MARTIN MARIETTA

MARTIN COMPANY

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APOLLO APPLICATIONS PROGRAM (AAP) PAYLOAD INTEGRATION

Technical Study and Analysis Report

General Design Plan

N68-23888

Contract No. NAS8-21004

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FOREWORD

This document is submitted in accordance with the requirements of DRL Line Item 20 of Exhibit C of Contract No. NAS8-21004. Separate addenda to this document are prepared for AAP 1, 2, 3, and 4.

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CONTENTS - (Continued)

1. SCOPE

The purpose of this General Design Plan for the Apollo Applications Program (AAP) is to identify those design tasks that are necessary to implement the total program. It is the intent of this volume to cover those design tasks which are:

a. Generally common to each of the individual flights of the entire program.

b. Required in support of the basic program, but not attributable to any individual flight or mission.

c. Special design tasks that are anticipated to be required to solve individual flights of the unassigned missions; these problems and their related tasks will require consideration prior to the period for detailed planning on those flights.

Design tasks identified herein are identified irrespective of the contractor or NASA agency responsible for their satisfaction. The scope of this plan does not include the identification of the contractor or agency repponsible; that responsibility determination and assignment is left to NASA authority as a logical follow-on product enabled by the plan. Those tasks that shall be assumed by Martin Marietta are included herein and are also identified separately and specifically as Payload Integration Contractor tasks in PL-2055, Design and Development Plan, of the Phase D proposal documentation.

This volume will be supplemented with individual flight addenda covering specific flights as the requirement for detailed planning develops. At the time of this submittal, four flight addenda are also being submitted for Flights AAP 1, 2, 3, and 4 of the Combined Cluster Configuration Mission.

This General Design Plan also establishes a general design criteria for each AAP flight to be used as a guide for hardware selection and planning by all engineering agencies associated with AAP payload integration during the program definition phase.

2. PROGRAM DEFINITION

This General Design Plan is based upon MSFC Guidelines for Payload Integration Phase D Proposal, Revision A, dated March 7, 1967, and upon documentation of Martin Marietta Phase C results.

2.1 AAP Engineering Documentation Relationships - Figure 2.1 presents a documentation tree depicting the interrelationships of Martin Marietta Corporation documentation to NASA documentation. The diagram portrays source data and data definition expansion relationships. It does not necessarily present documentation authority relationships.

2.2 Applicable Documentation - The following documentation was prepared by Martin Marietta during Phase C and is applicable to this General Design Plan as indicated.

Document Number	Document Title	Relationship
ED-2002-59 Rev 1	Mission Feasibility Analysis, AAP Unassigned Missions, dated 7 April 1967	Defines Mission Experiment List and Carrier Complement with major incompatibilities, problems identified.
ED-2001	General Design Reference Mission Document, dated 27 March 1967	Defines Mission Profile, Mission Objectives, Schedule
RS2C0000 Rev 1 w/SCN 1	General Specification for Performance and Design Requirements for Saturn Apollo Applications Combined Mission dated 30 December 1966	Defines AAP 1/2/3/4 Configuration Baseline for Phase C activities.
PL-2055	Design and Development Plan for AAP Payload Integration	Defines Payload Integration Contractor Design and Development Tasks and Techniques.
(part of PL-2055)	Design and Development Plan, Addendum for AAP 2	Defines AAP 2 PIC Tasks, etc.

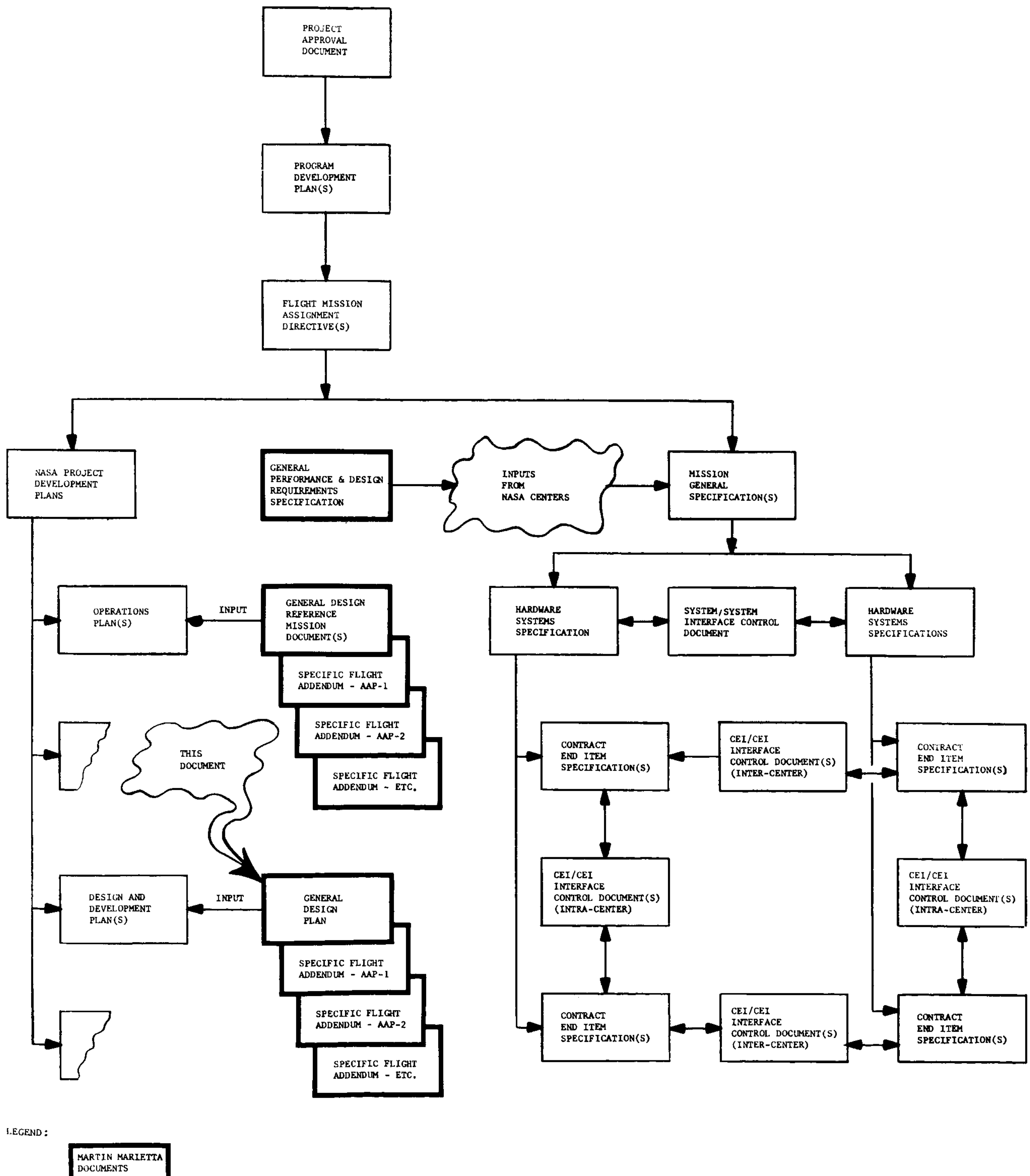


FIGURE 2.0 DOCUMENTATION TREE

Document Number	Document Title	Relationship
(part of PL-2055)	Design and Development Plan, Addendum for AAP 4	Defines AAP 4 PIC Tasks, etc.

2.3 Design Plan Addenda - The following addenda to this General Design Plan have been prepared to define the required design tasks for the initial AAP cluster mission. Similar documentation will be prepared by Martin Marietta for the remaining AAP missions for which MSFC has integration responsibility.

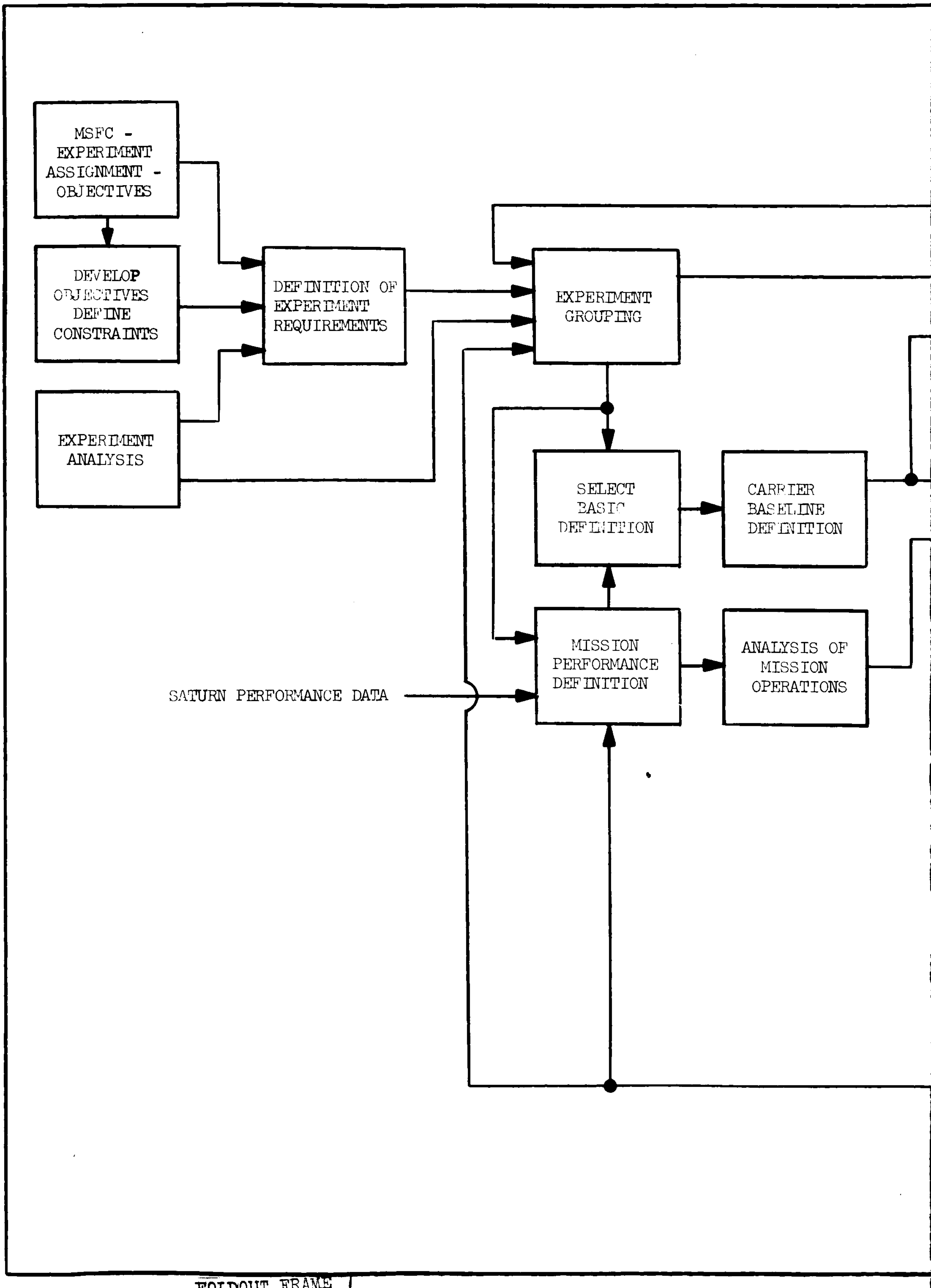
Document Number	Document Title
PL-2002-1	Flight AAP 2 Addenda to Design Plan, Combined Mission
PL-2002-2	Flight AAP 1 Addenda to Design Plan, Combined Mission
PL-2002-3	Flight AAP 3 Addenda to Design Plan, Combined Mission
PL-2002-4	Flight AAP 4 Addenda to Design Plan, Combined Mission

3. DESIGN TASKS

The approach selected to define the AAP mission is portrayed in figure 3.1. This diagram depicts the major functions of analyzing preliminary experiment groupings and of determining final flight assignments that will satisfy the objectives of the program. Figure 3.2 presents a major milestone schedule for the entire Apollo Applications Program.

