussed in Part VIII are followed, there would be at least a four month gap somewhere in late 1969 or early 1970. For the purposes of the FMAP, the assumption has been made that some means will be found to make S/C available at the times needed. If this assumption is invalid, some missions may have to be delayed.

4.4 APOLLO PROGRAM

The Apollo program is shown in accordance with the latest schedule data available to us. This schedule has not been officially approved. Changes in assignments for 208 through 212 will probably occur.

4.5 LAUNCH DATES

The launch date for each mission is shown on the accompanying chronological list, Figure 3. These dates are meant to imply a launch sometime during that month, and not necessarily on the first day of the month. The actual day of launch would be chosen to meet launch window constraints and also to minimize interference between missions. For example, it would be desirable to fit 211 between Apollo missions and not fly two missions concurrently. It is hoped that concurrent missions can be flown later in the program; otherwise, some juggling of launch dates will be required.

4.6 ALLOCATION OF HARDWARE

Launch vehicles and S/C have been assigned to the AES lunar and earth orbital program in accordance with the guide lines duscussed earlier. In this schedule the allocation is:

	Sa-IB	Sa-V	Missions
Lunar	0	9	6
Earth orbital	8	7*	15
Unmanned	5	0	
Unassigned	9	0	

*including 507

There are many alternative assignments, some of which are discussed in Part VIII.

4.7 AES LUNAR PROGRAM

The lunar program starts with an orbital survey 511 using sensors qualified a year before on 211. The first extended surface mission is scheduled for early 1970. Then orbital and surface missions are alternated at about six month intervals. This sequencing provides for maximum use of orbital and surface data and may also allow the simultaneous operation of more than one unmanned emplaced scientific station on the lunar surface.

4.8 AES EARTH ORIENTED APPLICATIONS CLASS

Flight 507 could be used for AES on an alternate basis with Apollo. Because of its uncertain availability, the AES mission is planned to use an unmodified Apollo S/C. About 9 months later, flight 215 would qualify the earth oriented experimental system as well as carry out some preliminary measurements. This flight would also be of relatively short duration because of the lack of modified spacecraft.

A gap of about a year is provided to optimize the pay load for flight 221 which would be of long duration. During this gap some experiments of this class can be done on flights 218, 219 and 513. Flight 518 would be a polar mission to acheive a global view, and in particular, an observation of polar weather. Finally, flight 521 would be a synchronous mission to provide a synoptic look at a portion of the total atmospheric profile with sufficient time to chart rapidly changing weather systems. This flight would complete the low inclination, polar, synchronous sequence indicated to be desirable for meterological experiments. Note that this class of missions has more flights allocated to it than any other earth orbital class.

4.9 AES ASTRONOMY CLASS

The astronomy payload is expected to require extensive development so the first mission, 516, is scheduled in mid 1970. This flight would qualify the payload and could proceed to synchronous orbit in order to measure radio signals absorbed by the ionosphere at low altitudes, to provide a more stable observatory for long exposure, and to avoid the occlusion by the earth of much of the field of view.

About a year after the first flight, the second astronomy mission would be flown on 523. This mission has a large payload capability which could be used for experiments of other types, in particular, biomedical/behavioral. After about a month, a logistics and resupply mission, 229, would be flown to rendezvous with 523. Therefore, 523 must be placed in a low inclination, low altitude orbit suitable to the S-IB capability. Finally, a third rendezvous mission, 230, could be flown. This flight could extend the time in orbit of the original crew to over 100 days, which would be almost twice as long as any earlier missions. Therefore, a great deal of biomedical/behavioral measurements should be made. Note that it will be difficult to re-assign Sa-IB's to avoid overlap of this mission and the 524-525 lunar mission without conflicting with the Mars window in that year.

4.10 BIOMEDICAL/BEHAVIORAL CLASS

Flight 211 would be the first mission of this class, and is intended to use the first AES spacecraft modified for long duration missions if a S/C now thought to be a spare from the Apollo program can indeed be used. If this S/C is available, the mission could probably extend to about 30 days, thus doubling previous manned orbital lifetime. This flight would also be used to qualify the remote sensors to be used on the first lunar orbital mission, 511, one year later.

About a year and a half after 211, a rendezvous mission, 218-219, is planned to yield 60-90 days in orbit for the crew, which would be some 2-3 times as long as in flight 211. Provision of a modified S/C for 218 bends the ground rules by a few months, but is felt to be a desirable goal.

Further increase in orbital time, perhaps over 100 days, would occur with the astronomy rendezvous mission 230. Since this would represent another step in orbital lifetime, 230 is also counted as a mission of the biomedical/behavioral class.

