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MANNED ORBITING LABORATORY
PROGRAM PLAN

VOLUME 2 OF 2

L/Col Kemp

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VOLUME 2

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VOLUME II

PREFACE

MOL SYSTEMS SEGMENT REQUIREMENTS

This volume describes in detail, the requirements and technical aspects of the MOL development program. Based on a general technical description and performance requirements for each MOL system segment, the development, test and manufacturing schedules are discussed in the light of critical design and system problems, and in terms of critical program milestones. The funding requirements reflect the consequence of the critical schedule constraints, technological feasibility and testing philosophy.

For the purpose of a clearer understanding of contractor responsibilities and the tasks that need to be performed in developing the MOL System, this volume is divided into system segments according to contractor involvement. The tasks performed by the integrating contractor and the other associate contractors in areas of test operations, flight operations, recovery, crew training, and other support are included in the major system segment discussions. The support activities treated separately are those which are accomplished by groups other than the major associate contractor.

The sections discussed herein are as follows:

I Laboratory Vehicle, Support Module and System Integration

II Mission Payload System Segment Integration

III Photographic System

IV Gemini B

V Titan IIIM Launch Vehicle

VI Flight Crew Equipment and AMD Support

Each section is treated in terms of general description, operating, concept, critical factors, schedule considerations, and funding requirements. Only the basic MOL program is discussed. All advanced studies and technology activities are treated separately in Volume I, Section V.

SECTION I

LABORATORY VEHICLE, SUPPORT MODULE AND SYSTEM INTEGRATION
(Douglas Aircraft Company)

Part 1. Segment Description and Performance Requirements

A. General

The Laboratory Vehicle is composed of two modules:

1. A Laboratory Module, which is approximately 10 feet in diameter and 19.0 feet long, has an unpressurized section and a 1,000-cubic foot pressurized compartment designed to provide a shirt-sleeve environment for a two-man crew to accomplish a 30-day mission, in a nominal elliptical orbit of 80/180 N.M. at 90 degrees inclination. The pressurized compartment is protected by a meteoroid shield which also houses the space radiator.

2. An unpressurized Mission Module structure, 10 feet in diameter and 37.0 feet long, located aft of the Laboratory Module. This module contains the Mission Payload, which is controlled and operated by the crew from the laboratory.

B. Technical Description

The MOL program involves two separate and distinct Laboratory Vehicle configurations which provide a capability to operate in two modes -- manned or unmanned. In the unmanned configuration, about 1000 pounds of major components and subsystems required for manned operation are removed, some components unique to unmanned operation are added, and provisions are made to enable the Laboratory Vehicle to interface with the Support Module which replaces the Gemini B. A feasibility and conceptual design study has been completed for a Support Module capable of supporting up to 60 days of orbital operation, although the baseline program contains only a 42-day unmanned capability. A 42-day operation is possible with the baseline expendables leading. The Subsystems will be qualified for a 30-day operation only, and the remainder will be flown on an open ended basis. In order to preserve the option for growth up to 60 days' capability, the Support Module will be designed to accommodate this growth and certain critical wearout components in the Laboratory Module will be validated or modified for 60 days operation. Definitive roles and responsibilities for the Support Module have been assigned as follows:

DAC will design and fabricate the Support Module structure, including provision for additional expendables required for the extended mission. Support Module integration is also a DAC responsibility.

GE will design and fabricate the Data Return Vehicles (DRV).

EKC will design and fabricate the film chute used to load the DRV's.

Since most of the other system segments interface with the Laboratory Vehicle, MOL System Integration has been included in this segment and has been assigned to the Laboratory Vehicle contractor.

The Laboratory Module contains subsystems or major elements to enable the crew to do the necessary housekeeping and vehicle management and to operate the Mission Payload. An environmental control and life support subsystem provides a habitable atmosphere in the Laboratory Module, thermal control for the orbiting vehicle, environmental control for space suit operations, and management of water and waste. A two-gas atmosphere consisting of 3.5 psia partial pressure of oxygen and a helium diluent, is maintained at 5.0 ± 0.2 psia. In a backup mode the compartment can be pressurized with 100% oxygen at 5.0 psia. A gaseous oxygen accumulator is provided to maintain nominal cabin pressure in case of accidental decompression through a hole as large as 1 inch in diameter for a period of 5 minutes.

The cabin atmosphere can be controlled to any temperature between 68 degrees and 78 degrees F primarily through use of water-cooled instrument panels. Dew point temperature is controlled between 36 degrees and 60 degrees F. Thermal control is provided by two coolant loops. The internal loop, containing water as the coolant, removes heat from electronic and electrical equipment, Mission Payload equipment located in the Laboratory Module, and the instrument panels and transfers this heat to the external loop through an interface heater to the Gemini B for on-orbit storage, to the waste management system, for waste processing, and to the cryogenic heat exchanger. The external loop, containing Freon 21 as the coolant, radiates heat to space through a radiator. Carbon dioxide is controlled at a nominal 5mm to Hg partial pressure by redundant molecular sieve beds. Trace contaminant control is also provided. For water management, potable water produced by the fuel cells is collected and thermally conditioned prior to delivery for use by the crew. Excess fuel cell water and atmospheric condensate are dumped overboard. Crew waste products are collected using positive air flow control, are processed and the residue is stored in sealed containers.

This subsystem also includes the atmosphere and reactants supply subsystem group which provides storage and pressure control of liquid hydrogen and liquid oxygen for the fuel cells and liquid oxygen and gaseous helium for the atmosphere.

The electrical power subsystem employs three modified Apollo design fuel cells as the primary power source to supply an average net power output of 1.83 kw for 30 days at a nominal 28v dc level with a peak power capability of 4.5 kw. Normal operation consists of two fuel cells operating with the third cell in a "hot" standby condition. The standby fuel cell replaces one of the operating cells through a time sequenced switching operation. However if any single fuel cell fails, the two remaining units can supply the required power including peak loads. This subsystem also has an emergency mode which supplies 28v dc to critical loads from an auxiliary bus.

The data management subsystem consists of the data acquisition, data computation, command, and timing subsystem groups. The data acquisition subsystem group contains the vehicle telemetry which processes all Laboratory Vehicle data. This subsystem group interfaces with the computer and all Orbiting Vehicle subsystems. It provides for the acquisition of data required for crew safety, status indication, fault isolation and for ground evaluation of system performance, both during and post flight.

The data computation subsystem group consists of two identical airborne digital computers, one auxiliary memory unit, one keyboard and display and control unit, two printers, two Laboratory Vehicle data adapter units and one computer subsystem controller. It interfaces, communicates with and performs data processing, computing and control functions for the Laboratory Vehicle and Mission Payload system segments. Each of the airborne digital computers has a memory capability of approximately 16,000 words (word length -- 32 bits) with a growth capability to 24,000 words. The computer memory has a storage capacity of two million data bits and can transfer a minimum of 600,000 bits of information per minute between itself and the computer. Either computer can support all currently planned on-board computation functions. The command subsystem group accepts digital encoded uplink command messages which are executed when received (real-time commands) or are stored in the memory with a time label and executed at the time indicated by the label. Both clear and encrypted data and commands are accepted, however the clear mode can only be initiated by a secure command. The data transmission rate is 1000 bits per second, which is compatible with the primary SGLS command uplink. A backup command capability is provided for a limited number of critical commands required for control of the vehicle in the event the computer subsystem is disabled. The timing subsystem group provides all Laboratory Vehicle and Mission Payload timing requirements. This includes generation of synchronization signals and supplying binary vehicle time for on-board displays, data correlation and vehicle elapsed time indicators.

The instrumentation subsystem provides the instrumentation and signal conditioning required for operation of the Orbiting Vehicle and Mission Payload through the displays and controls. A transducer subsystem group provides 173 transducers (not including redundancy) for monitoring all life-critical and mission-critical parameters and performance characteristics of the Laboratory Module subsystems. The signals from approximately 240 measurements in the Laboratory Module require conditioning prior to being presented to the displays and controls subsystem group, the monitor and alarm subsystem group and/or the data management subsystem. The monitor and alarm subsystem group continuously monitors 180 measured parameters to detect out-of-tolerance conditions. It provides visual and aural signals, and develops control signals where required, for out-of-limit conditions in all monitored functions. Twenty life safety parameters which are redundantly monitored are allocated to "warning" channels. The remaining 160 monitored functions are allocated to "caution" channels to alert the crew to mission critical or noncritical out-of-tolerance conditions, including those which could become critical to crew safety if corrective action were not taken. The displays and controls subsystem group provides the man/machine interface for operation of the Laboratory Vehicle and Mission Payload. It also provides data for status indication and telemetry. Approximately 515 system parameters are displayed and approximately 663 are controlled from the display and control panels.