The mission objectives and preliminary experiment assignments are received from NASA prior to the start of any effort. The objectives and assignments are then analyzed for major program effects. Constraints will be established to provide guide lines for the conduct of the mission analysis. A compilation of requirements based on the mission constraints and detailed experiment analysis will be made.

Performance analysis will be initiated parallel to the experiment analysis based on the NASA-defined objectives and constraints. These total-system-analysis results will be used



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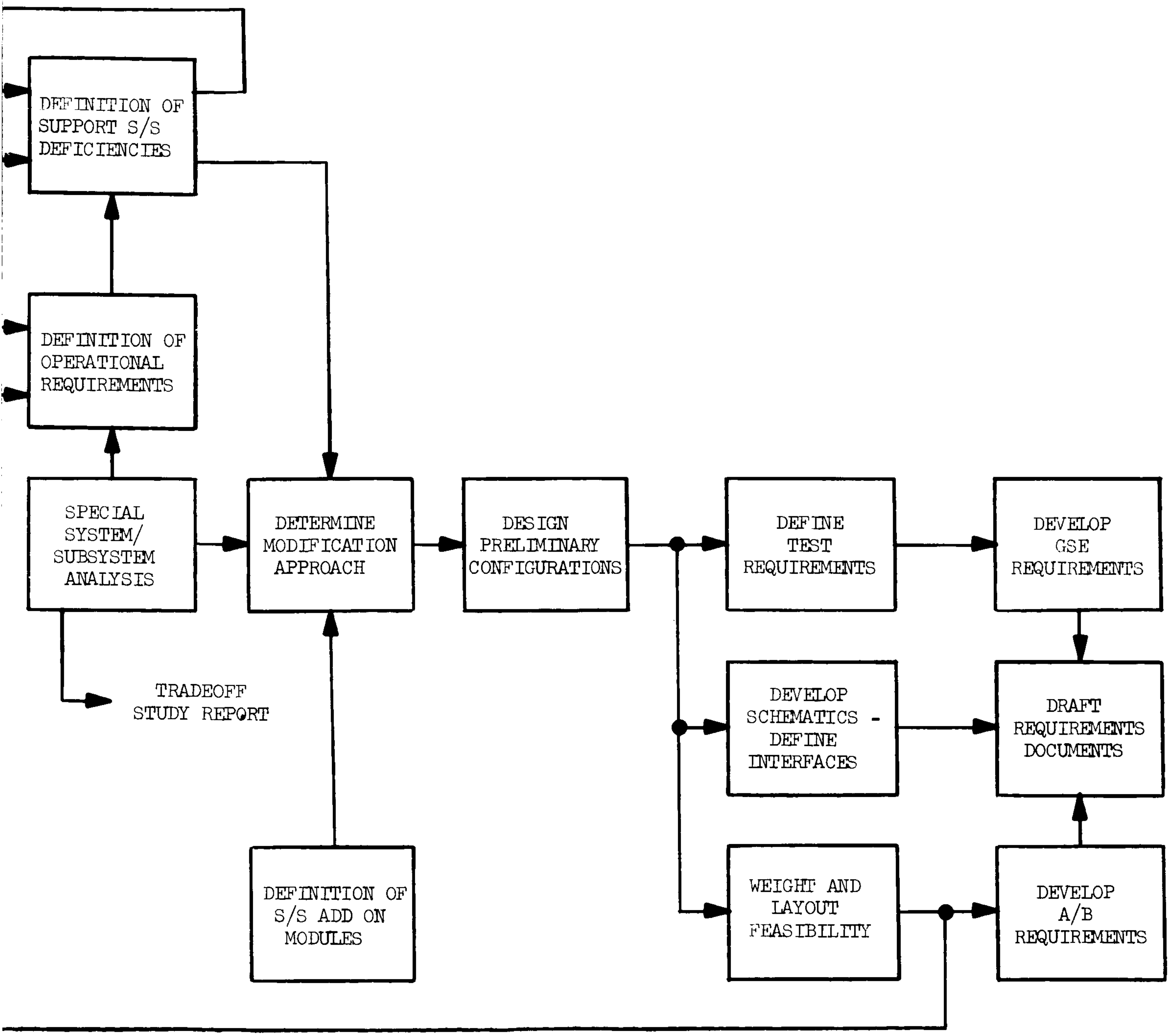


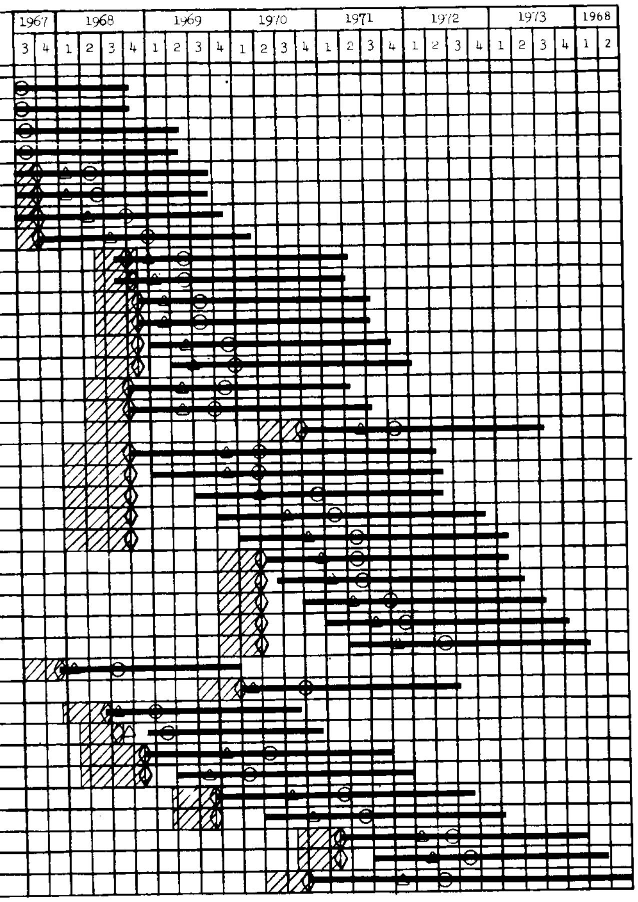
FIGURE 3.1

MISSION DEFINITION APPROACH

FIGURE 3.2

AAP MILESTONE SUMMARY SCHEDULE

			AAP NO.	INTEG. RESP.	PAYLOAD
EARTH ORBIT OWS CLUSTER MISSIONS (EARLY SPACE LAB)	LOW EARTH ORBIT	ASSY. CLUSTER	1	MSC	CSM-LM&SS
			2	MSFC	MDA-AM-OWS-1
			3	MSC	CSM-RESUPPLY
			4	MSFC	LM-ATM A
		SUPPT CLUST	5	MSC	LCSM
			6	MSC	APP-A, EMR on MSFC RACK
			7	MSC	LCSM
			8	MSC	LCSM
		ASSY. CLUSTER	9	MSC	LCSM-APP-B
			10	MSFC	MDA-AM-OWS
			12	MSC	LCSM-BIO LAB
			11	MSFC	LM-ATM-B
		SUPPT. CLUST.	13	MSC	LCSM
			13A	MSC	LCSM
	SYNC	SYNC. CLUSTER	17	MSFC	LCSM-MDA (short) AM-OWS
			18	MSFC	LCSM-RESUPPLY LM-ATM C
		SUPPT SYNC. CLUSTER	36	MSFC	LCSM-RESUPPLY LM-ATM D
GROUND OUTFITTED LABORATORY MISSIONS (IMPROVED SPACE LAB)	LOW EARTH ORBIT	EST. LAB	25	MSFC	LCSM-MDA (short) AM-MMWS
		SUPPT. LAB	26	MSC	LCSM
			27	MSFC	LM-RACK
			28	MSFC	LM-RACK
			29	MSC	LCSM
		EST. LAB	30	MSFC	LCSM-MDA (short) AM-MMWS
		SUPPT. LAB	31	MSC	LCSM
			32	MSC	LCSM
			33	MSC	LCSM
			34	MSC	LCSM
LUNAR MISSIONS	LUNAR ORBITAL SURVEY		14	MSC	CSM-LM&SS
			35	MSC	CSM-LM&SS
	LUNAR SURFACE EXPLORATION	SINGLE FLIGHTS	15	MSC	CSM-LM-ALSEP
			16	MSC	CSM-LM-ALSEP
		DOUBLE FLIGHTS	19	MSC/MSFC	CSM & LSSM-LM SHELTER
			20	MSC	CSM-LM TAXI
			21	MSC/MSFC	CSM & LSSM-LM SHELTER
			22	MSC	CSM-LM TAXI
			23	MSC/MSFC	CSM & LSSM-LM SHELTER
			24	MSC	CSM-LM TAXI
MARS UNMANNED EXPLORATION			37	---	VOYAGER



LEGEND:

- PROGRAM DEFINITION ACTIVITIES
- PROGRAM IMPLEMENTATION ACTIVITIES
- △ EXPERIMENT LIST DEFINED
- ○ P/L MODULE BASELINE DESIGN REVIEW
- ◇ FLIGHT MISSION DIRECTIVE ISSUE

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in the preliminary selection of basic carriers and in the initial grouping of experiments. The mission objectives, defined constraints, and special experiment requirements shall be used in conjunction with early knowledge of selected experiment carriers in the establishment of payload recommendations.

At this phase of the analysis the baseline of each carrier to be used on the mission will be defined through use of NASA documentation. Or, in those cases where a new experiment module is required, a baseline configuration will be established. The analysis of mission operations will determine flight profiles, necessary maneuvers and other pertinent data required to establish a sequence of operations. The determination of operational requirements for each flight of the mission will then be undertaken to establish subsystem requirements to meet the mission objectives of duration, attitude, attitude control, and crew considerations.

The information assembled, at this point in the analysis, will be gathered together to form a basis for definition of the deficiencies in each of the subsystem areas. The requirements, both experiment and operational, will be compared with existing carrier capability in order to determine areas where additional equipment will be necessary to meet total mission requirements. Iterations will be required to regroup experiment packages, update types of vehicles, and optimize the analysis results.

Determination of what approach should be used in the design of modifications and new hardware will then be undertaken. A list of available components and subsystem modules has been developed. This data will be kept current throughout these analyses. This information, in conjunction with the known subsystem mismatches and with the results of special studies needed to analyze mission/vehicle/subsystem major problem areas, will be used in the performance of trade studies of the alternate solutions and optimization of the modification approach.

The next step in the analysis is to define a preliminary configuration for each of the Flight Vehicles and to perform preliminary weight and layout analyses. The results will provide a top level proof-of-mission feasibility or define areas where major problems must immediately be solved. Document ED-2002-59 titled, "Mission Feasibility Analysis, AAP Unassigned Mission" is the first iteration in this process. This information will then be used to provide input for a more detailed performance and grouping analysis and initiate an iteration of the cycle which will provide a more detailed definition of the mission requirements.

The cycle will be repeated a sufficient number of times to provide the information necessary to describe an implementation program for the mission being studied. After the first iteration, a mission requirements document will be developed which will provide a baseline for further analysis. This document will be updated as new requirements or changes are developed.