4.11 AES SPACE OPERATIONS/TECHNOLOGY

This class of missions would begin with 209, which is an unmodified Apollo S/C. More extensive maneuvering could occur with flight 509 about a year later. Flight 513 completes the sequence and could possibly have a modified S/C if the ground rules were eased by a few months.

Some subsystems development experiments could well be carried out unmanned on flight such as 223 and 225, which are now shown to be unassigned.

4.12 UNMANNED MISSIONS

Unmanned missions have not been specifically discussed in this report. Mission assignments shown here have been assumed for AES planning but, of course, depend on plans by other NASA offices. Two Sa-IB/Centaurs have been allowed for the Mars launch window in 1969 and 1971. In addition, a Voyager qualification shot is shown in 1968. It is important that plans for these missions be determined because they affect scheduling and pad assignments for other missions during the AES time period.

4.13 UNASSIGNED MISSIONS

An effort was made to use all the Sa-V vehicles for manned flights. Sa-IB's were then assigned to the remaining S/C, and then to unmanned missions. Nine Sa-IB vehicles remain to be assigned. However, there are no S/C available for additional manned missions. There would be at least two Sa-IB vehicles available per year starting in 1969 for unmanned missions.

4.14 AVAILABILITY OF HARDWARE BY YEARS

This row on the FMAP Figs. 1 & 2 summarizes the Sa-IB, Sa-V and S/C assumed to be available for AES planning.

5.0 PROBLEM AREAS

In the development of a Flight Mission Assignment Plan for the AES many of the constraints were examined. Specific problems associated with the various hardware modules and experiments have been discussed in other sections of this paper and in other parts of this report. In this section some more basic problems will be mentioned. Unfortunately, the AES study has not progressed enough to provide ready answers to these questions among others.

Perhaps the most obvious problem area lies in the justification and integration of experiments for the AES, particularly for the earth orbital program. This problem is compounded by lack of certainty concerning the hardware capability, the extent of modification, time of availability, etc. A second factor to be considered is that only now are experimenters beginning to think seriously of worthwile objectives using Apollo hardware in earth orbit. The lunar program, on the other hand, has had the benefit of the emphasis placed on Apollo. Therefore, much more planning has gone into lunar exploration.

The interaction of the AES program with other programs must also be better defined. In the early phases, the AES is severely handicapped by the lack of modified spacecraft. The provision of "scar" weight to the Apollo system might make it possible to perform more useful AES missions without extensive modification delays. A more valuable, to the AES, contribution from the Apollo program would be spacecraft assigned to the AES from the beginning of production.

It also seems evident that the AES capability, while significantly better than Apollo, is still severely limited in terms of working volume and duration both in orbit and on the lunar surface. The AES does have tremendous propulsion capabilities to put heavy payloads into difficult-to-get-to places. This weight, particularly with the Sa-V, does not seem to be adequately used in the earth orbital missions now suggested. Even the heavy astronomy payload could be placed into polar orbit with weight to spare. In order to justify the use of this capability, it seems that a new module will eventually be necessary.

The AES program must be kept in perspective in the flow of technology. It seems that the program can serve as a contingency program for Apollo in its early phases, then can provide useful missions for several years, but must finally evolve into follow-on programs of some type. Therefore it is necessary to consider the growth potential of the AES even as AES utilizes the growth potential of the Apollo system.

The provision of a module for orbital use is one example of growth. A second example is the extension of lunar surface capability through the use of the LEM-Truck. If we are truly "to explore the moon, not just visit it or photograph it" and "to expand our earth laboratories into space laboratories", we must plan now for an orderly progression of programs. The AES appears to be a further step in that direction.

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SCHEDULE RESPONSIBILITY ______