The communications subsystem services both the Laboratory Vehicle and the Mission Payload. The tracking, telemetry, command and voice functions are provided by redundant SGLS compatible equipment. A voice control subsystem group provides and controls all voice communications between crew members. To provide secure voice communication between the crew and ground stations, analog-to-digital and digital-to-analog voice converters are being developed to work with modified existing airborne cryptographic equipment. This development and modification program is being accomplished by the NSA. The antenna subsystem group includes Earth-oriented directional antennas for downlink transmission and one omnidirectional antenna which, although normally used for uplink signals, can also be used for downlink transmissions.

An attitude control and translation subsystem (ACTS) will provide, without dependence upon the on-board computer: (1) automatic and manual attitude control; (2) orbit maintenance and adjust; (3) separation from launch vehicle; (4) vernier insertion capability; and (5) Laboratory Vehicle disposal. The ACTS provides for both manual and automatic operation and can be controlled from the Gemini B to separate the Orbiting Vehicle from the Launch Vehicle when initial orbit is attained and for certain abort modes. This subsystem consists of two subsystem groups. The ACTS propulsion subsystem group (ACTS/Prop) consists of four removable thruster assemblies located 90 degrees apart in the unpressurized service compartment of the Laboratory Vehicle. Each thruster assembly contains four 25-pound thrusters for attitude stabilization and control and one 100-pound thruster for longitudinal impulse. This thruster arrangement provides sufficient redundancy to permit non-degraded performance in the event of any single thruster or sector failure. The system employs a propellant combination of nitrogen tetroxide and monomethylhydrazine (2200 pounds, 2000 pounds usable). The ACTS stabilization control electronics subsystem group (ACTS/SCE) provides manual and automatic guidance signals to the ACTS/Prop necessary to control the Orbiting Vehicle attitude and to change or maintain the Orbiting Vehicle orbit. On-board attitude data are automatically generated in the system by means of signals from rate gyros, horizon sensors and a velocity vector sensor. Correction may also be initiated by ground station or manually by the crew.

Provision is made in the Laboratory Module for an option to incorporate a wide-band readout system and/or a Data Return Vehicle in Flights 3, 4 and/or 5. Space, weight and power provisions are being retained in these flight vehicles ~~and a decision on whether to exercise this option will be made at a later date.~~ although present plans [illegible] either capability to be incorporated [illegible]

The habitable volume of the Laboratory Module's pressurized compartment is concentrated in the central core area. This allows the crew members to operate the Laboratory Vehicle and Mission Payload from the displays and controls with minimum movement. Eight compartment bays, which contain the displays and controls, are arranged in the following manner:

BAY	FUNCTION
1	Photographic equipment and vehicle control
2	Mission Payload - acquisition, command, and instrumentation, electrical power and signal distribution
3	ECLS (Environmental Control & Life Sup. Sys.)
4	ECLS, film processor control
5	Mission Payload control
6	Electrical power
7	Data management
8	Mission Payload - duplicate of Bay 2

This arrangement is illustrated in Figure I-1. (A viewport is located in Bay 7 for visual horizon orientation.)

DAC will also provide various equipment and accommodations for crew members such as crew conditioning equipment (engineering prototypes being developed and evaluated by the Aero Medical Division), suit storage and donning station, restraint and locomotion equipment, sleeping equipment, a food management installation for GFE food, a medical kit storage compartment for GFE medical components, and a personal hygiene/waste management compartment. A radiation monitoring system, consisting of both passive and active devices, will be provided to measure the amount of incident radiation energy impinging upon the crew members.

The maximum weight allocated by DAC contract specification to the Laboratory Vehicle segment (the Laboratory Module and the Mission Module structures) is 14,449 pounds.

A mission simulator is required to develop and validate flight test procedures and flight plans, develop operational procedures and alternate flight plans for contingency situations, validate ground command software, and train flight crews and ground controllers in combined network operations. This mission simulator is an integrated equipment complex made up of a Gemini B Procedures Simulator, Mission Payload simulation equipment and Laboratory Module simulation equipment. These three elements can operate simultaneously as well as independently. The unit will be located at VAFB where the flight crew completes its training and where Mission Control Center (MCC) personnel are trained. A floor layout of the simulator is shown in Figure I-2. The mission simulator simulates the mission profile from launch through re-entry for development, training or validation in separate phases or tasks or in the complete mission profile. MCC flight directors are trained by a direct interface between the mission simulator and the MCC, while remote tracking station operators are trained with data tapes generated by the simulator.