Special system and subsystem analysis will be performed throughout the study period. These studies will support any major problem areas which develop and require more detailed analysis. Studies of this nature will be used to support major definition milestones such as: subystem deficiency definition, mission operational requirements definition, modification approach determination, experiment grouping, etc. They will include the necessary effort to introduce reliability, environmental, and criticality into the selection process.

Two compatibility analysis exercises have been completed for AAP 1/2/3/4 cluster configuration mission. Martin Marietta report 42-0001, Cluster Configuration Compatibility Analysis, resulted in a cogent baseline identification for the AAP 1/2/3/4 mission. The baseline identification enabled progress into still more definite phases of mission planning and requirements determination. In addition, it identified other questions or incompatibilities that were subsequently resolved via specific trade studies and by NASA management decision.

A second compatibility analysis for the AAP 1/2/3/4 Cluster Mission is in process and will provide the next level of refinement of the baseline requirements from which accurate interface definition may be established and negotiated.

At the completion of this iteration of the process, a requirements document will be prepared to enable detail design and to enable assignment of contractual responsibility.

3.1 General Design Tasks - Systems Oriented - This section of the report lists those design tasks that are generally common to each of the flights of each mission irrespective of their category, e.g. low earth orbit, lunar landing, etc. The tasks described here will generally be repeated for each flight, taking maximum benefit from preceding flights with similar requirements. These tasks are not oriented to the subsystem disciplines.

3.1.1 Experiment Grouping and Analysis - The analysis of individual experiments and groups of experiments is required in support of mission objectives. These areas of effort are:

a. Review and analyze experiments, experiment groupings and individual flight profiles provided by NASA to prepare mission requirements documents.

b. Analyze the gross feasibility and match/mismatch of the experiments to the mission.

c. Establish experiment priority for the individual experiments assigned to each flight.

d. Develop detailed timelines of crew tasks for experiment operation to integrate into an overall mission schedule and timeline.

e. Establish supporting subsystem requirements for individual experiments and establish total mission requirements including housekeeping and operational needs. These will include special safety and hazard monitoring systems, and ground command and control requirements for experiment support.

f. Correlate the individual experiment assignments to the overall scientific objectives of the Apollo Applications Program to insure satisfaction of these objectives. This must be accomplished via coordination with Principal Investigators and scientific community from the Payload Integration function.

g. An orderly progression of experiments must be established whereby knowledge gained from the earlier missions will be used to provide common hardware developments to accomplish and extend AAP objectives and to obtain maximum experiment results.

3.1.2 System Engineering Tasks - This activity integrates space vehicles, experiments and supporting subsystems into a coordinated space system.

a. Develop Design Criteria for Each Mission - Basic ground rules and guidelines (in conjunction with NASA/MSFC) will be established; such as mission baselines, list of experiments, test and checkout philosophies, availability of present Apollo GSE and facilities, program phase-in constraints, carrier configurations, basic design criteria, etc.

b. Coordination of Subsystem Requirements - Coordination of all subsystem requirements throughout AAP project. This effort will include normal mission analysis, coordination of special studies such as cluster compatibility analysis, and analysis of subsystem interactions.

c. Perform Tradeoff Studies on Missions - Tradeoff studies will be performed throughout the definition phase of the program at system level. Examples of this type of study is a tradeoff of major experiment group within various vehicles of a mission or with other missions to compare performance of costs.

d. Develop Top Requirements Document - Individual carrier and total cluster design requirements will be developed based on mission/vehicle analysis. A top performance design requirements document will be generated listing mission design requirements, operational carrier/payload requirements and constraints for each flight/mission, orbital and GSE interface requirements, and program design standards.

e. Participate in Periodic Inter-Center Panel Meetings and Program Milestone Reviews - Personnel will participate in periodic program reviews as required by NASA/MSFC to coordinate efforts. Effort will be expended to develop the systems engineering and integration task accomplishments so as to keep NASA personnel informed on program status and to support NASA during inter-center panel meetings.

f. Conduct Subsystem Design Requirements Reviews - Reviews will be conducted on contractor conceptual designs and the generated design requirements for experiment support subsystems. All subsystems will be reviewed, individually and with respect to each other. Emphasis will be placed on the man-machine interface by having special crew station reviews.

g. Develop AAP Program Test and Checkout Requirements - Test, checkout philosophies and requirements will be defined for all equipment on all carriers. Recommendation for testing of individual carriers, cluster configurations, special EMI testing and definition of operational checkout at KSC will be provided upon completion of the analyses of carrier requirements.

h. Identify Systems and Subsystem Test Criteria - The criteria for testing and checkout of experiments and their supporting subsystems shall be defined for each mission and will be updated as the analysis proceeds to maintain a consistent program philosophy.

i. Prepare Systems Functional Schematics - As the design of each system is established overall systems functional schematics will be prepared to illustrate the operational characteristics of each carrier system to show interface requirements, and to form a basis for compatibility analysis.

j. Conduct Compatibility Analysis - A compatibility analysis will be performed to integrate individual mission/flights into the program, based on experiment data and experiment assignment to the preselected carriers. The analysis objective is to match the requirements of the experiments to the capabilities of a selected carrier and its associated vehicle booster system. Existing carrier module feasibility will be evaluated in terms of size, weight and volume. If new carrier systems are required, subsystem requirements will be re-established. Total system requirements will then be re-evaluated to assure compatibility between subsystems and across carriers.

k. Perform Functional Analysis - A functional analysis which defines functional requirements for each mission will be performed. These diagrams will show the path for each carrier from point of manufacture through integration with the payload and booster vehicle at KSC. The analysis will consider: Testing requirements on functional and non-functional (prototype) test articles, operational checkout requirements, optimum location of carrier tests and checkout, and phase-in into the present Apollo program. Alternates will be carefully evaluated before recommendations are made.

l. Develop Storage Management Plan - The storage management plan will identify special equipment required for experiment support and operation. The plan will be divided in two parts; 1) storage during launch, and 2) storage during reentry. Storage requirements will be divided into loose and installed GFE, and loose and installed CFE. The plan will provide a complete complement of experiment and operational support hardware.

m. Documentation, such as the Design Plan, Schematics Criteria Documents - Interface Control Documentation, will be prepared and maintained to reflect latest status of mission and design requirements and carrier and cluster configurations.

n. Develop GSE Systems Level Requirements - GSE requirements will be generated to support the AAP program activities throughout the various test and checkout phases. The requirement for GSE will be analyzed taking into account test and checkout locations, availability of existing GSE and facilities and the type of testing to be performed.

o. Develop Facility Systems Level Requirements - Facilities requirements will be generated to support the AAP program activities throughout the various manufacturing, test and checkout phases. The requirement for facilities will be analyzed taking into account test and checkout location, availability of existing GSE and facilities and the type of testing to be performed.

p. Maintain Liaison and Coordination Between NASA Centers - Liaison with MSFC Engineering, NASA Centers, carrier contractors and support contractors will be maintained; 1) to coordinate systems design, schedules, program changes, hardware changes and integration requirements; 2) to advise all participants of incompatibilities that arise during the study phase; and 3) to provide design support to carrier and experiment equipment contractors.

q. Define Configuration Baseline for Each Flight Carrier - Establish the present configuration for each of the existing designed vehicles and the availability of documentation to describe the baseline. Preliminary baseline will be established based on mission needs in cases where no baseline exists. This can be used for initial analysis, and by iterative processes will become the requirements for design of a new vehicle.

r. Determine the hardware requirements associated with providing capability to accomplish functions required under contingency plan conditions.

s. Prepare and maintain ICDs for the definition of the vehicle/GSE interface, the GSE/facilities interface, the experiment/installation hardware interface, and the installation hardware/carrier interface requirements for all experiments.

t. Conduct Preliminary Design Reviews (PDR) - Prototype engineering, mockups, preliminary analyses, etc. will be reviewed by the appropriate engineering disciplines to verify the design approach to be used. All interfacing disciplines and contractors as well as the NASA control agencies will be represented to assure that the cognizant interface documents are adequate and understood.

u. Conduct Critical Design Reviews (CDR) - Specifications and drawings that control the manufacturing of an item will be reviewed just prior to their release for production. All interfacing disciplines and contractors as well as the NASA control agencies will be represented to assure that all design development deficiencies have been resolved. Development test results, prototype units, analytical studies, detail drawings and specifications, will be reviewed.

v. Certification of Flight Worthiness (COFW) - Each spacecraft shall be certified as having been satisfactorly fabricated and tested before being integrated into the total space vehicle. All cognizant contractors and NASA agencies will be represented. Engineering support is required to adequately analyze and review all anomolies of testing and fabrication to certify the article's worthiness.

w. Design Certification Review (DCR) - Certify that the total space vehicle design is compatible with the total mission objectives. The review will be conducted by the cognizant contractors and NASA agencies.

x. Conduct Flight Readiness Review (FRR) - Prior to flight a complete review of all testing, modifications, configuration, environmental and launch constraints is required. All cognizant contractors and NASA agencies will be represented. Satisfactory resolution of all anomalies incurred during testing, fabrication and checkout will be certified. Launch and mission constraints will be reviewed.

y. Specifications, design drawings, planning documents will be prepared and maintained through all phases of the program. Configuration control of drawings and specifications will be implemented per the terms of the contracts.

3.1.3 Mission Analysis and Definition - AAP missions will be defined by performing preliminary mission operational analysis and by accomplishing the preliminary engineering aspects of integrating the experiments into the experiment module. This analysis will be based upon NASA furnished descriptions of planned AAP experiments, primary experiment assignments, space vehicle configurations and mission assignments. The identification of design, performance, test, and experiment interface specifications required to accomplish mission definition will include the following tasks:

a. Mission/flight/experiment integration planning and analysis.

b. Integration of mission/flight/crew/experiment operations and preparation of integrated timelines.

c. Contingency Planning - Total systems contingency planning will be defined and integrated during program mission analysis. This analysis will include contingency planning for subsystem failure, experiment failure, single carrier failure, and complete flight failure within each of the missions. Consideration will be given to combining portions of different missions on a contingency basis.

d. Identify peculiar constraints that the performance of scheduled experiments impose on the mission plan, subsystem operation, reentry and recovery operations.

e. Prepare and maintain mission documentation for AAP experiments and experiment carriers in support of mission planning and operations.

3.1.4 Human Engineering and Crew Training Support

a. All experiment operations on all carriers will be reviewed to insure compatibility with mission. Detailed crew tasks and procedures will be defined. Each experiment will be reviewed to assure that the crew can perform the desired operation and obtain the necessary data. Requirements will be established for astronaut hand holds, foot restraints, and tethers.

b. Human engineering design criteria will be established for the experiment carriers and experiment operations. This shall include definition of working envelope for either the suited or shirtsleeved astronaut. Astronaut habitation parameters display and control panels, and experiment operations, stowage and installation will be reviewed for mission compatibility and recommendations made as required.

c. Develop mission crew details for experiments simulation and training requirements. Define experiment requirements on crew operations. Define simulation and training plans required by critical flights including extravehicular activities. Establish crew safety requirements and contribute to a contingency mission plan for experiment operations.

d. Develop plan to perform simulation required to confirm hardware and equipment design, and to verify the timelines associated with operational tasks.