STATUS RESPONSIBILITY ______

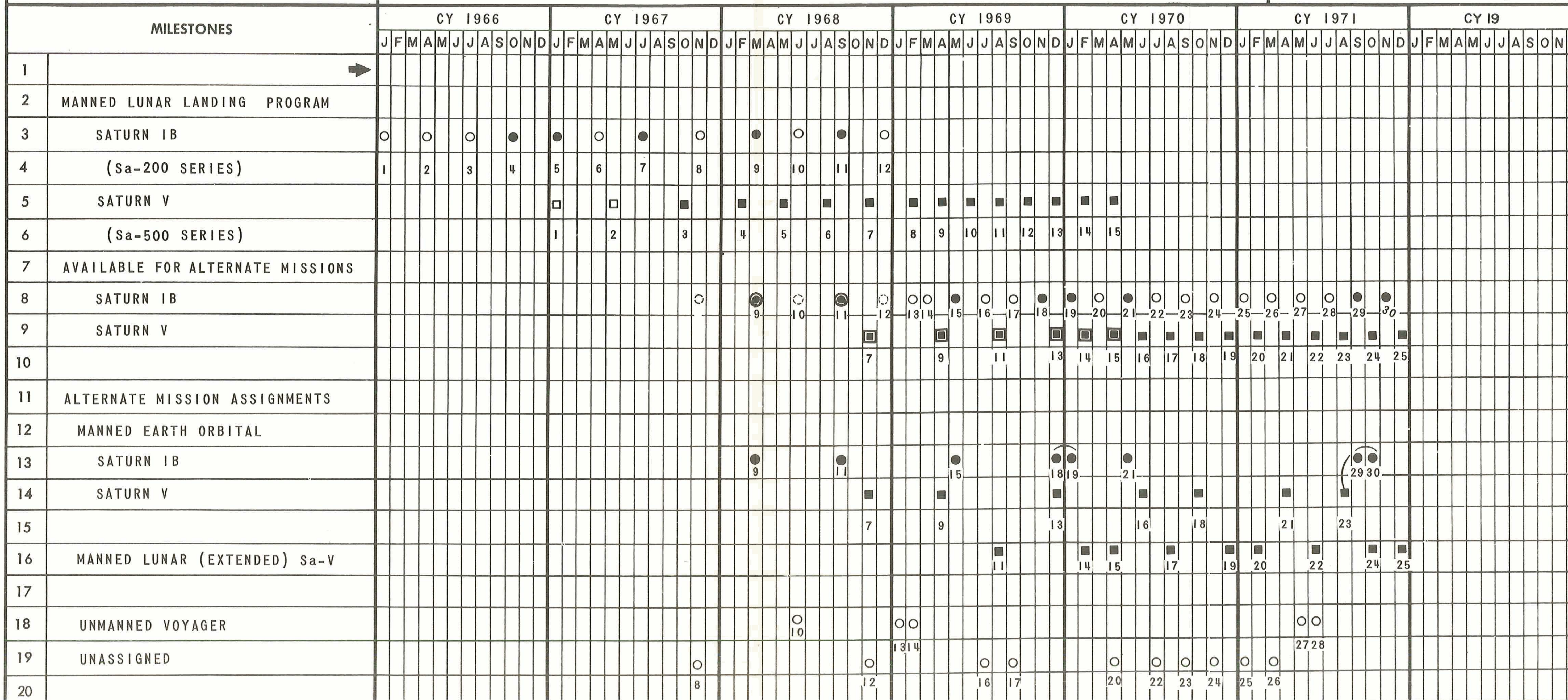
1966-1971 SATURN LAUNCHES FOR PLANNING PURPOSES

SCH'D NO: AE 65-1

ORIGINAL SCHEDULE APPROVAL ______ (Date)

LAST SCHEDULE CHANGE ______ (Date) (No) (Initials)

STATUS AS OF ______ (Date) (Initials)



NOTES SIB/S-V/SC 4/0/1 4/3/3 4/4/6 6/6/8 6/6/8 6/6/8

○ UNMANNED Sa-IB □ UNMANNED Sa-V ◌ ALTERNATE

● MANNED Sa-IB ■ MANNED Sa-V

1-1

FIGURE 1-2

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FLIGHT MISSION ASSIGNMENT PLAN FOR AES PLANNING

AE 65-1

	1968				1969						1970						1971					
SIB MISSION	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230
SIB PAD < X=37B, Y=34	X	Y	X	Y	XR	Y	XR	Y	XR	YR	X	YR	X	Y	XR	Y	X	Y	X	Y	XR	YR
SIB SC	105	C	103m	C	C	C	113	C	C	m	m	C	m	C	C	C	C	C	C	C	m	m
SV MISSION	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	526
SV PADS 39A or B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
SV SC	104	106	107	109	110	111	112	108m	114	m	m	m	m	m	m	m	m	m	m	m	m	m

	1968	1969	1970	1971
APOLLO	504 505 506 (507)	508 510 512		
AES	ALTERNATE (507)			
LUNAR		511	514 515 517 519	520 522 524 525
EARTH ORIENTED APPL'NS	507	215	221 518	521
ASTRONOMY			516	523 229
BIOMED/BEHAV'L	211	218	219	230
SPACE OPNS/TECH	209	509 513		
UNMANNED	210 VOY QUAL	213 214 MARS		227 228 MARS
UNASSIGNED	212 U	216 U 217 U	220 U 222 U 223 U 224 U	225 U 226 U
AVAILABILITY SIB/SV/SC	4/4/6	6/6/8	6/6/8	6/6/8