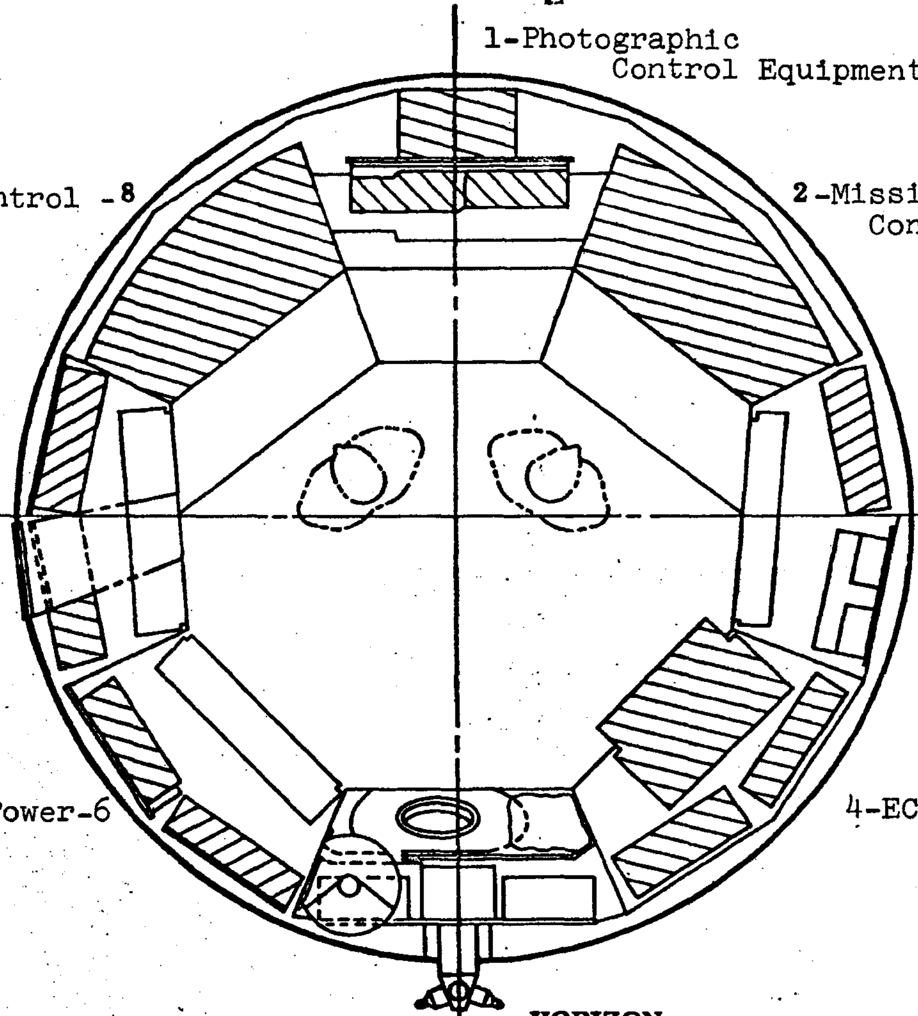


Figure I-1 Bay Layout Laboratory Vehicle Aft

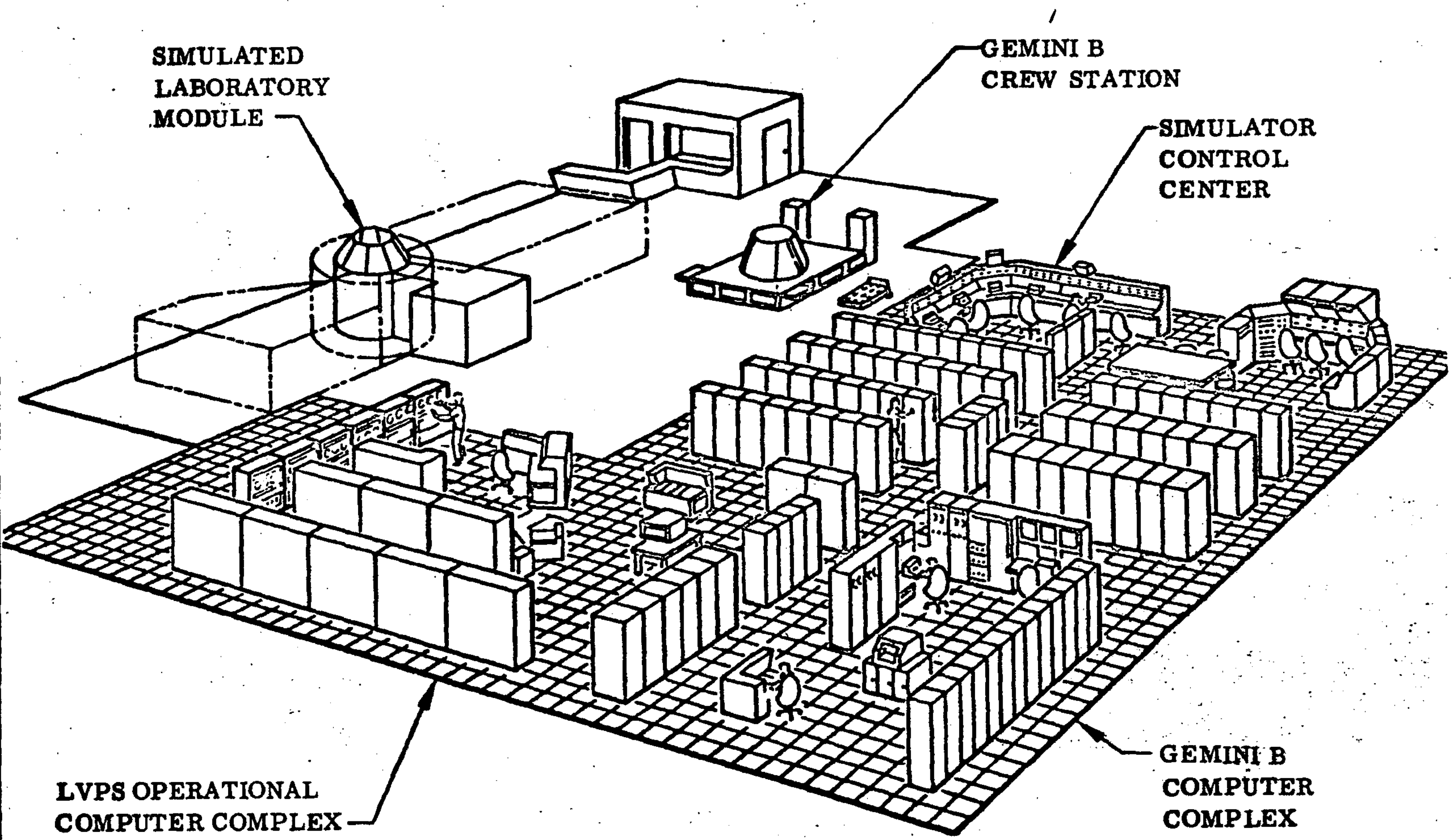


Figure I-2 MOL Mission Simulator

Part 2 - Operating Concept

The point of departure for defining the Laboratory Vehicle operating concept is the factory-to-pad flow, discussed in Book I, Section I, for the segments housed in the Laboratory Vehicle. The Laboratory Module will be acceptance tested in a vacuum chamber at the Laboratory Vehicle contractor's plant, where a simulated mission profile of several days duration will be run. Following acceptance, the Laboratory Module is mated with the Mission Module at the Laboratory Vehicle contractor's plant, to make up the Laboratory Vehicle. Following checkout and acceptance testing there, the Laboratory Vehicle is transported to the launch site where it is mated with the Titan III M and the Gemini B. Following the completion of integrated system tests at the launch site and a successful countdown, the integrated Orbiting Vehicle is launched into orbit. During launch and ascent phases of the mission, the Laboratory Vehicle is essentially dormant; it plays a major role in subsequent mission phases, as follows:

The early orbit phase, which begins when Mission Control determines that an acceptable orbital insertion has been accomplished, may encompass up to three orbits. This phase is primarily concerned with Laboratory Vehicle checkout, flight crew transfer, and orbit ephemeris updating. Upon attainment of an acceptable orbit, the flight crew will activate and check out Laboratory Vehicle subsystems to ensure an acceptable environment. One crewman will then enter the

Laboratory via the crew transfer tunnel that connects the Laboratory with the Gemini B. The crewman in the Laboratory will then activate and check out equipment while the crewman in Gemini prepares it for the 30-day standby mode. When both crewmen have accomplished their tasks, the second crewman transfers to the Laboratory through the same tunnel.

The on-orbit phase begins upon completion of initial crew transfer. During the nominal 30-day period the flight crew will operate and maintain the Laboratory Vehicle equipment and monitor the status of the Gemini B to accomplish the objectives of the mission. Except for extra-vehicular activity or emergency cabin depressurization periods, the crew will not normally wear pressure suits. Operations will be conducted in accordance with a detailed sequence of events. This sequence depends on mission objectives, equipment constraints, crew eat/rest/sleep cycles, time over stations, day/night conditions, etc. If this sequence of events must be modified as the mission progresses, the ground system will react to reschedule and replan the timeline sequence and transmit this information to the vehicle and flight crew. All commands to the crew and vehicle will be from the Mission Control Center. Telemetry and voice data from the Orbiting Vehicle will be available in real-time and stored modes. Selected data transmitted from the Orbiting Vehicle will be displayed in real time at the Mission Control Center. Although all data will be recorded at the remote tracking stations, none will be displayed there.

When the decision to terminate the mission has been made, the crew will activate the Gemini B and transfer from the Laboratory to the Gemini B in essentially the reverse of the procedure followed at the start of the early orbit phase. When all crew functions have been performed, the crew separates the Gemini B from the Laboratory Vehicle, re-enters and is recovered. Mission Payload data will be returned with the crew in data recovery containers carried in the Gemini B.

The Mission will be terminated by a Mission Control Center command to de-orbit and dispose of the Laboratory Vehicle in a pre-selected open water area.

The Laboratory Vehicle for Flights 6 and 7 will be assembled in the unmanned configuration. The Support Module, Laboratory Module and Mission Module will be mated, checked out and accepted at DAC prior to being transported to the launch site. The Flight Vehicle is then launched and the Orbiting Vehicle, after attainment of an acceptable orbit, automatically performs the mission as directed by commands stored in the on-board computer and/or transmitted from Mission Control. Mission Payload data will be returned in Data Recovery Vehicles ejected from the Orbiting Vehicle. As in the manned mode, the mission is terminated by de-orbit and disposal of the Orbiting Vehicle in a pre-selected area.

In summary, Douglas as the Laboratory Vehicle System Segment Contractor is also the integrating contractor and is responsible for the overall integration of the MOL system. In this role, it will provide the design engineering required to assure total system compatibility. It is also responsible for Orbiting Vehicle System Engineering and Integration. This task includes the detailed design engineering and integration of Orbiting Vehicle interfaces, AVE, AGE, special tooling, and special test equipment and the Support Module.

Part 3. Schedule Considerations

A. Critical Factors

Establishing the development plan for the Laboratory Vehicle involves consideration of numerous interrelated activities and constraints. The development schedule is aimed at meeting the program objective of the first all-up manned/automatic flight in December 1970. The Laboratory Vehicle schedule is affected by several critical factors which are unique to the program.

1. Critical Path

The principal factor is concerned with the critical path for the MOL Program, which hinges on the Eastman Kodak Company's (EKC) development of the Photographic System. The EKC schedule must be supported by General Electric's (GE) development of other Mission Payload equipment and the GE schedule in turn directly influences the Douglas Aircraft Company's (DAC) schedule for the Laboratory Module, which interfaces with both the GE and EKC segments. The following are examples of Laboratory interface subsystems for which DAC must in FY 1968 complete the design, and in some cases fabricate and deliver test items to support GE and EKC development schedules:

a. The first Mission Module Forward Section test structure, non-prime #1, must be shipped to GE for payload component tests in August 1967. The other structures follow in December 1967 (1F), February 1968 (2F), April 1968 (2FX)*, June 1968 (3F), October 1968 (4F) and January 1969 (5F).