3.1.5 Reliability and Quality Engineering Planning - Plan a Reliability and Quality Engineering program in support of all ground and flight hardware by performing the following tasks:

a. Evaluate each piece of equipment and determine Reliability Program Plan requirements. Establish the scope of its provisions and provide the requirements appropriate for that equipment.

b. Develop and implement a plan for control of all contractors' reporting, analysis, correction and data feedback of all failures and malfunctions which occur throughout the fabrication, test checkout, and flight operation of the experiment systems. The plan shall present a method to list system failures and current status of corrective actions which are critical to crew safety and mission success.

c. Develop and implement a plan to participate in reliability program reviews on all AAP equipment. Methods shall be established to standardize failure mode effect and criticality analyses (FMECA), critical items lists, preferred part and material applications. Equipment failures and problems resulting from test operations shall be assessed for adequacy of corrective action and will be summarized for flight readiness reviews.

d. Develop and implement a plan to combine the FMECAs of all contractors into a composite system analysis for the integrated experiment modules. It will include the propagation of failure mode effects across experiment interfaces, minimize single point failures, minimize failure mode effects on crew safety, and enhance mission success.

e. A quality control plan will be developed and implemented to set forth a reliability and quality assurance program. The disciplines outlined therein will be applicable to control manufacture, test, acceptance, inspection, etc. of all equipment.

f. Research will be provided to update inspection and testing techniques. Training and certification needs shall be determined.

3.1.6 <u>Test Requirements</u>

a. Develop and implement the testing effort required to support the qualification, reliability and design development programs.

b. Develop and implement the testing effort required to support subsystems compatibility and functional tests.

c. Develop and implement the testing effort required to support the integrated systems test and checkout.

3.2 General Design Tasks - Subsystems Oriented - This section of the report lists those design tasks that are generally common to each of the flights, irrespective of their mission category. These tasks are all related to the individual subsystem disciplines. The tasks will generally be repeated for each flight, taking maximum benefit from preceding flights with similar requirements.

3.2.1 Structures Design Tasks

a. Inboard and/or outboard profile layouts will be made for flight vehicle payloads for all missions, both in the boost conditions and in the in-orbit configuration. These configuration layouts will be made to define the physical interfaces between experiments, subsystems, crew activities, carriers, and launch vehicle.

b. Mass properties data such as weight, center of gravity positions, inertial properties and principal axis locations will be generated for the AAP mission configuration and in support of the booster vehicle performance analysis, the mission profile analysis, on-orbit sequence analysis, the experiment grouping analysis, and the systems tradeoff analysis. Using the configuration layouts for dimensional data, the mass inertial properties of the various in-orbit vehicle combinations will be derived in order to support guidance and control studies, structural dynamic studies and propulsion and reaction control system studies.

c. Structural design loads, environmental and other stress analysis criteria will be developed for inclusion in the interface and design requirements specifications.

d. Design layouts will be made to verify the configurations selected during the mission analysis process.

e. Stress analyses necessary to assure structural integrity will be conducted on all carrier modifications and mounting and installations of all experiment packages and supporting subsystem components. Vehicle design limitations shall be determined and performance restrictions shall be recommended as a result of completed dynamic analyses.

f. Structural dynamic analyses will be performed to define load, acoustic, shock and vibration requirements, and conditions for experiment carriers and subsystems. Necessary structural response parameters and dynamic models will be established for Guidance and Flight Control analyses.

g. Full scale mockups and 1/10 scale models will be prepared as a three dimensional systems integration design layout tool for new or extensively modified carriers and cluster configurations.

h. Handling equipment and GSE of all new or modified carriers will be identified and design criteria will be established as required.

i. Materials - Plastic and elastomeric materials must be studied to determine effects of the applicable environments. Characteristics such as deterioration, outgassing, corrosion, erosion, flammability, compatibility, as well as structural properties with and without these environments will be tested. Design data will be generated and incorporated into appropriate specifications on the basis of such tests.

j. Criteria generated by astronaut life support and operational analysis will be used to define and produce hardware modifications. Living and laboratory facilities, will be provided. Detail drawings to control fabrication, testing and installation will be produced.

k. Prepare detail instructions to be used in passivating or activating spacecraft systems per the mission operations requirements. These instructions will cover items such as sealing tank outlets, setting up experiments, purging, depressurization of tanks, seal-off compartments, install fans, lights, etc.

l. Design meteoroid and radiation shielding provisions as required for crew, mission protection.

m. Develop and maintain a detail accounting system to control and record mass properties data for conception through post flight analysis needs.

3.2.2 Electrical Power and Distribution Design Tasks

a. All subsystems and experiment electrical power and distribution requirements for each mission will be identified and documented. Carrier and cluster orbital parameters associated with each mission will be summarized. Load analyses will be used to determine power profiles from which subsystem design will be established.

b. After selection of the appropriate source power, analysis will be performed to insure all mission conditions can be met by the subsystem selected. Normal and worst-case analyses and reliability analysis of each subsystem operation will be conducted. Studies will be made to investigate failure modes, need for redundancy, minimization of connections, methods to ease assembly and checkout procedures, grounding and isolation optimization, and susceptibility to electromagnetic radiation interference along with techniques for suspression. In the case of solar array power sources the array output profile will be established with respect to cluster maneuvers and orbital parameters.

c. Battery applications will be evaluated to establish safe thermal environmental and operating conditions. Secondary battery usages will be analyzed with regard to charge rates, overcharge control, depth of discharge, and cycle life. Load and charge control parameters will be investigated with regard to battery and electrical bus performance.

d. Interface control documents, schematic diagrams, and load analyses will be prepared and maintained to show functional operation related to each carrier and cluster configuration.

e. Develop electrical illumination design to meet the mission requirements.

f. Develop the electrical cabling, shielding, grounding, signal separation, connectors, etc. required to meet the mission operational requirements and in consonance with the fail-safe and redundancy requirements.

g. Develop electrical system test and checkout criteria, sequence and controlling documentation.

h. Prepare wiring diagrams, schematics, block diagrams and logic diagrams required to effect the subsystem design of a power source and its distribution system.

3.2.3 Guidance and Control Design Tasks

a. Analyses shall be performed to list all experiment pointing requirements, spacecraft solar orientation requirements, and to establish modes of operation and operational requirements for rendezvous, docking and maneuvers. Detailed timelines for vehicle attitude and maneuver requirements will be prepared.

b. For each configuration, the capabilities of the carriers will be evaluted against the envelope of experiment and operational requirements.

c. A control system stability analysis will be conducted for those configurations which differ significantly from the Apollo configurations.

d. Modifications to existing guidance and control systems will be specified as required to satisfy experiment, operational, or stability requirements.

e. The necessary guidance and control constants and flight program parameters will be determined for each flight.

f. A budget of attitude control propellants will be generated for each vehicle. It will be based on the attitude timelines and will identify add-on requirements.

g. Systems functional schematics and block diagrams will be generated.

h. Compute the effects of gravity gradient and other disturbance torques on vehicle attitudes and resulting RCS propellant requirements.

3.2.4 Communications Design Tasks

a. Conduct analyses to determine the adequacy of antenna coverage on each carrier. This study will include consideration of carrier orientation and mission profile.

b. The inter-crew, inter-vehicle, and vehicle-to-ground communications requirements for each mission will be defined. A design for each carrier will be prepared and add-on equipment requirements will be identified. The number and purpose of command links required for the carriers in each AAP mission will be defined.

c. A Mission Support Plan for each type of mission will be prepared. This plan will summarize how the R.F. links are utilized by the ground communication system and includes the utilization of the NASCOM for data relay to control centers.

d. Electromagnetic compatibility (EMC) control of design, test and operations will be established. Engineering drawings and test results will be reviewed and requirements established for corrective action as required.

e. Electromagnetic analysis will be conducted and plans for Electromagnetic Interference (EMI) testing for each carrier or combination of carriers used on the particular missions will be prepared.

f. Communications requirements will be coordinated with Data Management, Displays and Controls, Systems Engineering, and Crew Operations to assure efficient interface design and compatibility for each mission.

g. Systems functional schematics, wiring diagrams, interface drawings, and block diagrams of each type of carrier system will be generated and maintained.

h. Develop planning for execution of integration tests on the spacecraft communications subsystems.

i. Prepare an operation profile for the communications subsystems for the following parameters:

Prime Power
Transmitter Status
Command Link Status
Antenna System Status

j. Perform an analysis for the reactivation and storage of the communications subsystems. Write detail instructions for the reactivation and storage process.

k. Conduct a study to determine the best means for providing communications subsystem backup in the event of RF failure on any carrier.

l. Prepare a requirements list to define specific crew tasks needed to operate the communications subsystems during the mission. Coordinate this task with crew operations and displays and controls groups.

m. Prepare physical and electrical layout drawings and data for use in mockups and prototypes. Support the developmental test program.

3.2.5 Data Management Design Tasks

a. A data management system capable of acquiring the data required from the mission and the add-on equipment to supplement existing carrier systems will be identified. Total mission data requirements will be established, consolidating experiment data requirements with housekeeping and operational needs. Special safety and hazard monitoring systems for experiments will be identified. The requirements for designing and installing a hazard detection system shall be specified.

b. Analyses and tradeoff studies will be performed to optimize systems design.

c. Studies on optimum use of the unified S-band system will be conducted for experiment data transmission after final experiment requirements have been defined.

d. Data management and command requirements of all experiments and support systems must be compiled.

Measurement requirements must be defined in terms of measurement source, sampling rate or frequency response, real time and storage requirements, and mission phases during which data is required. The number of commands required by experiments, support systems, and the data management system must be determined and documented. Requirements will be maintained in agreement with current source documents, and will be coordinated with data management system capabilities.

e. AAP missions that involve multiple carriers docking together, operating independently and conducting revisitations to an orbiting station will be analyzed for an optimum experiment data management system. A system with a central handling point capable of being "plugged into" by other vehicles will be analyzed for feasibility. Such systems must bring experiment data into the multiplexing, recording and transmitting equipment through simple interfaces from each carrier to reduce redundant equipment that is provided for each vehicle. Centralized and standardized controls for data handling will be evaluated for reduction of EMC problems resulting from multiple RF links.

f. Characteristics of all time signal generators currently included in the baseline configurations of mission carriers will be investigated. The degree of correlation between the various time signals will be determined. Any incompatibilities with data requirements shall be identified, and techniques for resolution will be determined.

g. The feasibility of providing a single voice recording facility to serve the needs of all docked carriers will be examined. Consideration shall be given to reliability aspects, power consumption, and interface complexity.

3.2.6 Displays and Controls Design Tasks

a. A standardized and integrated display and control system will be defined to support experiment operations and status.

b. Equipment modifications and add-ons will be identified.

c. Systems functional schematics and block diagrams of each type of carrier system will be generated.

3.2.7 Propulsion Design Tasks

a. Identify RCS and SM main propulsion system operational and experiment constraints, establish propulsion system duty cycles, determine propulsion system operational requirements and based on mission objectives, predict propulsion system propellant usage.

b. Conduct mission operational analysis and propulsion systems thermal analyses.

c. Identify and resolve propulsion system mismatches and provide list of add-ons. Identify any new propulsion interfaces. Define requirements for propulsion system modifications and/or new systems.

d. Conduct propulsion systems reliability analysis.

e. Conduct thermal control systems reliability analysis.

f. Prepare and maintain new and modified equipment hardware specifications.

g. Prepare propulsion system development test and checkout requirements for new or modified systems.

h. Evaluate the exhaust gas impingement and/or deposition conditions that will exist as a result of firing the various propulsion systems that are to be fired during docking and stabilization of the cluster. Exhaust gas effects on such things as solar cells, thermal control coatings and nearby structure should be considered.

i. Perform thermal analyses on propellant or gas tanks and lines for long duration missions.

j. Conduct long duration storage analysis for the teflon bladders used in the CM, SM and LM RCSs.

k. Analyses and tradeoff studies will be performed to optimize systems design. Special consideration will be given to; the effects of thermal and slosh cycling on propellant bladders, propellant decomposition over extended periods of storage, and propellant diffusion and possible mixing in pressurization systems.

l. Prepare detail instructions for safing or deactivating propulsion systems that will no longer be used.

m. Systems functional schematics and block diagrams will be prepared.