C=CENTAUR
R=RECONFIGURE PAD
m=MODIFIED SC

FIGURE 2

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Figure 3-a FLIGHT MISSION ASSIGNMENTS PLAN FOR AES PLANNING

AE65-1

Launch Date	Flight No.	Prime Purpose	Orbit n.m./Inc.	Duration Days	Crew	Configu-ration	Remarks
2/68	504	Apollo					
3/68	209	Space Operations/ Technology	200/low	10-14	2-3	CSM-LEM AS	Maneuvering, extra-vehicular activities
5/68	505	Apollo					
6/68	210	Voyager			U	C-IB/ Centaur	Voyager qual. test (included for AES planning purposes)
8/68	506	Apollo					
9/68	211	Biomedical/ Behavioral	200/low	30-45	3	XCSM & LEM-Lab	Extended duration biomedical/behavioral testing; lunar survey qual. for #511
11/68	507	Apollo					Alternate earth orbit
12/68	212				U		Unassigned
1/69	213	Voyager Mars			U	C-IB/ Centaur	Mars observation (included for AES planning purposes)
2/69	214	Voyager Mars			U	C-IB/ Centaur	Mars observation (included for AES planning purposes)
2/69	508	Apollo					
4/69	509	Space Operations/ Technology	Synch.	10-14	2-3	CSM & LEM AS	Maneuvering; sub-systems development

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Figure 3-b FLIGHT MISSION ASSIGNMENTS PLAN FOR AES PLANNING

AE65-1

Launch Date	Flight No.	Prime Purpose	Orbit n.m./Incl.	Duration Days	Crew	Configu-ration	Remarks
5/69	215	Earth-oriented applications	200/low	10-14	2-3	CSM & LEM AS	Qual. of remote sensors for #221. Preliminary observations of earth
6/69	510	Apollo					
7/69	216				U		Unassigned
8/69	511	Lunar Orbital Survey	L.O. <80/low	-35	3	XCSM & LEM-Lab & DS	Lunar survey; probe delivery
9/69	217				U		Unassigned
10/69	512	Apollo					
12/69	513	Space Operations/ Technology	200/polar	10-14	3	CSM & LEM AS	Maneuvering, subsystems development
12/69	218	Biomedical/ Behavioral	200/low	30-45	3	XCSM & LEM-Lab	Biomedical/behavioral, zero-g lab
1/70	219	Biomedical/ Behavioral	200/low	30-45	3	XCSM & LEM-Lab	Rendezvous and resupply of #218
2/70	514	LEM-Shelter delivery	L.L.		2-3/ U	CSM & LEM-Shelter	Deliver LEM-Shelter for surface mission #515
4/70	220				U		Unassigned
4/70	515	LEM-Taxi mission	L.L.	-20	3/2	XCSM & LEM-Taxi	Extended lunar surface operations up to 14 days. Surface rendezvous #514

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Figure 3-c FLIGHT MISSION ASSIGNMENTS PLAN FOR AES PLANNING

AE65-1

Launch Date	Flight No.	Prime Purpose	Orbit n.m./Incl.	Duration Days	Crew	Configu-ration	Remarks
5/70	221	Earth-oriented applications	200/low	30-45	3	XCSM & LEM-Lab	Meteorology, oceanography, agriculture
6/70	516	Astronomy	Synch.	30-45	3	XCSM & LEM-Lab	Payload qual. for #523; preliminary observations
7/70	222				U		Unassigned
8/70	517	Lunar Orbital Survey	<80/med.	-35	2-3	XCSM & LEM-Lab & DS	Lunar survey; probe delivery
9/70	223				U		Unassigned
10/70	518	Earth-oriented applications	200/polar	30-45	3	XCSM & LEM-Lab	Meteorology, geophysical observations
11/70	224				U		Unassigned
12/70	519	LEM-Shelter delivery	L.L.		2-3/ U	CSM & LEM-Shelter	Deliver LEM-Shelter for surface mission #520
1/71	225				U		Unassigned
2/71	520	LEM-Taxi mission	L.L.	-20	3/2	XCSM & LEM-Taxi	Extended lunar surface operations up to 14 days. Surface rendezvous with #519
3/71	226				U		Unassigned