UPDATE

* 2FX is a dynamic test article

b. Four Mission Module Aft Section test structures must be shipped to EKC in July and November 1968 and May and September 1969.

c. A required AVE digital computer functional equivalent prototype was provided to GE in October 1966 for software development.

2. Long Lead Subsystems

The second critical factor involves a number of the Laboratory Vehicle flight subsystems, which have been identified as long lead items. Although MOL design criteria stress maximum use of available hardware components and established technology, design and development of these long lead subsystems was begun early in the program and is being vigorously pursued in order to meet requirements of minimum weight and/or 30-day life qualification. These long lead subsystems include the attitude control and translation subsystem, Laboratory Module structure, atmospheric and reactants supply subsystem group, electrical power subsystem, and the data management subsystem.

3. Mission Simulator

Another critical element for which the Laboratory Vehicle contractor is responsible is the design and development of the Laboratory Module segment of the Mission Simulator and the integration of the total mission simulator. This work was initiated immediately after ATP, primarily because of its early need date. The simulator, to be located at VAFB, must be operational nine months prior to the all-up manned flight in December 1970. It is needed for nine months prior to this flight to develop and validate flight test procedures and test plans, develop operational procedures and alternate flight plans for contingency situations, validate ground command software and train ground crews and ground controllers in combined network operations. The schedule of development, fabrication and checkout of the Laboratory Vehicle segment of the simulator and its integration by DAC with other simulator equipment cannot be completely defined until subsystem and segment designs are well underway. Therefore, preliminary or provisional designs and computer substitutes will have to be used in the early development tests of the mission simulator in order to meet the compressed schedule. To meet the need date of March 1970, the design will be frozen by July 1968 to allow release of detail hardware drawings in November 1968. Fabrication and assembly of this segment of the simulator will be completed by August 1969 followed by 7 months of installation, checkout and system development testing. The simulator will become operational in March 1970 and be available for mission planning, software and procedures validation and crew training. Its configuration is to be updated by a block change in June 1970.

B. Laboratory Vehicle Development Schedule

In addition to the critical factors discussed above, which are unique to the program, all of the other interrelated activities associated with the Laboratory Vehicle development must be properly time phased to support the first all-up manned flight. The Laboratory Vehicle development involves, in addition to the Aerospace Vehicle Equipment (AVE), a number of ground test vehicles and AGE sets. To generate the overall Laboratory Vehicle schedule, key elements are identified and the time required to complete each of them is determined. Then, working backward from the date for the first all-up manned launch, December 1970, the interrelated schedules for the ground test vehicles, AGE and AVE are aligned and need dates for the key elements are determined. The schedule derived in this fashion identifies the critical milestones for engineering, test and manufacturing activities required in developing the Laboratory Vehicle. These milestones are discussed in the following paragraphs and shown in Figure I-3.

Laboratory Vehicle No. 3 for the first all-up manned flight must be shipped by end September 1970 to allow two and a half months for integration, checkout and launch countdown at VAFB. Sixteen months are required for fabrication, assembly and checkout of the Laboratory Module, followed by a two and a half month period which includes mating with the Mission Module, electromagnetic compatibility testing and final checkout of the Laboratory Vehicle. This establishes March 1969 as the start date for fabrication of Laboratory Module No. 3.

The Mission Module structure is designed and manufactured by DAC in two sections. The aft section is shipped to EKC for installation of the Camera-Optical Assembly and associated AVE. The forward section is shipped to GE for installation of the tracking mirror drive, environmental doors, and other GE AVE. It is then shipped to EKC for installations of the tracking mirror and mating with the aft section. The complete Mission Module is then returned to DAC for mating with the Laboratory Module and final acceptance testing before shipment to VAFB for launch.

The forward section of Mission Module No. 3 must be shipped to GE in April 1969 to allow time for installation of GE equipment, shipment to EKC for installation of the tracking mirror and assembly with the aft section and return to DAC for mating with the Laboratory Module and final testing. To meet this need date, fabrication and assembly of the forward section, which required 8 months, must begin in September 1968. Fabrication and assembly of the aft section of Mission Module No. 3 must begin in April 1969 to meet a shipping date to EKC of December 1969.

An Electronic Development Compatibility Test Unit (EDCTU) (previously identified as "hot mock-up") is required for several purposes. It is used in conjunction with the development AGE for early development integration of interfaces between the various subsystems assembled together for the first time, between the Laboratory Module and its supporting AGE and between the Laboratory Module subsystems and other system segments. This unit is also indispensable to the development and validation of Orbiting Vehicle and AGE computer programs and procedures required for on-orbit operations. The need date for the Electronic Development Compatibility Test Unit with all subsystems installed is November 1968. To meet this requirement, prototype hardware of major subsystems is required prior to August 1968 for integration into the unit and validation of its functional capability.

One of the major ground test vehicles is the Laboratory Module Qualification Test Vehicle (LMQTV). This is a production Laboratory Module which is required to demonstrate in advance of the first all-up launch that it can be successfully operated through a simulated 30-day on-orbit mission while exposed to the on-orbit thermal and vacuum environment. This qualification test will be conducted in a thermal-vacuum chamber and will utilize programs and procedures developed with the Electronic Development Compatibility Test Unit. The qualification test must be completed by the end of May 1970 to free the thermal-vacuum chamber for acceptance testing of Laboratory Module No. 3. Fabrication of the vehicle must begin in July 1968 in order to complete the qualification by that date.

Following qualification in the thermal vacuum chamber, the LMQTV will undergo qualification acoustic testing. Upon completion of this test, the LMQTV will be refurbished and converted to the unmanned mode for use in Flight 7. Acoustic testing will be restricted to expected flight levels since testing at higher levels would preclude use of the refurbished structure for flight.

The LMQTV schedule described above establishes an operational need date of December 1969 for AGE needed to support LMQTV checkout activities in the Production System Integration Area (PSIA). The test flow associated with compact 12 schedule requires additional AGE-PSIA to support checkout of Laboratory Vehicles. The schedule for Laboratory Vehicle No. 3 establishes an operational need date of May 1970 for this additional AGE. In addition to the AGE-PSIA, launch checkout AGE is required at VAFB. This is manufactured essentially in parallel with the PSIA sets. Cabling is installed at VAFB before Flight No. 1 and the remainder of the AGE is installed and checked out between Flights 2 and 3.

Another significant requirement in the Laboratory Vehicle development schedule is completion of qualification of all subsystems individually, in addition to qualification as part of the Laboratory Module Qualification Test Vehicle. In order to complete this prior to environmental acceptance of the first all-up vehicle, it must be accomplished by May 1970.

Structural test vehicles are required to insure by adequate ground testing prior to the first structure flight in April 1970 that the Laboratory Vehicle can accommodate the boost and on-orbit structural environment. A Laboratory Vehicle primary (load bearing) structure will be subjected to 12 months of structural testing (model survey, shock, acoustic and burst). In addition, an LM/MM primary structure must be subjected to 5 months of static testing. All of this testing must be completed in sufficient time so that any required changes can be incorporated into the design of the flight Laboratory Vehicle. This establishes a need date of January 1969 for these vehicles. Fabrication and assembly, which requires 12 1/2 months, must start in December 1967.

The above discussion defines the activities required to support the first all-up manned launch in December 1970. Laboratory Vehicles subsequent to No. 3 will require equivalent periods of time for fabrication and checkout and will be scheduled accordingly to meet required launch dates. Since the Laboratory Module Qualification Test Vehicle will have fulfilled its purpose by qualification in the thermal-vacuum chamber and acoustic facility in May 1970, it will be refurbished and used as the flight article for Launch No. 7. Mission payload equipment that had previously undergone qualification testing at GE and EKC will also be refurbished and used for Launch No. 7.

In addition to the development/test/fabrication activities described above, the program is taking advantage of the NASA S-IVB Orbital Workshop for an on-orbit test of some specific MOL equipment/crew relationships. The flight date of the S-IVB Orbital Workshop permits the performance of these tests in sufficient time so that results can be incorporated into the MOL development if appropriate.

The crew members will perform specific maintenance tasks on selected MOL equipment using MOL baseline tools and crew restraints to evaluate on-orbit maintainability and to establish timelines and procedures for performing the tasks.