3.2.8 Life Support Systems (LSS) Design Tasks

a. Establish subsystem design and identify add-on equipment. Define interface requirements for LSS/experiments, LSS/carriers and LSS/GSE.

b. Define new or modified hardware requirements.

c. Analyze and define atmosphere control requirements. Consider two-gas supply problems, CO_2 and contaminant buildup humidity control leakage, and astronaut denitrogenation prior to EVA performance.

d. Design and develop water management system. Analyze and compare water storage versus water reclamation. Review water management for life support, thermal control, and electrical power areas to insure adequate onboard water supply and to avoid overlapping uses of water sources.

e. Define food and feeding requirements.

f. Define waste management system requirements.

g. Perform crew comfort analysis.

h. Define normal and emergency LSS operating procedures.

i. Develop requirements for experiment life support systems.

j. Perform analysis of LSS in support of mission experiment contingency planning.

k. Perform resupply analysis for life support systems relating to all mission operations by defining resupply commodities and quantities and transfer techniques.

l. Provide liaison with MSFC experiment developers, carrier contractors and support contractors to coordinate system design and integration procedures.

m. Define development, qualification and acceptance test and checkout requirements for experiment support subsystem (LSS).

n. Generate systems functional schematics and block diagrams for each carrier affected and for orbital cluster configurations.

3.2.9 Thermal Control System (TCS) Design Tasks

a. Conduct experiment thermal analysis to determine heat dissipation rates, operating and storage temperature requirements, temperature control design and operational constraints.

b. Analyze experiments for thermal integration into carriers and to evaluate overall thermal design of experiments and packaging influences.

c. Analyze Experiments to Carrier thermal interface requirements to define functional and physical interfaces; to evaluate experiment mounting requirements; to define all experiment support hardware for thermal influences on carrier TCS such as heat dissipation rates from electric solenoids, meters, gages, motors, G&N, etc.

d. Conduct carrier thermal analyses to define housekeeping loads (electronics, electrical, pumps, etc.); to define metabolic requirements for loads; to analyze exterior heat gain or interior heat loss from carrier.

e. Analyze carrier to carrier interfaces to determine thermal influence; to study materials to be used between interfaces; to determine effects of separating physical and functional interfaces on thermal control system.

f. Analyze TCS Operational Constraints on Integrated System to describe physical or functional interferences and to analyze effects of electrical interference, radio or navigation or guidance interference.

g. Conduct Carrier/Experiment Mismatch Study to; analyze experiment heat loads and dissipation rates, analyze carrier heat loads and TCS capability, perform mismatch analysis and make recommendations, and to define carrier module add-on equipment.

h. Write TCS design criteria to 1) document TCS requirements including NASA input and the ground and airborne parameters considered and 2) present general requirements and systems functional schematics and block diagrams for each carrier and orbital cluster configurations.

i. Prepare and maintain schematics, design drawings and flow diagrams on all new or modified thermal control system equipment.

j. Prepare and maintain instruction documents to define specific crew tasks needed to operate the thermal control system during the mission and to activate or passivate the thermal control system.

k. Perform thermal environmental analyses to assess requirements for maintaining batteries within required storage and operational temperature limits.

l. Perform thermal analyses to determine solar array operating temperatures and methods of control as cluster orientation and orbital parameters vary.

m. Determine requirements for ordnance devices and protective measures associated with ordnance.

n. Establish criteria for experiment ordnance items.

o. Review experiment packages for ordnance devices and necessary compliance with safety requirements.

3.2.10 GSE and Facilities Design Tasks

a. Analyses will be performed to establish GSE requirements in support of the AAP mission hardware flow. Differences between existing Apollo equipment and new requirements will be identified.

b. GSE design criteria will be established for:

1) Mechanical Systems

2) Electric/Electronic System

3) Structural Modifications

4) Handling, transportation and stowage of equipment, carriers, etc.

5) Propellant, commodity, cryogenic fluid servicing equipment

6) Environmental control equipment

c. Define GSE required at each integration test location to satisfy servicing, checkout and maintenance requirements based upon experiment identification, experiment support subsystems, and experiment module checkout and maintenance.

d. Determine requirements for electric power and power distribution to satisfy GSE, carrier and experiment power consumption during ground tests and operation.

e. Review communication and data management interfaces with GSE to insure adequate checkout capabilities. A continual effort will be maintained to upgrade the GSE to improve costs and schedules, to incorporate technological changes, and to measure or check out new parameters. These modifications will come about as:

1) The experiments become better defined.

2) The analysis of early mission results will introduce or delete parameters requiring checkout or servicing.

3) Anamolies occur which must be resolved.

4) The sharing of equipment between programs, missions or facilities can be effected.

5) Differences in missions will require changes to servicing, checkout, or handling parameters.

6) Changes to the carrier subsystems will cause changes to the ancillary equipment.

7) Experiment support GSE developed for the earlier missions will be analyzed for subsequent usage in the program.

f. Determine the amount of available space on the MSS, the umbilical towers, umbilical booms, and MSS platforms for routing of new service lines and for the location of mobile experiment/carrier equipment. The space availability and loading capability of booms and platforms will be investigated to define the modifications required.

g. Facility requirements will be established to support the AAP missions at KSC, MSFC and any other test or checkout area as required.

h. Criteria for new or modified facilities will be established on a Facilities Plan.

3.3 Mission Peculiar Tasks - Martin Marietta Corporation Report ED-2002-59, Mission Feasibility Analysis, AAP Unassigned Missions, evaluates each of the groups of flights in AAP for which MSFC has integration responsibility. This evaluation is made to determine basic feasibility of the mission and experiment grouping planned by NASA. During the course of this analysis potential incompatibilities were identified. This section defines some of those problems and identifies the special design tasks that are required to reach a resolution to permit the subsequent evolution of subsystem design in a timely manner. Certain of these problems exist on several missions. They are discussed here only on initial occurrence.

3.3.1 Low Earth Orbit Mission Problems and Design Tasks - Mission AAP 5/6/7/8 consists of reuse of the S-IVB workshop and ATM from the previous mission AAP 1/2/3/4 plus a set of stellar astrophysics experiments, and a set of atmospheric physics experiments. The stellar/physics experiments are essentially searches of the celestial sphere for radiation of various wavelengths of which data will then be used to pinpoint more in-depth observations of interesting points for later missions using instruments with higher resolution. The atmospheric physics experiments represent an evaluation of the active and passive sensors to be used in studying atmospheric structure. These experiments are capable of unmanned operation, but the purpose of operation of these experiments on this mission lies in developing operational systems for subsequent mission use in northern and southern latitudes using polar orbits to survey and measure atmospheric properties which determine weather patterns on the earth. As in all the missions, study of man and his abilities in long term space "soak" continues. Crew motion effects on pointed experiments need further work as do contamination studies on the ATM and possibly the stellar astrophysics and atmospheric physics experiments. ATM alignment, the role of the astronaut in ATM operation, and thermal distortions as the ATM goes behind the earth and back out remain as major challenges to early ATM operation.

On Flights AAP 9/10/11/12/13/13A, an S-IVB is again converted to an orbital workshop and a new ATM put into service. Based on the results of earlier missions, the S-IVB conversion should provide decisive data on the conversion and habitability of the S-IVB LH_2 tank. ATM-B comes at a time of decreasing solar activity and hence provides excellent relative data on solar activity. Contamination and pointing problems will have been thoroughly evaluated from the previous missions and the experimental data will be of high quality. A remote earth sensors experiment group, Applications B, will also be flown. These experiments sense the earth's surface over a spectral range including the visible, IR, and UV. This group of experiments will look mostly at Africa and South America and parts of Southeast Asia and Australia. This will be primarily a calibration and sensor development test of such a system for future long term operational (unmanned) flights in which the natural resources of the earth are surveyed and cataloged for action by agencies interested in food, forestry, geological, hydraulic, oceanographic, and mineral resource management. Ultimate use as an operational system will involve all latitudes, not just those below 29°. Biomedical and technological objectives remain much as in previous missions, with the addition of some biological experiments.

3.3.1.1 Experiment Grouping Incompatibilities - NASA guidelines have presented experiment groupings for individual missions that are beyond the available payload capability of the individual flights of the mission. For the AAP 9/10/11/12/13 low earth orbit, long duration mission, weight constraints were not compatible with the complete experiment list. Accordingly, the following experiments were tentatively moved to alternate flights:

Exp. No.	Title	Remarks
MSFC 47	Multisphere Satellite	Moved to AAP 6
-	Project Thermo	Performed on AAP 27
M426	Condensing Heat Transfer	Moved to AAP 27
-	Electromagnetic Radiation (EMR)	Performed on AAP 25, AAP 6

Several flights presently show negative payload margins. Since payload weight always tends to increase as better definition of system hardware is completed, this item is considered a major program problem. Several approaches are available to resolve this condition. Although the most obvious is to decrease the experiment assignments, other avenues appear open to examination. The reduction in the amount of expendables required on the long-duration missions would result in significant weight savings. The prime candidates for investigation are the atmosphere supplies and associated tankage, and the makeup water for the environmental control and life support systems. Support equipment requirements for experiments perhaps could be reduced extensively without compromise to experiment performance or redords.

The amount of atmosphere resupplies which can be stored cryogenically appears to be limited by state-of-art development in the sizes of tanks under consideration. Cryogenic storage duration is also limited. As a result, most of the resupplies must be stored as gas in the heavier gaseous storage tanks (for a given amount of gas, cryogenic tank weights are about one-quarter those of gaseous tanks). A reduction in carrier leakage will also directly reduce the heavy gas storage tank weight. On longer flights, water recovery systems will be used, and fuel cell water will not be available. Makeup water supplies are required to compensate for recovery system inefficiencies and miscellaneous overboard losses. Preliminary water balance analysis indicates a significatnt loss through the molecular sieve system. Use of a more complex molecular sieve system to permit water recovery instead of overboard loss could effect a significant overall saving. There are some expendables, such as food and metabolic oxygen, that cannot be significantly reduced. Data gathering, recorders, and operating equipment for experiments must be evaluated to determine if sharing of equipment or by a better grouping or related experiments could reduce the amount of experiment support equipment required.

The preceding approaches are generalized as design tasks required to solve weight problems as indicated.

a. Evaluate alternate carriers capable of being introduced to the mission that would enable the mission to be performed within weight limitations.

b. Analyze experiment support subsystem add-ons for optimized weight solutions.

c. Evaluate the feasibility of reduced mission duration in order to constrain consumable weight to be compatible with available payload capability.

d. Evaluate alternate mission profiles capable of satisfying experiment group requirements, e.g. lower mission altitudes, elimination of docking maneuvers to conserve RCS propellant weight, redistributing individual flight spacecraft equipment to other launches having positive payload margins, etc.

e. Regroup experiments to other missions that have the required payload margin.

3.3.1.2 Solar Array Analysis - Future missions will make considerable use of large solar arrays. Past experience on solar arrays has not included arrays of the sizes required for these missions; there are many design tasks attendant to their utilization. Consideration must be made for the batteries on discharge depth, cycle life, charge rates, thermal environment, etc. Consideration must be made for the solar array on thermal environment, pointing requirements, contamination, radiation degradation, etc. Results from earlier missions and testing programs must be analyzed and modifications made, as required, to gain the required balance of design. Consideration must be given to sizing arrays to adequate charge rate for the batteries and adequate protection against battery overcharging must be included in the design. Analysis will be required on the solar array system to determine shadowing effects of the cluster unique to the particular mission,since the power output of the solar array can be significantly reduced by shadows. Similarly, the effect of solar array shadowing on the thermal control of the orbiting spacecraft must be evaluated.