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Figure 3-d

FLIGHT MISSION ASSIGNMENTS PLAN FOR AES PLANNING

AE65-1

Launch Date	Flight No.	Prime Purpose	Orbit n.m./Incl.	Duration Days	Crew	Configu-ration	Remarks
4/71	521	Earth-oriented applications	Synch.	30-45	3	XCSM & LEM-Lab	Meteorology, oceanog-raphy
5/71	227	Voyager Mars			U	C-IB/ Centaur	Mars observations (included for AES planning purposes)
6/71	228	Voyager Mars			U	C-IB/ Centaur	Mars observations (included for AES planning purposes)
6/71	522	Lunar Orbital Survey	L.O. <80/polar	-35	2-3	XCSM & LEM-Lab & DS	Lunar survey; probe delivery
8/71	523	Astronomy	200/low	30-45	3	XCSM & LEM-Lab	Extra-terrestrial observations
9/71	229	Astronomy	200/low	30-45	3	XCSM & LEM-Lab	Rendezvous and re-supply of #523. Con-tinued astronomical observations
10/71	524	LEM-Shelter delivery	L.L.		2-3/ U	CSM & LEM-Shelter	Deliver LEM-Shelter for surface mission #525
10/71	230	Biomedical/ behavioral	200/low	30-45	3	XCSM & LEM-Lab	Rendezvous and re-supply of #229. Biomedical/behavioral; astronomy

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Figure 3-e FLIGHT MISSION ASSIGNMENTS PLAN FOR AES PLANNING

AE65-1

Launch Date	Flight No.	Prime Purpose	Orbit n.m./Incl.	Duration Days	Crew	Configu-ration	Remarks
12/71	525	LEM-Taxi mission	L.L.	-20	3/2	XCSM & LEM-Taxi	Extended lunar surface observation up to 14 days. Surface rendez-vous with #524

Note: The exact launch dates of each flight will be determined from launch window constraints and minimum mission overlap.

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APPENDIX

AES FLIGHT DATA SHEETS

LAUNCH DATE: 3/68

FLIGHT #: 209

PURPOSE: Space Operations/Technology

ORBIT: E. O. 200 nm/Low inclination

DURATION: 10-14 days

CREW: 2-3

CONFIGURATION: CSM & LEM-Ascent Stage-SIB

OBJECTIVES: Space maneuvering, extra-vehicular activity

REMARKS: Engineering experiments can be performed. These might include pumping fuel in the zero-g environment, measuring enthalpy changes, boiling rates, momentum transfer etc. The performance and maintenance of subsystems such as regenerative oxygen systems and auxiliary power supplies would be studied.

Extra-vehicular operations would be attempted. Antennas can be erected and their patterns measured. Space operable airlocks and hatches as well as space tools would be evaluated.

LAUNCH DATE: 6/68

FLIGHT #: 210

PURPOSE: Voyager Qualification

ORBIT: Escape

DURATION: -

CREW: Unmanned

CONFIGURATION: Voyager S-IB/Centaur

OBJECTIVES: Qualification test for Mars mission

REMARKS: Included in AES for planning purposes.

LAUNCH DATE: 9/68

FLIGHT #: 211

PURPOSE: Biomedical/Behavioral Observations

ORBIT: E. O. 200 nm/Low Inclination

DURATION: 30-45 days

CREW: 3

CONFIGURATION: XCSM & LEM-LAB -SIB

OBJECTIVES: Extended duration biomedical testing (primary); Testing of lunar survey equipment (secondary).

REMARKS: This flight would be the first observation of man in a zero-g environment for an extended period. However, earlier data can be extrapolated to 30-45 day missions providing a basis for a biomedical/behavioral test program on this flight.

In addition to the biomedical/behavioral testing, this flight would be used for operational qualification of the lunar survey equipment. The availability of astronauts to perform simple engineering modifications or calibrations on the mapping equipment is required for successful testing.

LAUNCH DATE: 12/68

FLIGHT #: 212

PURPOSE: Unassigned

ORBIT: -

DURATION: -

CREW: Unmanned

CONFIGURATION: SIB

OBJECTIVES: -

REMARKS: No spacecraft available for this launch vehicle

LAUNCH DATE: 1/69

FLIGHT #: 213

PURPOSE: Voyager - Mars

ORBIT: Escape

DURATION: -

CREW: Unmanned

CONFIGURATION: Voyager S-IB/Centaur

OBJECTIVES: Mars observation

REMARKS: Included in AES for planning purposes.

LAUNCH DATE: 2/69

FLIGHT #: 214

PURPOSE: Voyager - Mars

ORBIT: Escape

DURATION: -

CREW: Unmanned

CONFIGURATION: Voyager S-IB/Centaur

OBJECTIVES: Mars Observation

REMARKS: Included in AES for planning purposes.

LAUNCH DATE: 4/69

FLIGHT #: 509

PURPOSE: Space Operations/Technology

ORBIT: E. O., Synchronous

DURATION: 10-14 days

CREW: 2-3

CONFIGURATION: CSM & LEM Ascent Stage - S-V

OBJECTIVES: Maneuvering, technology experiments, rendezvous

REMARKS: This flight mission would demonstrate the capability of manuevering a spacecraft into a synchronous orbit. To accomplish this, the S-IVB stage engine would be steered during its thrusting time.