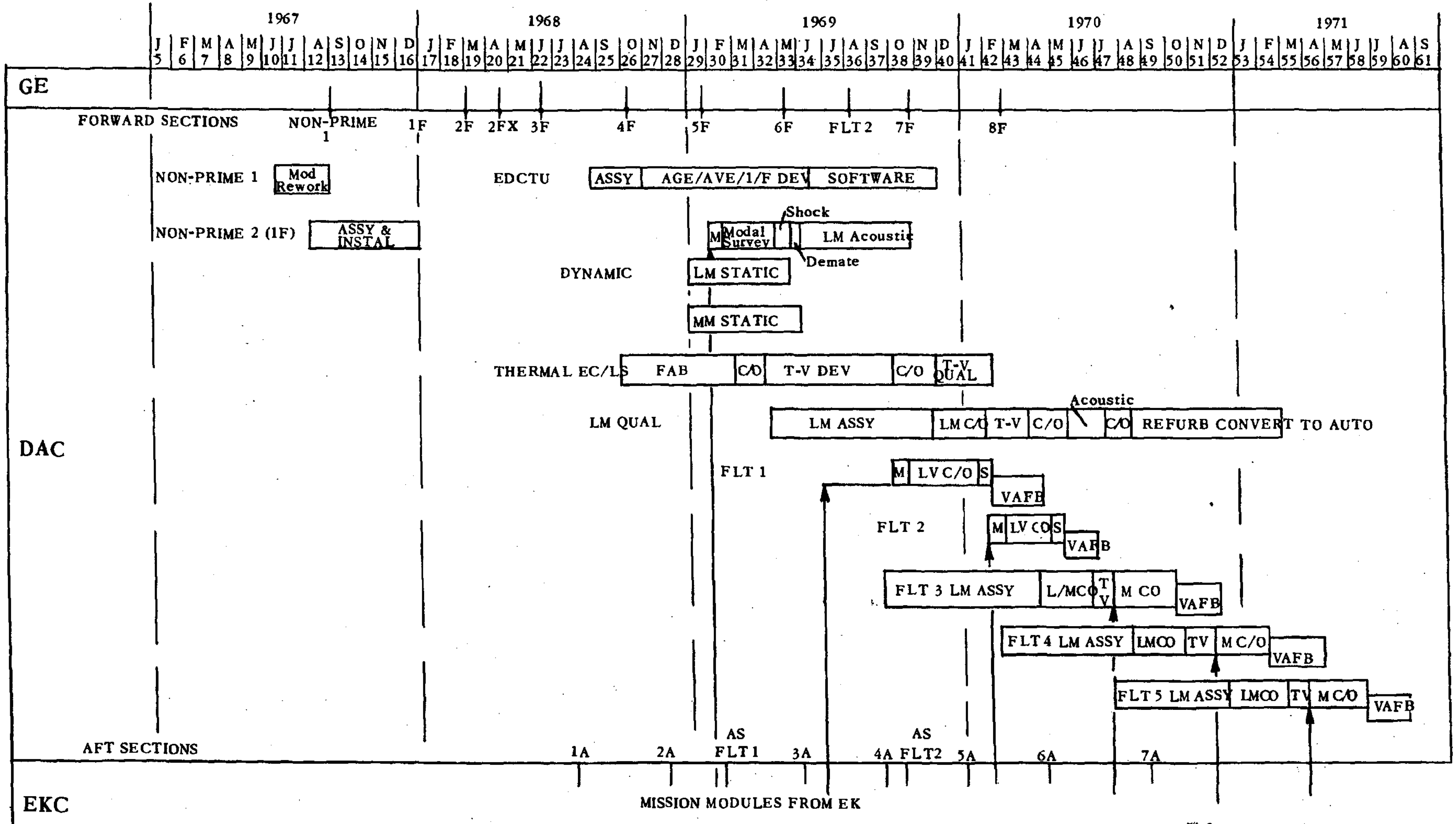
It is planned that a molecular sieve CO_2 removal system of the MOL environmental control and life support subsystem equipment be tested in this effort. Since no molecular sieve will have been flown in space prior to its use in MOL, information which will be obtained about on-orbit performance of this unit will be a valuable bonus.

The MOL baseline suit-donning/sleep station will also be evaluated in the S-IVB Orbital Workshop. This will permit a more realistic evaluation of the donning station design and pressure suit entry method than can be accomplished through one "G", neutral buoyancy, or zero "G" simulations. Suit donning and doffing techniques will be evaluated; the envelope required for donning and doffing will be verified and the time required for donning in a zero "G" environment will be determined. The MOL pressure suit, which will be used in this evaluation, is currently planned to be a primary suit on the S-IVB flight. Thus a subjective evaluation of MOL suit performance as well as signficant operational experience and performance data will be obtained.

A preliminary agreement has been reached with the NASA to conduct the majority of the MOL suit qualification testing at the Manned Spacecraft Center using NASA facilities and technical assistance. This effort will result in program fund savings and enhance the interchange of suit technology information.

INTEGRATED TEST PLAN

12 MONTH COMPACT FLOW



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Part 4. Funding Requirements

A. General

The estimate of Laboratory Vehicle costs is a result of MOL Systems Office estimates and Phase II contract negotiations, and include an estimate for the schedule adjustment costs. The original estimate was built up from detailed labor hour and material costs at the subsystem (or equivalent) level using cost data from similar space programs such as Gemini and Apollo. The costs shown are based upon the MOL baseline program of three manned/automatic flight configuration Laboratory Vehicles, two unmanned/automatic flight configuration Laboratory Vehicles, two test flights for structural verification, and one Mission Simulator. Also included are funds for the Support Module and National Security Agency secure communications hardware.

The major work breakdown structure tasks are as follows:

1. Orbiting Vehicle Hardware

This task includes the material and fabrication costs of the Orbiting Vehicle AVE, AGE, special tooling and test equipment and the Mission Simulator and the Support Module.

2. Laboratory Vehicle Hardware

This task includes material and fabrication costs of the Laboratory Vehicle subsystems. Also included are Laboratory Vehicle AGE, special tooling, special test equipment and assembly and checkout of the Laboratory Vehicle at the contractor's facility.

3. Systems Engineering and Integration

Includes system engineering and detailed design engineering of the Laboratory Vehicle system segment and its subsystems, AGE, special tooling, special test equipment, and the associated engineering testing and test support. The major subsystems of the Laboratory Vehicle segment are the Laboratory Module pressurized and unpressurized compartment structures, Mission Module structure, attitude control and translation subsystem (ACTS), environmental control and life support subsystem (EC/LS), data management subsystem, instrumentation, communications, electrical power, and the crew stations and accommodations. Mission Simulator Systems Engineering and Integration includes the detailed design engineering of the Mission Simulator, integration of associate contractor equipment, and Mission Simulator test and test support.

4. Services Test Operations

This task consists of the Laboratory Vehicle contractor participation in launch site preparation, acceptance, assembly and checkout of the flight vehicle at the launch site, launch, orbit and recovery operations, flight planning, data management, and flight analysis. Site activation and operation of the Mission Simulator at VAFB and in the in-plant support are also included. This task includes training and support of flight crew, support personnel, and mission control network personnel.

5. Management and Administration

This task consists of Program Control Management, Configuration Management, System Effectiveness Management, Material Support Management and Procurement and Production Management. Funding requirements, by major work breakdown structure, are shown in Figure I-4 and include the negotiated contract amount with an estimate of the schedule adjustment cost, deferral amounts, and identified program changes. The deferrals are described in paragraph B and program changes in paragraph C.

B. Deferral Status

The following were deferred from contract negotiations. (Costs shown for these items are included in Laboratory Vehicle segment cost charts).

1. Field Test Operations at Vandenberg AFB - $71.9M

This effort is near end of test flow cycle. Deferral eases FY 68 funding requirements and produces better definition of contractor activities at Vandenberg AFB.

2. Simulator O&M - $2.0M

This item was deferred as part of the Test Operations package for Vandenberg AFB.

3. Acquisition Tracking System Integration - $2.1M

This item was deferred pending the outcome of a study effort.

4. Data Readout System - $1.0M

The hardware for this item has been deferred. However, it is necessary to retain an effort aimed at reserving the capability for re-inserting the hardware at a later date.

5. Support Module - $32.411M

Deferred so as to ease FY 68 funds requirements.

6. Ground Station Conversion for Secure Voice Communication - $1.532M

The decision to require MOL Program funding rather than SCF funding for the Ground Station conversion was not firm at the time of contract negotiation. Consequently, this item was deferred.

C. Identified Program Changes

Revised or new technical requirements and Management decisions since December 1966 have resulted in additional tasks. The estimated cost and reasons for these change items are described below. The costs are included in the Laboratory Vehicle segment cost charts.