3.3.1.3 CSM/AM Power Interface When Two CSMs are Docked - Flights 1/2/3/4 have only one CSM docked to the cluster at any given period of time. Flights 5/6/7/8 and subsequent flights have two CSM docked with the cluster for certain time periods of the mission. Additional analysis will be required to determine the effect of this requirement on the Multiple Docking Adapter and other carriers of Flight AAP 2. An additional interface could be required on Flight AAP 2 of this cluster configuration that would not be used during flights 1/2/3/4 but would be required during flights 5/6/7/8.

3.3.1.4 Connection of CSM/AM Power Interface - The connection of power from the AM to the CSM has generally been considered through the CSM ground umbilical when the CSM is docked with the cluster.

Studies should be made of:

How this connection will be made by EVA.

How the cables mating with the CSM umbilical will be stored until hooked up.

How the cabling will be supported after hook-up.

How this interface connection can be quickly disconnected in an emergency situtation.

Hookup of the power interfaces between different carriers at different times have problems unique to the individual missions and all should be analyzed.

3.3.1.5 Battery Life - The longest known available wet stand time for silver-zinc batteries is 90 days. The life of the batteries is marginal for a 90-day mission if contingencies arise or if the 90-day mission is not a lower boundry.

Studies are necessary to determine the actual requirements. Testing programs are required to determine lower boundary "wet stand time" with the required reliability and confidence margins. Modification and development may be required to satisfy the requirements. Design goals should be established to increase the useful life of silver-zinc batteries to a life of 120 days to allow for launch time, extended hold periods during launch and other contingencies.

3.3.1.6 Battery Temperature Environment - Batteries operated in a low-temperature environment will have a loss of output, and those operated in a high-temperature environment will deteriorate at a faster rate. These temperatures must be clearly defined.

Analysis must be made to compare the required temperature environment of the batteries used in these missions to the expected temperature environment in which the batteries will operate. If the expected environment temperature range is greater than the required range of the batteries, environmental control must be provided in the area of the batteries to insure proper operation.

3.3.1.7 Storage and Reactivation Requirements - Certain spacecraft subsystems will require a useful life of several years on long duration missions that are reactivated after a period of dormancy.

Design development tests will be required on the earlier missions to improve reliability and maintainability of these operating subsystems. Feedback data from the earlier missions will be analyzed to determine the environment and requirements governing the design. The effects of long term exposure to space environments must be determined such that reactivation can be accomplished with minimum effort. Design must be made that provide for simplicity of operation and maintenance and for reliability under these conditions.

3.3.1.8 Definition of Requirements for LCSM Missions - Missions involving the use of the 90-day LCSM must find alternate means for satisfying certain functional requirements previously satisfied by CSM systems. This is necessary because the LCSM systems are essentially deactivated to preserve their life capability for the deorbit functions.

Design tasks are necessary to determine more precisely the extent of quiescence of the LCSM. Similarly, provisions must be designed into the remainder of the orbiting configuration to fill the void left by deactivating LCSM systems.

3.3.1.9 Life Limitations on Propellant Storage Bladders - On the teflon bladders used in storage tanks for CM, SM, LM reaction control systems, material sensitivity to propellants, temperatures and radiation will cause degradation of the teflon bladder. The helium will permeate into the propellants during extended periods of exposure. The limit of duration has not been established beyond 14 days. Evaluation of alternate bladder material, thicknesses, processes, sealing techniques will be required. Other research studies and development testing will be required to improve existing designs and/or to implement new design concepts.

3.3.1.10 Engine Heater Requirements - Existing engine heaters do not prevent propellant freeze-up when shading of the engine occurs for periods of three to four hours and longer. Design tasks shall evaluate alternate means for preventing propellant freeze-up and for reactivation systems exposed to freeze-up conditions. Passive means shall also be considered to alleviate these conditions.

3.3.1.11 SPS-Propellant Pressurization System - For engine shut-down periods in excess of 21 days it is possible for fuel and/or oxidizer to migrate through the helium check valve assembly and ignite in the helium portion of the propellant fuel system or ignite when propellant flow commences.

Hardware designs must be modified to insure adequate protection from this possibility. Additionally, backup reentry impulse capability must be provided to preclude sole dependence upon the SPS for this function.

Another problem area or potential problem area, deals with the possibility of propellant leakage from the SPS. Mission success and crew safety are dependent upon SPS restart capability if redundant reentry impulse provisions are not available. Accordingly, some means of leak detection and propellant quantity gaging in the SPS tankage is required. Such a system must be capable of gaging propellant quantities in the absence of gravity.

3.3.1.12 Standardized Propulsion Configuration for CSM and LCSM - An area of concern for several flights is a need for additional SM-RCS propellant over CSM and LCSM capability. Proposed solution to this problem is expected to result in a series of optimum modifications as a function of increased capability desired. However, since it would be undesirable to modify each vehicle on an individual basis, one or possibly two modifications would be selected for use.

3.3.1.13 Experiment Data Handling - The weights and volumes of return data for all the experiments on each mission must be determined in detail, including exact dimensions. These packages must then be checked with available spaces in the CM to ensure compatibility. The effect of the stowed data on astronaut maneuverability, CM weight and center of gravity and hence, reentry behavior, will be carefully considered. The volume of data to be returned by telemetry from the cluster experiments should be compared with MSFN capability. It may turn out, for example, that the amount of housekeeping data issued from the many experiments of a complex mission may be prohibitively large. It may limit the primary experiment data. One solution may be to use some type of on-board data processing and/or checkout system to monitor the bulk of the experiments, feeding only go/no-go type of information back on the downlink when interrogated. This would free the telemetry system for primary data.

Longer duration missions will generate larger data quantities in weight and volume. Accordingly, the requirement will exist to return data in excess of the command module's return capacity and/or prior to the command module scheduled reentry.

Design tasks must include development or adaptation of data return cassettes or capsules to satisfy mission requirements. Spacecraft stowage provisions, loading provisions, launch and guidance provisions, command provisions for the data return device must be determined and provisions must be designed for satisfying these requirements.

3.3.1.14 Experiment Pointing Accuracies - The earth oriented series of experiments such as AAP-A, AAP-B require relatively accurate pointing to the local vertical or extended periods. It may be necessary to add a complete local vertical control system or to use the ATM-A control moment gyro (CMG) system. Use of the CMGs will require that they be capable of reactivation and that they accept signals from a local vertical sensing system.

Several of the Electromagnetic Radiation (EMR) experiments require accurate pointing to stars. They also require stabilization at very low rates for several hours at a time and, at other times, scanning maneuvers. The existing guidance, control, and reaction jet systems cannot satisfy these requirements. Study tasks will be required to explore alternative solutions and select a solution.

3.3.1.15 Orbital Inclination for Earth Resources Experiments - The meteorological and earth resources experiment groupings (AAP A and B) are currently shown on flights which have inclinations of 29°. From an experiment standpoint, a higher inclination, in the order of 40 to 50° or more, is desirable. This, however, presents a problem in terms of the range safety picture due to land mass overflight required to achieve such inclinations. Further, payload weight restrictions may become paramount at the higher inclinations, particularly on the longer duration flights when extra expendables must be carried, or if a dog leg boost trajectory is required to solve the range safety problem. Studies will be accomplished weighing the various factors involved to determine the most desirable mission plan for these experiment groupings.

3.3.1.16 Crew Workload - Present analysis indicates that a crew workload problem exists on at least several of the low-earth orbit missions. Techniques, procedures, and system designs must be developed to insure maximum return from each flight commensurate with reasonable crew workload capability.

3.3.1.17 Human Factors - Since a basic objective of AAP is to determine long-term manned space flight capability, the integration of biomedical experiments on each flight and the maintenance of continuity of testing on succeeding flights is a problem. Of major consideration is the development of biomedical experimentation techniques that are acceptable to the crew. An approach to the work-sleep-relaxation duty cycle and physical environment must be developed that will permit future long-term interplanetary travel.

3.3.1.18 Crew Safety - Provisions must be developed to ensure that catastrophic fires within the orbital spacecraft will not occur. Fire detection and suppression techniques must be analyzed to determine the most feasible methods, both automatic and crew-operated.

3.3.1.19 Dynamic Characteristics of Cluster - As an alternate backup mode of operation in performing the ATM experiments, the hard and soft-tethered LM/ATM methods must be investigated. Complete dynamic response characteristics of the cluster configuration when the LM/ATM is tethered to the S-IVB/MDA/AM-CSM vehicles must be determined. Proposed dynamic vibration nodal analysis results will be used in associated guidance pointing accuracy studies.

Also, the requirement for accommodating artificial "g" experiment M484 in the orbital workshop during Flights 6 and 7 will require an extensive structural dynamic analysis of the mechanics of spinning up, in orbit, of the CSM attached by cables or hard-docked to the S-IVB stage. Studies will be completed for definition of dynamic cable characteristics of soft-docked configurations. This analysis requires data coordination with the Guidance and Control analysis activities.

3.3.2 Synchronous Orbit Mission Problems and Design Tasks - The synchronous orbit flights represent a start of a space station for stellar astronomy. As such, the S-IVB workshop activation carries a special significance as does the evaluation of radiation biomedical effects at this altitude. The laser communications experiment, performed where continuous line-of-sight contact with the ground station is possible, permits the evalation of a key communications technique for deep space use (for example, Mars flyby). Several particle physics experiments allow evaluation of the flux of such particles sensibly above the high intensity magnetosphere (high energy heavy particles will not be affected by the earth's field at this altitude). The maser clock relativity experiment requires vehicle altitude information beyond the present capability of the S-band system using phase-lock-loop techniques. Finally, we note that the lack of atmosphere makes the contamination problem again important, and careful study will be necessary for the synchronous orbit case.

3.3.2.1 Space Radiation Exposure - The trapped electron and solar proton radiation environments on synchronous orbit can deleteriously affect the astronauts and experiments. An investigation must be made to resolve the uncertainties that exist concerning the radiation environment at synchronous orbit. At this altitude, the fringe of the Van Allen radiation belt is encountered and the weak geomagnetic field that exists there provides only a small amount of magnetic shielding effect from solar flare radiation. Additionally, starting in 1968, the solar flare activity will be at the maximum of its 11 year cycle. To work within these envirommental constraints, the following parameters will be analyzed and traded-off to effect a technically feasible mission:

a. Provide radiation protection for the astronauts and experiments.

b. Continue the research that will better predict periods of maximum solar activity and permit the scheduling of missions at the most opportune time.

c. Provide propellants for maneuvering to an alternate orbit to ride out the solar storm.

d. The radiation dose will be monitored and when the levels reach specified levels the mission will be terminated.

3.3.2.2 Meteoroid Hazards - The AM Solar Array from Flight 17 may not be suitable a year later for usage on Flight 36 because of damage caused by the deep space meteoroid environment while on synchronous orbit. The spacecraft will not have the bulk of the earth as a shield at synchronous altitude; consequently, the rate of meteoroid impact on the spacecraft will be about double the rate at low altitude. Analysis to predict the degree of protection required will be based on previous mission results. Abnormal activity will result in termination of the mission. Means for surviving meteoroid impact and effecting repairs to meteoroid damage must be analyzed. Similarly, additional meteoroid protection must be designed for the spacecraft.

3.3.2.3 Spacecraft Particulate Matter Cloud - The astronauts on past flights were consistently unable to see stars of less than first magnitude due to light scattering from the sun on particulate matter emanating from the spacecraft in the form of:

- Spacecraft atmosphere leaks (oxygen, nitrogen, water vapor, CO_2, CO)

- Gaseous or frozen material originating from disposal of waste materials

- Exhaust products from RCS thrusters

This problem is accentuated in a synchronous orbit flight due to the extended length of time the spacecraft and experiment package will be in sunlight.