The subsystems tested during this flight would include those needing continuing in-space life testing and also improved versions of existing components.

Radiation detectors would be carried and shielding materials tested. On this flight preliminary scientific experiments can be performed which results will form the basis of the experimental programs on later flights.

LAUNCH DATE: 5/69

FLIGHT #: 215

PURPOSE: Earth Oriented Applications

ORBIT: E. O. 200 nm/Low inclination

DURATION: 10-14 days

CREW: 2-3

CONFIGURATION: CSM & LEM-Ascent Stage-S-IB

OBJECTIVES: Testing of remote sensors which will be used in the earth oriented applications flight missions

REMARKS: This flight would operationally qualify the sensors that are planned for the future earth oriented applications flights. Multi-spectral region detectors will be provided for testing on this flight. The astronaut performing the evaluation will be able to use many sensor combinations over differing earth areas.

A satellite rendezvous could be attempted, e.g., Vanguard I, for inspection and/or for earth return.

Materials, considered promising for space applications, can be given short engineering tests.

LAUNCH DATE: 7/69

FLIGHT #: 216

PURPOSE: Unassigned

ORBIT: -

DURATION: -

CREW: Unmanned

CONFIGURATION: - SIB

OBJECTIVES: -

REMARKS: No spacecraft available for this launch vehicle.

LAUNCH DATE: 8/69

FLIGHT #: 511

PURPOSE: Lunar Survey

ORBIT: L. O. 80 nm or lower, low inclination or equatorial

DURATION: up to 35 days

CREW: 3

CONFIGURATION: XCSM & LEM-LAB & Descent Stage, S-V

OBJECTIVES: Partial lunar survey; probes of lunar far side

REMARKS: Earlier lunar landings (Apollo) will have produced data that are significant but perhaps unique to particular regions of the lunar surface. This partial mapping mission would provide gross data in the equatorial regions (encompassing the earlier landing sites). From this data and the earlier ground truth, recommendations could be made concerning experiments contained on future extended duration lunar landings. Probes could be used to examine the lunar far side.

This would be only the second long-time manned flight (the first #211). Biomedical and behavioral data would again be significant.

LAUNCH DATE: 9/69

FLIGHT #: 217

PURPOSE: Unassigned

ORBIT: -

DURATION: -

CREW: Unmanned

CONFIGURATION: SIB

OBJECTIVES: -

REMARKS: No spacecraft available for this launch vehicle

LAUNCH DATE: 12/69

FLIGHT #: 513

PURPOSE: Space Operations/Technology

ORBIT: E. O. 200 nm/polar

DURATION: 10-14 days

CREW: 3

CONFIGURATION: Unmodified CSM & LEM Ascent Stage - S-V

OBJECTIVES: Testing of lunar based equipment; polar manned observation

REMARKS: This would be the third subsystems test flight. The equipment that is proven on these flights could be flown on extended duration missions.

Experimentation on these flights would be limited to communications, engineering and space technology. Further testing of the sensors and cameras to be used in later earth oriented applications missions can be performed.

The use of the spacecraft in a polar orbit would demonstrate the maneuverability of the launch vehicle/spacecraft combination.

The use of the LEM as an earth orbit excursion vehicle may be tested.

LAUNCH DATE: 12/69 - 1/70

FLIGHT #: 218 - 219

PURPOSE: Biomedical/Behavioral

ORBIT: E. O. 200 nm/Low inclination

DURATION: 30-45 days each; 60-90 days total

CREW: 3 each

CONFIGURATIONS: XCSM & LEM LAB - S-IB

OBJECTIVES: Long duration biomedical and behavioral testing; scientific experimentation in zero-g environment.

REMARKS: Earlier flights #211 and #511 are planned to provide medical and behavioral data on astronauts in zero-g up to 30 days. This flight would double the time of the astronauts in zero-g.

Experiments performed in the zero-g laboratory can include biological experiments in which incubation periods run several months, materials analysis, fluid dynamics, thermodynamics and chemical processes.

The rendezvous of two spacecraft and either a material transfer or crew transfer is unique to this mission and can be considered a high priority item.