1. Additional AGE-PSIA - $10.0M

Differences in test flow requirements (particularly acoustic and vibration testing) now cause an overlap in test and production flow which requires additional AGE-PSIA.

2. Vandenberg AFB Cables - $.556M

Since insufficient time is available for electrical AGE installation between flights 2 and 3, a new set of electrical cables must be obtained and installed in advance.

3. Refurbishment of LMQTV for Flight No. 7 - $8.0M

Additional damage to LMQTV is anticipated because of high acoustic test levels.

4. Additional Test - $4.5M

Additional acoustic, thermal vacuum and other tests are now recognized as requirements.

5. Tower Mod - $1.2M

Because of the test flow impacts, a modification is required to the service tower at DAC to accommodate a second test area.

6. Mission Module Forward Section - $.222M

An additional Mission Module Forward Section is needed to meet an earlier static testing schedule.

7. Integration of Sliding Mask - $1.032M

A sliding mask to provide protection to the optics from thermal gradient and contamination is now recognized as a requirement and will be provided by GE. The mask must be integrated into the Mission Module by DAC.

8. Interface Hardware - $.293M

A number of additional exchange interface hardware substitutes (electrical, thermal and structural) are needed.

9. Mission Module Forward Section Doors - $2.95M

A set of MMFS doors is needed to test the interface with the sliding mask.

10. Reconnaissance and Rendezvous Study - $.100M

A study to explore certain aspects of reconnaissance and rendezvous has been recognized as a requirement.

11. Water Simulation - $.300M

An extension of zero "g" testing via a water environment is needed.

12. Static Test Hardware - $1.0M

Schedule revisions and exchange hardware due dates require the qualification of LM/MM primary structure prior to delivery. Hence, a requirement exists to provide an additional vehicle primary structure for the static tests.

LABORATORY VEHICLE AND INTEGRATION

FUNDING REQUIREMENTS

(In Millions)

	FY 67	FY 68	FY 69	FY 70	FY 71	FY 72	TOTAL
Orbiting Vehicle Hardware	51.5	101.4	145.1	105.3	43.6	13.4	460.3
Lab Vehicle Hardware	3.2	7.0	12.3	5.9	5.0	1.0	34.4
System Engr & Integr	34.3	47.3	63.9	71.2	31.9	8.7	257.3
Services/Test Opns	9.6	8.8	12.3	22.2	17.6	6.8	77.3
Management and Admin	8.6	10.5	12.3	17.8	10.8	3.4	63.4
TOTALS	107.2	175.0	245.9	222.4	108.9	33.3	892.7

LV Misc.	1.0	.6	.1	.1	.1	-0-	1.9

Figure I-4

SECTION II - MISSION PAYLOAD SYSTEM SEGMENT (MPSS) INTEGRATION

(General Electric)

Part 1 - Segment Description and Performance Requirements

A. General

The Mission Payload System Segment (MPSS) includes is composed of the photographic system and the subsystems necessary for its control and dynamics. These The subsystems are located in the Laboratory Module and/or the Mission Module depending on the specific function concerned. General Electric is responsible for the overall integration of the MPSS and development of its the hardware with the exception of the camera and the main optical system. This section describes, in some details defines General Electric's responsibilities with regard to the MPSS responsibilities.

The functions dynamic elements of the MPSS are to: the responsibility of General Electric and must perform the following functions:

1. Establish vehicle/target location relationship.
2. Establish vehicle attitude reference.
3. Acquire targets.
4. Provide 2-degree-of-freedom motion to tracking mirror.
5. Track targets with high precision.
6. Provide commands to primary camera.
7. Control tracking mirror thermal environment.
8. Regulate and distribute electrical power to the Mission Payload
9. Provide Mission Payload Command & Control data handling.

B. Technical Description

1. Aerospace Vehicle Equipment (AVE) Subsystems

to McDonnell

The Mission Module structure as provided by Douglas is 10 feet in diameter, and 37.0 feet in length, and is fabricated in two sections. The forward section, approximately 14 feet long, contains much of the mission related AVE provided by General Electric, such as the gimbal, mount and thermal control system for the tracking mirror. and associated equipment. The tracking mirror itself, is provided by Eastman Kodak. The Mission Module aft section (MMAS) houses Eastman Kodak optical equipment, as shown in Figure II-1.

The specific performance and description of the subsystems related to the MPSS Mission Payload dynamics are best presented in terms of the support they provide to the critical functions as depicted in the Subsystems/Critical Functions Matrix, Figure II-2.

a. Navigation and Control Subsystem

The navigation and control subsystem generates the commands and provides the drive for pointing the optical system, slewing the primary optics tracking mirror, slewing the acquisition and tracking subsystem (ATS), and tracking targets with high precision. It depends on the Laboratory Vehicle attitude control and translation subsystem (ACTS) for vehicle attitude and stability; however, it establishes the precise attitude references needed to generate the pointing commands for the tracking mirror, and precision tracking refinements after target acquisition. This Nav Control subsystem subsystem includes two star trackers to provide precise orientation of the vehicle with respect to the celestial reference frame. A low-G accelerometer measures drag effects, thus permitting precise correction of the orbit ephemeris. In addition, an image velocity [motion] sensor (IVS) detects relative motion of the target across the optical format and provides an error signal to correct the rates of the tracking mirror drive. Three drive units are provided to allow two-axes control of the main tracking mirror, single-axis servo control of the tracking mirror viewport aperture, and two-axes servo control of the acquisition and tracking subsystem optics. The mechanism which drives the main optics tracking mirror must provide line of sight coverage of ± 40 degrees in roll and ± 30 degrees in pitch with extreme precision and smoothness. The successful fabrication of Cer-Vit material mirrors will allow -40° in pitch. The smear contribution of the tracking mirror drive mechanism must not exceed [redacted] per second. To meet this specification the roll gimbal motions must be capable of providing smooth action at angular rates less than ± 0.5 degrees/sec and must be accurate to ± 0.001 degrees/sec when the tracking mirror is rotated at a rate of .001 degrees/sec.

b. Structures and Thermal Control Subsystem

The structures and thermal control subsystem consists of mountings, bearings and other hardware which comprise the gimbal structure for support and [allow] movement of the tracking mirror, and the environmental control necessary to assure proper functioning of the tracking system and to minimize distortion of the tracking mirror.

The gimbal structure must provides:

1. Support for a 1200 pound tracking mirror and assembly during launch.

2. A Housing for a control system capable of simultaneous pitch and roll motion.

3. A Stiffness (13.5 CPS) sufficient to maintain a limited margin between the natural frequency of the control system and the mounting structure.

4. A capability of operating in a one "g" field and yet maintain alignment on orbit.

The gimbal will be (is) fabricated mainly from beryllium and (may) will be one of the largest structures ever made from this material. Beryllium was chosen primarily due to its high modulus of elasticity, its low density and ability to support the loads.

The thermal control equipment includes necessary thermal coatings, hatches, blankets, louvres and heaters to maintain the tracking mirror bay at a temperature of 70 degrees F. ± 5 degrees. The temperature differential (face to back) of the tracking mirror (TM) must be no more than 0.1 degree throughout the photographic pass. When the TM is exposed to the direct impingment (impingement) of external heat fluxes during photographic periods, the thermal design must minimizes this disturbance by limiting the irradiation of the TM from areas outside the optical field of view. To assist in accomplishing this (accomplish this task) the TM bay is provided with a viewport door, and a servo controlled viewport aperture to aid in maintaining an acceptable average linear gradient throughout the tracking mirror thickness.

c. Acquisition Subsystem

The acquisition and tracking subsystem (ATS) enables man to make his most important contribution to the system. The quality and amount of reconnaissance data which can be acquired by an unmanned, completely automatic reconnaissance satellite is degraded by such things as target location errors, ephemeris errors, computation or servo errors and weather obscuration of targets. Crew members using the ATS can minimize these effects by exercising judgment in appraising targets for intelligence value, rejecting pre-programmed targets which are obscured by weather or considered to be less valuable than other observed targets and driving the tracking mirror to more valuable alternate targets. The crew members can also refine the automatic pointing and image motion compensation systems, thereby enhancing the photographic quality. With the 2 acquisition scopes of the ATS, the crew members can view the earth with magnification of from 15X to 30X and 63.5X to 127X with corresponding fields of view of from 4 degrees to 2 degrees and 1 degree to 0.5 degrees. The subsystem provides a maximum ground resolution capability of about 3.6 feet for detailed target study in a 0.5 degree field of view at 127K magnification. The two acquisition scopes operate independently and have a computer driven servo system with an automatic pointing accuracy of 0.1 degree. Two scopes are provided to allow the crew members to inspect different areas simultaneously thereby increasing the systems flexibility considerably. The limits of the tracking angles are +70 degrees to -45 degrees in pitch and ± 45 degrees in roll.