Study will be required to select the types of instruments that would be acceptable in such an environment. Spacecraft constraints that would increase the chance of obtaining useable and valuable data from a given group of experiments will be defined. These constraints will include:

- Type of attitude control method required to minimize local contamination

- Limit leak rate from the life cell

- Recommend methods of waste disposal for minimizing local contamination

- Possible elimination of the IM water boiler

3.3.3 Low Earth Orbit - Mission Module Workshop (MMWS), Problems and Design Tasks - The Mission Module Workshop appears here as the first ground outfitted space living and working quarters and as such is a prototype low earth orbit space station. Project Thermo solves many of the zero-g fluid problems essential to assembly in orbit and long term space operation of liquid management systems. There are serious questions about the effects of crew motion on these experiments, but we do not feel that these will be decisive. They can be overcome easily by the time Project Thermo goes into orbit. With a 50° orbit inclination AAP-A and/or AAP-B should be aboard this flight if we are to exercise these sensors and the subsequent data usage systems against the United States and Europe, where we have accurate knowledge of resources and weather information for extensive ground truth information.

3.3.3.1 Basic Design - Both MSFC and this contractor have already identified several concepts for a ground outfitted workshop, but the problem still exists to arrive at a preferred or recommended configuration. Until this is accomplished, subsystem problems cannot be identified and evaluated in depth. One approach involves the refurbishment of an S-IVB structure into suitable workshop accommodations. Although this configuration now appears acceptable, comparative analysis must be performed against several other alternatives.

3.3.3.2 Electrical Power Demands - A trade study will be performed to form the method of power generation to be used on long duration, high power usage missions. Development status of radioisotope thermoelectric generators and other potential sources will be investigated. Factors to be considered in selection of a final system will include reliability, availability, cost, weight, vehicle restraints, handling procedures, and life. Specific factors that must be considered on the radioisotope powered closed Brayton cycle system include as a minimum:

a. Costs

b. Radiation Protection (Ground Handling and Airborne)

c. Thermal Control

d. Space Availability and Utilization

e. Status of Development (Reliability, Maintainability, Efficiency)

f. Weight vs Performance Penalty

Similarly the radioisotope thermoelectric generator will be compared to a solar cell system study which will, as a minimum, cover the following parameters:

a. Cost

b. Orientation Problems

c. Drag Effect

d. Space Utilization and Availability

e. Weight vs Performance Penalty

Currently the photovoltaic systems appear to be the major contender on the basis of scheduled availability.

3.3.3.3 Conditioning and Exercise - For long duration orbital stay times crew members will require means to maintain their physical fitness. The centrifuge system was selected as the technique for maintaining the conditioning and physical fitness of the astronauts in a zero gravity environment. Studies will be made in subsequent phases to incorporate state-of-the-art developments for conditioning and exercise. Parameters to be considered are:

a. Creation of an artificial "g" environment for the MMWS by rotation of the complete cluster.

b. Gymnasium-linear accelerators (trampolines).

c. Isotonic exercises.

d. Centrifugation

3.3.3.4 Project Thermo - This experiment was assigned to this mission due to a weight incompatibility with its original vehicle assignment. The stringent operational constraints for this experiment require that the feasibility of placing it on this mission be verified at an early date.

Some of the specific areas requiring study are:

a. How can the longitudinal and lateral acceleration and attitude control requirements best be provided? The Project Thermo acceleration requirements cannot be met by the existing LCSM configuration. The propellant storage and RCS capability will be augmented by additions to the Project Thermo rack. It may be necessary to provide a very accurate, low level thrust acceleration system. The system should be designed to be stable without active, on-off attitude control which would disturb the acceleration level. Crew motions may also distort the acceleration level significantly. If this is true, it may be necessary to conduct the experiment in an unmanned vehicle or perhaps alter this severe experiment constraint.

b. Can the experiment be geometrically rearranged and placed on Vehicle 25?

c. Safety requirements associated with handling and storing the experiment fluids on a manned mission.

d. Can the experiment be best performed on either a manned or an unmanned flight, or is some combination thereof required?

e. Can certain of the experiments be separated from the thermo module to gain advantages in combination with the above study parameters?

f. The provisioning of power for the experiment is beyond the nominal LCSMs present capability without EVA resupply from the thermo rack. A rearrangement of power supplies, commodities, etc. is required to extend the LCSMs 7-day flight capability to 13 days.

3.3.3.5 Project Thermo Propellant Requirements - The LCSM from Flight 27 is required to provide propulsive forces, stability and orientation during Project Thermo experiments. These requirements consume an estimated 4200 pounds of propellant in addition to that required for rendezvous and docking maneuvers.

The propellant capabilities for the Flight 27 LCSM cannot be increased to meet the Project Thermo requirements and the LM-RCS system does not have the engine life capability or proper sizing to meet the Project Thermo propellant requirements. The prime contractor for the Project Thermo experiment is designing a RCS system to meet the requirements for this flight.

Fuel requirements for Flight 25 exceed the LCSM design capabilities by approximately 177 pounds of propellant. Since this is within allowable tolerance accumulated in estimating the mission propellant requirements, no change is recommended at this time. Should future mission estimates indicate a need to increase the current propellant supply capability, a system change would be required to provide the necessary capability.

3.3.3.6 Electromagnetic Radiation (EMR) Experiment - Incorporation of the EMR experiment group to AAP 25 presents a basic layout problem in that all of the available volume on that flight payload is utilized for other experiments. The large volume and attitude orientation requirements of the EMR experiments impose special layout problems. Design tasks to correct this incompatibility must consider:

a. Alternate layout of equipment within the constraints of identified carriers

b. Consideration of altered adapter sections with increased available volumes

c. Consideration of configuration modification of the planned carriers to accommodate the EMR experiment package

d. Consideration of reassignment of the experiment group to other flights

e. Consideration of external pod mounts for experiment groups or for expendables

3.3.3.7 Optimization of Logistic Support Provisions - Optimum choice of on-board commodities must be arrived at through comparative analysis of resupply vs experiment space requirements vs utilization of the workshop over long duration. Studies will be required to determine what the best quantity balance will be for those commodities initially taken into orbit and still leave adequate space for experimentation, considering resupply intervals with a space-limited CSM, that could also be utilized for additional experiment packages.

3.3.3.8 Cluster Configuration - Effort will be expended in optimizing an MMWS design. The use of the S-IVB stage structure for a ground outfitted workshop will be reevaluated in conjunction with any major changes resulting from the studies listed above. A MMWS can be developed that will be more suitable to the mission objectives and/or constraints.

3.3.3.9 Thermal Control - The design of a spacecraft thermal control system that can operate continuously for one year with high reliability and low maintenance is a challenge. The design and development of this system will be a pacing item in the overall mission program.

3.3.3.10 Crew Safety - Analysis of the operating and safety problems involved with potential use of radioisotope electric generating systems in a zero gravity environment must be made to identify constraints and to provide protective measures to insure no harmful exposure to the crew. The problem of sudden decompression with the crew in shirtsleeves must be dealt with in a positive manner. Fire, meteoroid, poisionous gas, concentration and other hazard corrective action and warning problems, must be worked for these missions.

3.3.4 Lunar Surface Mission Problems and Design Tasks - These missions are specifically for geological exploration of the lunar surface. The surface is studied and the subsurface is probed to a depth of 30 feet or so and its structural, chemical and physical characteristics are well covered. The Lunar Scientific Survey Module, the Lunar Survey System and the Emplaced Scientific Station are all involved in each of the three 14-day missions. The principal question relative to the accomplishment of this scientific work relates to the ability of the astronauts to perform the required work. How much can they do and at what pace are unresolved issuea. Biomedical experiments are included in order to access and resolve these questions.

Determination of lunar landing sites is a prime requisite for mission planning, subsystem design, carrier modification requirements determination.

3.3.4.1 Propulsion System - The exposure of the propulsion system to the lunar environment results in potential safety and contamination problems. Deactivation of the LM/Shelter propulsion systems may be required during the 5-day period preceeding the manned landing of the LM/Taxi. The extreme deltas in temperature pose a propellant storage hazard from the unused quantities. If the propellant supplies are vented or inadvertantly spilled, contamination of the experiments, equipment and surrounding area can jeopardize the mission or the astronauts' safety. Design studies are required to effect subsystem capabilities to meet these stringent requirements. Operational constraints to work within these hazards will be determined.

3.3.4.2 Cryogenic Storage - The environmental and operational restraints on cryogenic usage must be defined at an early date. The extreme temperature variations during the lunar day-night cycle impose stringent restraints on cryogenic storage and functional equipment selection. Investigate possibility of extending cryogenic storage time capability by using more advanced tank insulation schemes such as the cooled shield concept used on the Bio-Satellite. In this scheme the boil-off gases near the internal tank temperature are first passed through tubes in the interstitial area between the inner and outer wall and obtain a large decrease in wall transmitted heat. Utilization of this design approach is recommanded for the purpose of being able to extend the present 30-day storage limit of cryogens.

3.3.4.3 Communications - LSSM to shelter communications and navigational problems must be evaluated and traded off because of the problem inherent in lunar line-of-sight due to experimental traverse distances. This line-of-sight problem can also adversely affect astronaut travel-taxi to shelter.

LM Shelter and Taxi command system operation and design must be evaluated and scoped to meet the needs of the presently defined operations.

3.3.4.4 Extra Vehicular Activity (EVA) - The accomplishment of scientific work by the astronaut in the lunar environment is now an unknown or theoretical quantity. Extensive analysis, crew training, biomedical research, will be required. These efforts will be closely associated and dependent on data gathered from the previous Apollo missions. EVA support equipment design will be refined based on earlier operational experience to maximize the effort.

Reliability factors for man-rated operations within this environment must be determined. EVA activity, equipment function, adequate and safe storage of consumables with respect to environment will be subjected to intensive analysis, product development programs, crew training exercises and contingency planning. The 90-day requirement for the useful life of the shelter will be re-evaluated in terms of the environmental restraints and mission objectives. A shortening of useful life can to some extent lesson the design restrictions for all subsystems.

3.3.4.5 Electrical Power Requirements - As for the Mission Module Workshop, the power requirements for the lunar missions demand consideration of all available power sources. The use of the radioisotope thermoelectric generator (RTG) power generation system emphasizes the following problem areas that require priority for an early resolution:

a. Cost and availability of fuels

b. Radiation hazard during handling and operation

c. High heat load that must be dissipated

d. Development of a mission qualified unit that meets the restraints of weight, capacity, safety, cost, reliability, maintainability and volume

All of the factors mentioned above will be considered with respect to mission objectives and experiment requirements. Trade studies, technical analyses, prototype testing, qualification testing, system and subsystem testing will be rigidly implemented to assure compatibility.

3.3.5 Interplanetary Flight Mission - Problems and Design Tasks - The interplanetary mission is planned to soft-land experiment carriers on Mars to observe and measure the Martian environment. The mission will use the Saturn V vehicle launched on an azimuth compatible with the position of Mars at the time of launch.

3.3.5.1 Sterilization - A National policy on planetary guarantine has been established to preserve Mars' ecology. An unsterilized probe could deposit microbes on Mars that might multiply and destroy any future chances of determining if life forms originated on the planet. It is essential that no act be performed that might irretrievably remove a planet as a base for scientific investigation. To enforce such a quarantine, rigid controls and special decontamination equipment will be provided. Special ground support equipment and facilities will be designed to effect this decontamination program. Additional procedures will be developed to control test and checkout requirements.

All aspects of the proposed mission, including interaction of the spacecraft with the interplanetary environment, shall be examined in order to isolate every conceivable source of planetary contamination. Each separate source will be investigated to determine the degree of contamination possible and how to control the contamination to acceptable limits.