LAUNCH DATE: 2/70 - 4/70

FLIGHT #: 514 - 515

PURPOSE: Lunar exploration

ORBIT: Lunar Landing

DURATION: up to 14 days on the lunar surface

CREW: 3

CONFIGURATION: CSM & LEM-Shelter - S-V
XCSM & LEM-Taxi - S-V

OBJECTIVES: Extended duration lunar exploration

REMARKS: This 14 day lunar surface mission would probably be in a mare region where smooth surface features will permit relatively easy mobility. Surface instruments would be implanted to collect lunar physical data. A hole would be drilled, a multipurpose probe inserted, the hole logged and permanent probes inserted and connected to the emplaced scientific station (ESS) telemetry station. The ESS would be set up to collect long-term data on lunar body tides, seismicity, magnetism, atmosphere, radiation and meteoroids. These instruments would have an operational lifetime of 1/2 - 1 year and can transmit data to future lunar orbiting vehicles or directly back to earth.

LAUNCH DATE: 4/70

FLIGHT #: 220

PURPOSE: Unassigned

ORBIT: -

DURATION: -

CREW: Unmanned

CONFIGURATION: - SIB

OBJECTIVES: -

REMARKS: No spacecraft available for this launch vehicle

LAUNCH DATE: 5/70

FLIGHT #: 221

PURPOSE: Earth Orientated Applications

ORBIT: E. O. 200 nm/Low inclination

DURATION: 30-45 days

CREW: 3

CONFIGURATION: XCSM & LEM-LAB--S-IB

OBJECTIVES: Meteorology, oceanography, agriculture, forestry

REMARKS: The meteorological experiments would examine and evaluate the advantages of a manned space facility for synoptic observations in a meteorological research program leading to accurate global weather predictions. Included in the study would be cloud motion studies, energy and water exchange processes, high altitude dust measurements and pressure and temperature profiles. Agriculture and forestry experiments would consist of timber and crop census taking, meat and dairy animal survey feasibility study and soil characteristics surveys.

Probes would be launched to investigate areas of the atmosphere not readily reached by earth launched sounding rockets.

LAUNCH DATE: 6/70

FLIGHT #: 516

PURPOSE: Astronomy

ORBIT: E. O. Synchronous

DURATION: 30 - 45 days

CREW: 3

CONFIGURATION: XCSM & LEM - LAB - S-V

OBJECTIVES: Telescope qualification tests; preliminary observations

REMARKS: This mission would include the qualification testing of the astronomical telescope components including its stable platform. Preliminary astronomical observations would be made to provide a basis for the detail studies planned in later missions.

This flight can also be used to test improvements in subsystems and man's visability and operational capability in the space environment.

LAUNCH DATE: 7/70

FLIGHT #: 222

PURPOSE: Unassigned

ORBIT: -

DURATION: -

CREW: -

CONFIGURATION: SIB

OBJECTIVES: -

REMARKS: No spacecraft available for this launch vehicle

LAUNCH DATE: 8/70

FLIGHT #: 517

PURPOSE: Lunar Survey

ORBIT: L. O. 80 nm or lower, medium inclination

DURATION: Up to 35 days

CREW: 2 - 3

CONFIGURATION: XCSM & LEM - LAB & Descent Stage - S-V

OBJECTIVES: Lunar Survey - extended areal coverage

REMARKS: The first lunar mapping mission (#511) is planned for a near equitorial orbit which would have limited coverage. As experience with the spacecraft is increased, higher lunar inclination orbits can be attempted. The higher orbit permits a larger areal coverage.

Probes would be used to investigate regions of particular interest not readily accessible for a manned landing.

Non photographic sensors such as UV or IR detectors used on LS #1 will be again used.

LAUNCH DATE: 9/70

FLIGHT #: 223

PURPOSE: Unassigned

ORBIT: -

DURATION: -

CREW: -

CONFIGURATION: SIB

OBJECTIVES: -

REMARKS: No spacecraft available for this launch vehicle

LAUNCH DATE: 10/70

FLIGHT #: 518

PURPOSE: Earth Oriented Applications

ORBIT: E. O. 200 nm/polar

DURATION: 30-45 days

CREW: 3

CONFIGURATION: XCSM & LEM - LAB - S-V

OBJECTIVES: Meteorology, oceanography, geophysical

REMARKS: From its polar orbit this flight could provide total earth coverage. This flight would also provide weight and volume to perform basic scientific experiments in a zero-g environment.

Air pollution experiments, consisting of measurements and identification of fine particle consistency in the atmosphere, could be performed.

In addition aurora/air glow intensity and spectra would be studied. These data would provide information on the earth's magnetic field and its fluctuation plus data on solar particles.