d. Consoles and Displays Subsystem

The consoles and displays associated with the mission payload are physically located in the pressurized compartment of the Laboratory Module. They essentially provide the visual and mechanical man-machine links to allow the crew to monitor and control, as well as to identify out-of-tolerance conditions, in the Mission Payload. In general, the crew functions supported by this subsystem are related to ground station contacts, payload status and calibration checks, payload pass preparation, the payload pass, postpayload pass analysis and reporting, preventative maintenance, and data processing and return activities as required. Figure II-1, View A-A gives the general location of these consoles and display units. There are crew stations located at bays 2 and 8 which each contain display and operating panels for the visual optics, acquisition scopes, cue displays, magnification controls, and teleprinters. Each crew station provides access to one acquisition scope and to visual optics viewing through the primary telescope. There are also miscellaneous indications of time-to-target, target priority, and other operational visual displays. The crew member at bay 8 has access to the window in bay 7 to enable him to view the horizon. Both crewmen have access to the computer keyboard located in bay one. When operation of the film processor and readout (if provided) is desired, the crew members may turn to bay 4 and utilize the provided controls.

e. Communications, Command and Instrumentation Subsystem

The heart of the communications, command and instrumentation subsystem for the Mission Payload is the Mission Data Adapter Unit (MDAU) which provides the interface for command and reaction between the Mission Payload and the Laboratory Vehicle data management subsystem. There are two redundant mission data adapter units wired with the two redundant airborne digital computers in the Laboratory Vehicle data management subsystem to provide high reliability. The commands generated on the ground are fed to a mission data adapter unit through a laboratory data adapter unit and the airborne computer. Commands generated on board are provided to the mission data adapter unit through the airborne computer. The mission data adapter unit translates these commands into mission payload actions and provides feed back to the computer which in turn provides the verification functions to the Laboratory Module telemetry equipment for transmission to the ground either in real time or by delayed recording.

f. Electrical Power and Signal Distribution Subsystem

The electrical power and signal distribution subsystem conditions and distributes power and signals to meet all requirements of the Mission Payload. This subsystem is supplied power by the Laboratory Module electrical power subsystem.

2. AVE Related Items

5. Software

The Mission Payload subsystems software including the incorporation of the mission logic is the responsibility of GE. Before any final design can be accepted a great number of simulation studies using the crew members must take place, to evaluate and measure the man-machine factors concerning command and control and on board software affecting decision. Software is also being developed for system checkout in conjunction with the Aerospace Ground Equipment (AGE) and for system simulation equipment.

6. Simulation Equipment

A comprehensive simulation program is an essential element of the successful development and operation of the Mission Payload. The overall objectives of the simulation program are: (1) to measure and optimize the man-machine-mission interface and (2) to provide mission training. The first Mission Payload simulator is called an Elemental Development Simulator and is to be used primarily for establishing measurements for proper systems design of both AVE and software. It will provides test data in three basic categories:

1. Man-Machine (cueing philosophy, sensor controls and alignment, etc.);

2. Machine-Mission (targeting mix, sensor drive signal validation, etc); and

3. Man-Mission (targeting mix, cloud and atmospheric effects, activity detection, target acquisition, timing, etc.).

The Elemental Development Simulator is in operation at the General Electric plant, Valley Forge.

Mission Payload simulation equipment is being designed to perform four basic functions:

1. facilitate training the flight crew in the complete mission;

2. develop and practice in-flight maintenance procedures;

3. facilitate MOL integration with the Satellite Control Facility (SCF); and

4. develop operating and contingency plans.

It will includes hardware and/or software simulation of control/display interfaces for all major functions of the Mission Payload.

2. Aerospace Ground Equipment (AGE)

Aerospace Ground Equipment (AGE) will be provided to provides support the development, test, and operational activity of the Mission Payload. The mechanical AGE includes the common type such as handling and support equipment but which is peculiar to the type, size and weight of AVE which it is required to support; mechanical checkout equipment to perform alignment of the optical elements to tolerances as close as 5 seconds of arc; and transportation and environmental control equipment which must to limit shock and vibration induced to the

Mission Module during transportation and maintain the required temperature, pressure, humidity and cleanliness.

The electrical AGE consists primarily of the Computer Integrated Test Equipment (CITE) which is a programmable checkout system. The CITE can operate in a manual or semi-automatic mode via a stored computer program with a minimum of operator assistance. This equipment ~~will be~~ is used ~~to~~ in the conduct of ~~support~~ electrically mated system compatibility tests, development tests, qualification tests and performance demonstration including mission profile test. CITE ~~will~~ performs these tests on all the Mission Payload System Segment subsystems and on the Photographic System subsystems. This checkout system will be deployed at the General Electric ~~factory,~~ plant, the McDonnel Douglas ~~factory~~ plant and VAFB. A modified configuration of CITE will be deployed at Eastman Kodak Company to support the Photographic System performance tests. At ~~the~~ McDonnell Douglas ~~factory~~, and at VAFB, the CITE ~~will~~ interfaces with the ~~Douglas checkout equipment~~ McDonnell Douglas All Systems Test Equipment Group (ASTEG) to support the integrated systems testing performed at these locations. The CITE ~~will~~ provides for functionally identical tests at all locations and ~~will~~ provides for direct correlation of data throughout all levels of MPSS testing. This equipment ~~will~~ permits malfunction detection and isolation within the AVE to a replaceable black box level and ~~will~~ is to be capable of self-verification and fault localization. During all testing the CITE, in conjunction with ~~through the~~ AGE software, ~~will~~ permits modification of the test procedure to correct errors in the procedure or to retest a subsystem or component using a slightly modified procedure.

5. <u>Data Return Vehicle (DRV)</u>

In the automatic configuration of the orbiting vehicle, the Gemini B is replaced with ~~replaces the Gemini B~~ with a Support Module. In this mode, ~~This mode will utilize~~ Data Return Vehicles (DRV) are ~~located in and~~ ejected from the Support Module to return the exposed film. The film is transported and loaded into the DRV's using ~~by~~ equipment supplied by Eastman Kodak. The DRV's are ~~will be~~ similar to the General Electric Mark V model, modified as necessary, to return approximately 60 pounds of film each. The number of DRVs per orbiting vehicle is dependent ~~depends~~ on the final configuration of the Support Module~~, which to date has not been finalized~~.