3.3.5.2 Accommodation of Spacecraft on Launch Vehicle - The Voyager launch vehicle will have the same configuration as those developed for Project Apollo except that a new nose fairing and shroud is required forward of the instrument unit. The structure required to protect and support the two planetary vehicles, mounted in tandem, will be of larger diameter and longer. This will require modification to all ancillary ground equipment located in this area such that the new geometry can be accommodated. The planetary vehicle decontamination and servicing requirements will result in functional or commodity supply differences also. Analysis and layouts will be made to satisfactorily resolve there discrepancies by modification to the existing equipment and structure.

APPENDIX A

1. DESIGN CRITERIA

The following criteria are applicable to the presently identified AAP missions, Flights 1 through 37. These criteria are general in nature and apply only to a requirement definition phase activity.

Constraints for a particular mission will be listed in the applicable design plan addendum to this document.

1.1 General Criteria - Launch Vehicle, Spacecraft, Experiments, Supporting Subsystems, and Inflight Operations

1.1.1 All carrier/subsystem modifications shall use existing flight-rated and man-rated components and/or assemblies wherever possible. Subsystem add-ons shall be selected in conformance with "Manned Spacecraft Criteria and Standards," NAS-MSC.

1.1.2 Basic Apollo mission perfrrmance objectives shall not be compromised for AAP requirements.

1.1.3 Spacecraft systems shall be designed as integral modular units which can be developed, tested, and checked out as a unit. Spacecraft equipment shall be arranged for easy accessibility such that component replacement requires checkout of only the effected system.

1.1.4 In the event of technical conflicts affecting the following mission characteristics, the relative priorities of the following parameters shall be considered:

a. Probability of success

b. Performance of mission objectives

c. Cost savings

d. Contributions to subsequent missions

e. Safety

1.1.5 Experiments and operations shall not deleteriously affect the operation of a basic subsystem if a single mode failure occurs. Interfaces will be kept to a minimum and as simple as possible. Display or display circuitry failure shall not cause failure to the associated equipment.

1.1.6 Temperature and hazard monitoring systems, with visual and auditory warning devices, shall be used to warn the crew of out-of-tolerance conditions and hazards.

1.1.7 Subsystem connections across pressure locks or hazard barriers shall not interfere with rapid hatch opening/ sealing or the emergency isolation of the faulted area from its adjacent compartments.

1.1.8 Multiple gas life support systems will be used for vehicles that operate with a crew for periods in excess of 30 days. These systems will provide an oxygen partial pressure atmosphere of not less than 3.5 psi. Multiple gas systems will also include provisions for maintaining an EVA-scheduled crewman on 100 percent oxygen for a TBS time period prior to the scheduled EVA start time.

1.1.9 Sufficient test points shall be provided on carriers to enable fault isolation to the module level without removing the module from the spacecraft. Sufficient test points shall be provided to verify acceptable system performance levels after spacecraft mating to the launch vehicle, without either remmving individual modules or disconnecting flight wire bundles or fluid lines.

1.1.10 Penetrations of carrier pressure shells shall be avoided wherever possible. Changes of modifications shall not be made to the SLA except for AM usage. Modifications and additions to basic carriers will retain the SLA/GSE servicing provisions.

1.1.11 Redundant paths for fluid lines, electrical wiring, connectors, and explosive trains shall be located such that an event which damages one line is not likely to damage the other. Similar care shall be taken in the location of redundant components when primary failure modes of adjacent equipment could disable both components.

1.1.12 Subsystems shall be designed such that they can be reactivated following a dormant period. They shall be designed so that expendables can be resupplied. Add-on subsystems shall not degrade the operation of the carrier or the experiments by contamination or the introduction of thermal gradients in supporting structures.

1.1.13 AAP displays and controls shall only be added to spare panels or where non-functional displays and controls can be removed.

Common display and control equipment for multiple experiments and support subsystems shall be utilized to conserve panel space.

1.1.14 Subsystems needed to support experiment requirements shall be provided as a part of the experiment carrier. These subsystems will be self sufficient to the maximum extent possible. Existing subsystem excess capability will be available for use to fulfill experiment requirements. Additional needs may be satisfied by modification of existing subsystems.

All subsystems shall be designed for independent checkout from that of the spacecraft. Commonality of components/assemblies between modified and basic subsystems shall be maintained. Existing piping and wiring from basic carriers shall be retained and used where applicable.

1.1.15 The experiments and support subsystems shall be mounted such that the center of gravity or mass is not shifted sufficiently to cause an instability or major mass unbalance.

1.1.16 A single point failure shall not compromise astronaut or checkout crew safety, cause spacecraft subsystems to fail, or cause a premature mission abort. Spacecraft design to meet requirements shall include, but is not limited to, the following redundancy types:

a. Alternate path/logic

b. Off-line

c. Series

d. Parallel

e. Series/parallel

f. Internally inherent

1.1.17 An EVA may be accomplished from any capable mission carrier. For missions with AMs, all experiment EVA shall be performed from the AM.

1.1.18 Excess data handling capability from existing carriers can be utilized to accomplish AAP mission objectives.

1.1.19 All astronauts associated with a mission operation will be provided with continuous communications.

1.1.20 No ground station network changes shall be made for AAP missions. Housekeeping data to meet mission requirements will be transmitted when the vehicle is in station contact and recorded at all other times. Recorded housekeeping and experiment data will be dumped during over-station transmission.

1.1.21 The VHF band (225 to 260 MHZ) will be available for AAP missions.

1.1.22 TV requirements will be satisfied by the present Apollo operational TV camera. Experiments which require better-quality TV will provide the required system.

1.1.23 Experiments will provide their own signal conditioning. Onboard display of selected experiment parameters essential to operations or safety will be available to the astronauts.

1.1.24 Sector 1 of the service module (SM) may be used to store expendables to extend CSM orbit time or to resupply other carriers.

1.1.25 Modifications of the basic Apollo carriers used for AAP alternate missions will be limited such that the original configuration can be restored within 90 days. Replacement of the carriers by separate modules, such as ATM/Rack in place of descent stage, is permissible.

1.1.26 Interlocks will be employed to prevent incorrect operation when proper operation is dependent on a sequence of events.

1.1.27 Power will be supplied to experiments only at the following voltages: 1) 28 VDC nominal and 2) 115 VAC, 400 Hz 1-phase and/or 3-phase. No special voltage control will be provided for experiments other than that normally required for the electrical system. When considering total power consumptions a 7% distribution loss factor will be added. Each carrier power subsystem will be self-contained if practicable. Experiment power busses will be separated from the normal spacecraft electrical buss.

1.1.28 The experiment data return capability of the CM shall be limited to a net weight of 800 pounds and a net volume of 30 ft^3. Additionally, 266 pounds and 8.25 ft^3 is available for boxes, containers, canisters, refrigerators and support structures. (Ref. NAA report #SID 66-773, Command Module Return Payload Capability, 26 May 1966)

1.1.29 Carrier, support subsystem, and experiment hardware shall be designed to accommodate ground test and checkout requirements. Grounding and bonding techniques will conform to existing launch vehicle/spacecraft techniques.

1.2 General Criteria - Payload Integration, Testing, and Checkout

1.2.1 The design, development, and production of experiments will be accomplished under the management of various NASA centers. AAP experiments will be delivered to the payload integration center in a flight-qualified condition. Experiment developers will provide all specialized test tooling and equipment for checkout of individual experiments.

1.2.2 The integration areas will provide environmental and cleanliness control facilities in accordance with applicable carrier experiment and subsystem manufacturer's specifications. The levels of cleanliness and environmental control for each experiment package or subsystem-modification kit will be at least to the same level requirements of the area of the carrier in which the package or kit is to be assembled. Where more stringent requirements exist, such as for experiment assembly, fixed or portable clean area facilities will be provided.

1.2.3 Experiment support subsystems, GSE, simulators, and test tools furnished by the contractors will be fabricated at the contractor's facilities and delivered to the integration area.

All carrier, experiment, and subsystem components shall have been subjected to predelivery acceptance (PDA) tests at the manufacturer's location.

1.2.4 Checkout of experiment-related functions shall be performed independent of the launch vehicle/spacecraft checkout.

1.2.5 Certified master gages or simulators will be utilized for prefit checkout activity.

1.2.6 Compatibility between experiments and between experiments and their supporting subsystem will be verified during both the functional checkout phase at the PIF and prelaunch readiness checkouts at KSC.

1.2.7 All redundant operating modes will be checked for proper functioning of each redundant element.

1.2.8 No test shall overstress a flight system. Checkout methods and procedures employed at each test location shall, to the maximum extent possible, be identical. Annotated records of all checkout and launch data shall be maintained from the integrating function through launch. Retest of repaired subsystems shall be required. PIF through launch checkout implementation shall be as nearly identical as possible. Vehicle/GSE electrical interfaces shall be verified prior to mating.

1.2.9 Ordnance circuits will be verified through the use of inert devices.

1.2.10 Quantitative testing shall be used during checkout in preference to go/no-go testing. Checkout and fault isolation shall not invalidate the flight electrical cabling. Checkout and fault isolation shall be manually implemented with portable test equipment. Flight cable lengths and equipment layouts shall be duplicated or simulated during acceptance and thermal vacuum testing. Experiments or support subsystems shall not require checkout after 12 hours before launch.

1.2.11 Integrated carrier and experiment checkout will be conducted utilizing on-orbit mission sequence. Mission real-time checkout can be shortened if no compromise of test results occurs.

1.2.12 The completed flight carrier with experiments will not be subjected to flight or qualification-level vibration inputs prior to flight.

1.2.13 All experiments and support subsystems will be subjected to electromagnetic interference (EMI) tests as outlined in the PIF test plan. This test plan will be prepared to implement specification requirements of MIL-E-6051C, MIL-I-6181D, and MIL-B-5087B.

1.2.14 Mechanical and electrical acceptance tolerances will be established at the component, subsystem, and system levels. This requirement will be met by developing pyramid tolerance requirements, starting at the most narrow acceptance limit for component tests and increasing to the widest acceptance limits for system-level acceptance. Thermal vacuum tests for large modules (LM,AM, MDA, etc) will be performed on qualification articles. Carrier articles available from past Apollo program activity will be modified and utilized if practical.

1.2.15 For newly-developed components, off-limit testing shall be planned for those components known to use a high proportionate share of the system's allocated unreliability. Those components shown to be critical to astronaut safety and/or mission success in the failure mode, effect and criticality analysis (FMECA) shall also have off-limit testing.

1.3 <u>General Criteria - GSE and Facility</u>

1.3.1 CSM carriers, modified for AAP will continue to be verified by the ACE-S/C.

LM carriers will be verified at MSFC by the RCA-110A system (AAP #1 through #4 excepted).

1.3.2 The GSE will interface countdown functions with umbilicals and RF test circuitry after launch pad evacuation.

1.3.3 GSE required at the KSC industrial area will make maximum use of data transmission and time-sharing of equipment in order to minimize major hardware requirements.

1.3.4 GSE operation will be verified through test article simulators prior to actual marriage.

1.3.5 The capability to isolate malfunctions to the vehicle or GSE shall be provided.

Remote capability shall be provided to permit relief of dangerous pressure buildup within the experiment-related systems.

1.3.6 GSE failures shall not cause corresponding spacecraft equipment failures.

Functions affecting crew safety or equipment integrity shall be verified through the use of extremely reliable or redundant GSE circuitry.

1.3.7 GSE requirements shall be met by employing existing hardware wherever possible and with minimum modifications to existing Saturn/Apollo GSE and facilities.

There shall be maximum utilization of existing facility resources. The AAP program will be conducted on a non-interference basis with the basic Apollo program.