LAUNCH DATE: 11/70

FLIGHT #: 224

PURPOSE: Unassigned

ORBIT: -

DURATION: -

CREW: Unmanned

CONFIGURATION: SIB

OBJECTIVES: -

REMARKS: No spacecraft available for this launch vehicle

LAUNCH DATE: 12/70 - 2/71

FLIGHT #: 519-520

PURPOSE: Lunar Exploration

ORBIT: Lunar Landing

DURATION: Up to 14 days on the lunar surface

CREW: 3

CONFIGURATION: CSM & LEM Shelter - S-V
XCSM & LEM Taxi - S-V

OBJECTIVES: Extended duration lunar exploration

REMARKS: Data obtained from previous lunar landings and orbital survey missions could be used to select a scientifically promising region for exploration, e.g. a lunar crater.

The astronauts mobility in or near a crater may be substantially less than on the mare but previous knowledge of the lunar surface should compensate for this. A procedure for exploration similar to that of LL #1 would be followed.

LAUNCH DATE: 1/71

FLIGHT #: 225

PURPOSE: Unassigned

ORBIT: -

DURATION: -

CREW: Unmanned

CONFIGURATION: SIB

OBJECTIVES: -

REMARKS: No spacecraft available for this launch vehicle

LAUNCH DATE: 3/71

FLIGHT #: 226

PURPOSE: Unassigned

ORBIT: -

DURATION: -

CREW: -

CONFIGURATION: SIB

OBJECTIVES: -

REMARKS: No spacecraft available for this launch vehicle

LAUNCH DATE: 4/71

FLIGHT #: 521

PURPOSE: Earth Oriented Applications

ORBIT: E. O. Synchronous

DURATION: 30-45 days

CREW: 3

CONFIGURATION: XCSM & LEM-LAB - S-V

OBJECTIVES: Meteorology, oceanography, geology, geography, hydrology

REMARKS: This synchronous orbit flight would be used to confirm data obtained from earth orbital flights relating to meteorology, oceanography, earth thermal balances, albedo, etc. Materials research could be performed on this flight, testing the applicability of various materials to a space environment.

Water vapor flux mapping, electromagnetic signature identification of minerals, and geomorphological feature studies would be conducted in the geology/hydrology. Biological experiments could also be carried on this flight.

LAUNCH DATE: 5/71

FLIGHT #: 227

PURPOSE: Voyager Mars

ORBIT: Escape

DURATION: -

CREW: Unmanned

CONFIGURATION: Voyager S-IB/Centaur

OBJECTIVES: Mars Observation

REMARKS: Included in AES for planning purposes

LAUNCH DATE: 6/71

FLIGHT #: 228

PURPOSE: Voyager-Mars

ORBIT: Escape

DURATION: -

CREW: Unmanned

CONFIGURATION: Voyager S-IB/Centaur

OBJECTIVES: Mars Observation

REMARKS: Included in AES for planning purposes.

LAUNCH DATE: 6/71

FLIGHT #: 522

PURPOSE: Lunar Survey

ORBIT: L. O. 90°, 80 nm or lower

DURATION: Up to 35 days

CREW: 2-3

CONFIGURATION: XCSM & LEM LAB & Descent Stage - S-V

OBJECTIVES: Complete Lunar survey

REMARKS: This lunar mission would permit mapping of the total lunar surface. The entire surface would be observed twice (at different phase angles).

This would be the first observation of the lunar poles. Probes could be used for more detailed study of the lunar poles.

LAUNCH DATE: 8/71-9/71-10/71

FLIGHT #: 523-229-230

PURPOSE: Astronomy - Biomedical/Behavioral

ORBIT: E. O. 200 nm/Low inclination

DURATION: 30-45 days each - 90 - 135 day total

CREW: 3

CONFIGURATION: XCSM-LEM-LAB--S-V
XCSM-LEM-LAB--S-IB

OBJECTIVES: Long duration astronomy and biological experiments

REMARKS: An optical and radio telescope would be carried into earth orbit by a Saturn V and sustained for an additional 60 - 90 days by two Saturn IB flights. Planets would be studied by high resolution visible and ultraviolet photography and the form and intensity of the solar corona studied with coronagraph. The long duration orbital stay time can also be used for biological experimentation.

LAUNCH DATE: 10/71 - 12/71

FLIGHT #: 524 - 525

PURPOSE: Lunar Exploration

ORBIT: Lunar Landing

DURATION: Up to 14 days on the lunar surface

CREW: 3

CONFIGURATION: CSM-LEM-Shelter - S-V
XCSM-LEM-Taxi - S-V

OBJECTIVES: Extended duration lunar exploration

REMARKS: The purpose of this mission would be the manned exploration of a third region of the lunar surface, e. g., a continent. Also either of the two earlier extended lunar exploration missions may indicate areas that warrant further study. This could be accomplished on this flight.

The same procedure as in LL #1 and LL #2 would be followed.