MISSION PAYLOAD SYSTEM SEGMENT

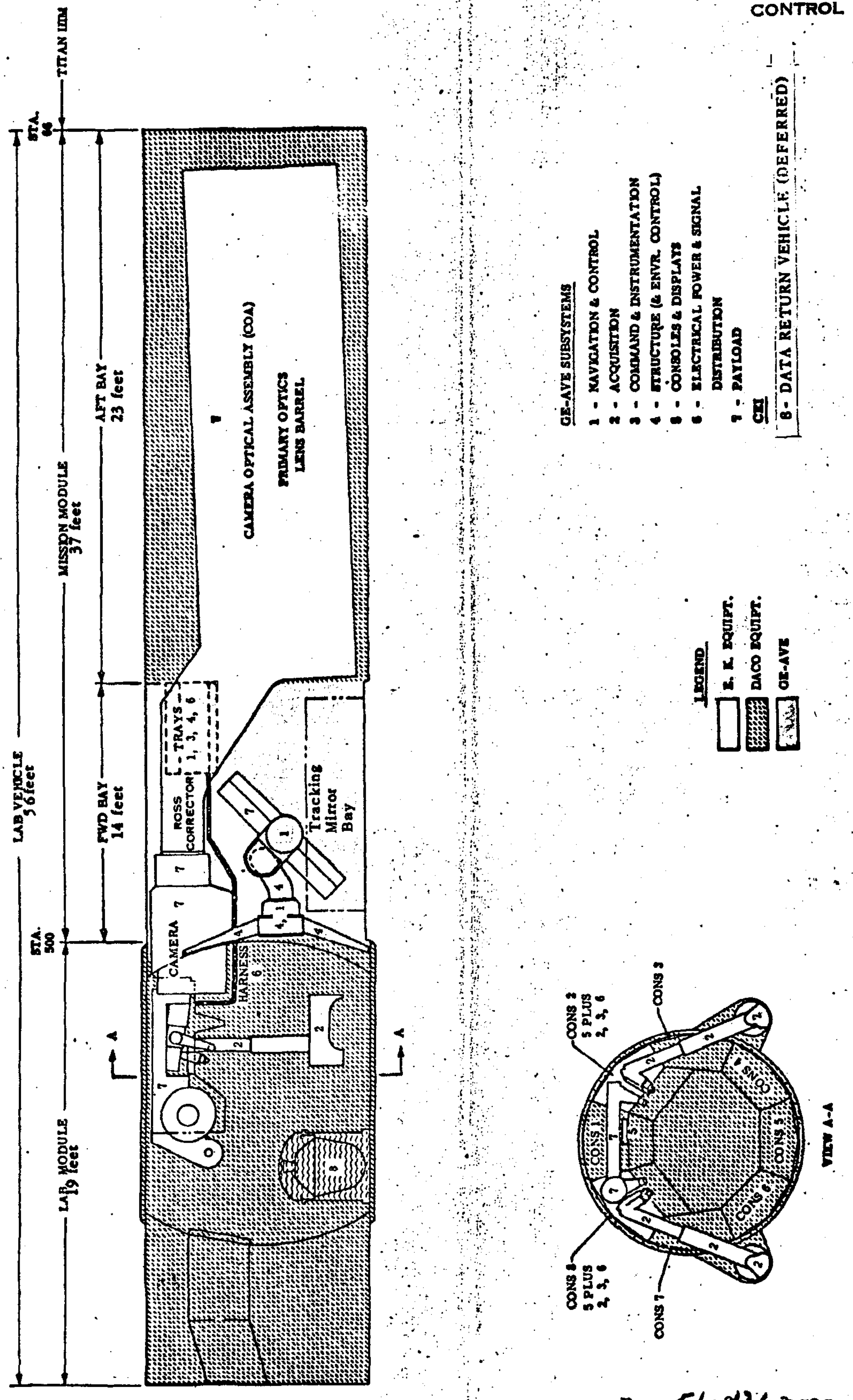

Figure II-1

DORIAN

AVE SUBSYSTEMS/CRITICAL FUNCTIONS MATRIX

GE SUBSYSTEM \ CRITICAL FUNCTION	ESTABLISH VEHICLE/ TARGET LOCATION	ESTABLISH VEHICLE ATTITUDE REF.	ACQUIRE TARGETS	DRIVE TRACKING MIRROR	TRACK TARGETS	PROVIDE COMMANDS TO CAMERA	CONTROL TRACKING MIRROR THERMAL ENVIRONMENT	FILM AND DATA HANDLING AND RECOVERY	REGULATE AND DISTRIBUTE ELECTRICAL POWER
I. NAVIGATION AND CONTROL	X	X	X	X	X				
II. STRUCTURES AND THERMAL CONTROL				X			X		
III. ACQUISITION SUBSYSTEM			X	X	X				
IV. CONSOLES AND DISPLAYS	X	X	X	X	X	X	X	X	X
V. COMMUNICATIONS, COMMAND AND INSTRUMENTATION	X	X	X	X	X	X		X	
VI. ELECTRICAL POWER AND SIGNAL DISTRIBUTION							X		X

Figure II-2

Part 2 - Operating Concept

After injection of the Orbiting Vehicle into orbit, the protective hatch covering the tracking mirror viewport ~~will be~~ is ejected. The tracking mirror bay viewport ~~will~~ is thereafter ~~be~~ covered by a sliding mask door except during photography. This mask is slaved to the tracking mirror pitch drive to assure that the bay is ~~only~~ open only the amount necessary for photography, ~~thereby~~ so as to aid~~ing~~ in thermal control of the TM bay.

An on-board computer, periodically updated with target coordinates and ephemeris data from the tracking stations, ~~will~~ separately program~~s~~ pointing angles and tracking rates for the acquisition scopes and the primary tracking mirror. ~~independently.~~ In the manned/automatic mode the crew may override or refine this automatic tracking by use of console mounted controls. Visual target cues will be provided to aid in recognition of targets. Crew members may correct target centering, provide vernier control to tracking rates, determine target visibility and select active or secondary targets.

UPDATE

Provisions are being retained in the system design for a ~~If the~~ readout option ~~is exercised in Flights 1 and/or 2 the~~ by which the crew may select and edit photography to be transmitted to a ~~data~~ ground data readout station. During station contact the selected photographs ~~will~~ would be automatically scanned and transmitted by the readout system. ~~If~~ Use of the ~~the~~ DRV, as presently provided in the program baseline, ~~option is exercised in the manned/automatic version,~~ calls for the first week's primary record ~~will~~ to be returned by DRV. All other film is returned with the remainder of the photographic take in data recovery capsules in the Gemini.

In the automatic configuration the film ~~will be~~ is loaded into the Data Recovery Vehicle by means of Eastman Kodak film chutes, cutters and sealers. ~~and~~ Then the Data Recovery Vehicle re-entry sequence ~~will be~~ is initiated by ground or stored command at the appropriate times.

Part 3 - Schedule Considerations

General Electric, ~~is the~~ in its function as integrating contractor for the Mission Payload System Segment, ~~and~~ requires close coordination with both EKC and ~~DAC~~ McDAC. ~~The~~ This coordination is particularly critical areas of thermal protection for the Mission Module Forward Section (MMFS), and the precision mounting bearings and servo mechanism for the large tracking mirror ~~requires~~ which require detailed design, breadboarding, analysis, and development effort. GE is also responsible for an extensive mission payload simulation and training program.

An image velocity sensor (IVS) is required in the automatic and manned/automatic mode to provide image motion tracking to less than 0.1% of the velocity/range ratio in order to provide the extremely high resolution photography desired. GE is responsible for the integration of the ~~image velocity sensor~~ IVS into the vehicle, and selection of the sensor subcontractor. ~~procurement once the sensor is developed and a supplier chosen.~~

The total GE schedule for design, development, fabrication, and test is shown in Figure II-3. The GE effort is a continuing interaction between the systems and design engineering requirements and the implementation process. Cost effectiveness trade-off studies, degraded mission mode analysis, and systems effectiveness determination are to be pursued throughout the entire program. There ~~will be~~ is a continuous interchange of information among the USAF, GE and other associate contractors to insure systems optimization. System engineering tasks during the design engineering phase are:

a. establishment of systems, subsystems and environmental design requirement specifications;

b. technical and mathematical analysis to evaluate and optimize selected configurations (stress analysis, thermal analysis, reliability analysis, etc.);

c. development and evaluation of subsystems and systems test specifications and procedures to insure that simulated tests determine capability of hardware to meet the design criteria;

d. management of the interface to insure overall system continuity.

Concurrent with the above effort is the development, installation and checkout of the software for command and control of the payload operation on orbit. Detailed software planning must also be generated so that subsequent data reduction and evaluation of flight data may be accomplished in a timely and efficient manner. The systems cross checking and feedback loop of the aforementioned effort is accomplished on the ground, prior to flight, through simulation and training programs which establish optimum relationships between flight crew, hardware and software.

The test flow at GE is shown in Figure II-4. The Mission Module Forward Section engineering model, (non-prime #1) is used for payload component and system tests before assembly and test of the first flight. The mission Module Forward Section test article, 1F, is used for thermal testing at GE; upon completion of these tests it is transferred to EKC to provide the forward interface for thermal testing of the Mission Module Aft Section, and is then returned to GE for the use as their engineering model. A second test article, 2F, is used for dynamic structure tests of the tracking mirror support structure at GE. It is then transferred to EKC and mated with an aft section for Flight Vehicle 1. A third test article, 3F, is used for development testing of the Forward Section AVE, including extended thermal/vacuum operating tests of the gimbal and environmental door mechanisms. A fourth test article, 5F, is used for qualification testing to verify all manufacturing and test procedures, and to qualify the Mission Module Forward Section in ambient, vibration, and thermal/vacuum tests and to conduct electromagnetic interference tests. Upon completion of qualification tests this Forward Section is transferred to EKC for the Mission Module Qualification Tests. In addition, two other Forward Sections are assembled, checked out and shipped to EKC to mate with Aft Sections for EKC dynamic testing and development testing, - 2FX for dynamic testing and 4F for development testing.

NRO APPROVED FOR
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GE MISSION PAYLOAD SYSTEMS SEGMENT (MPSS)

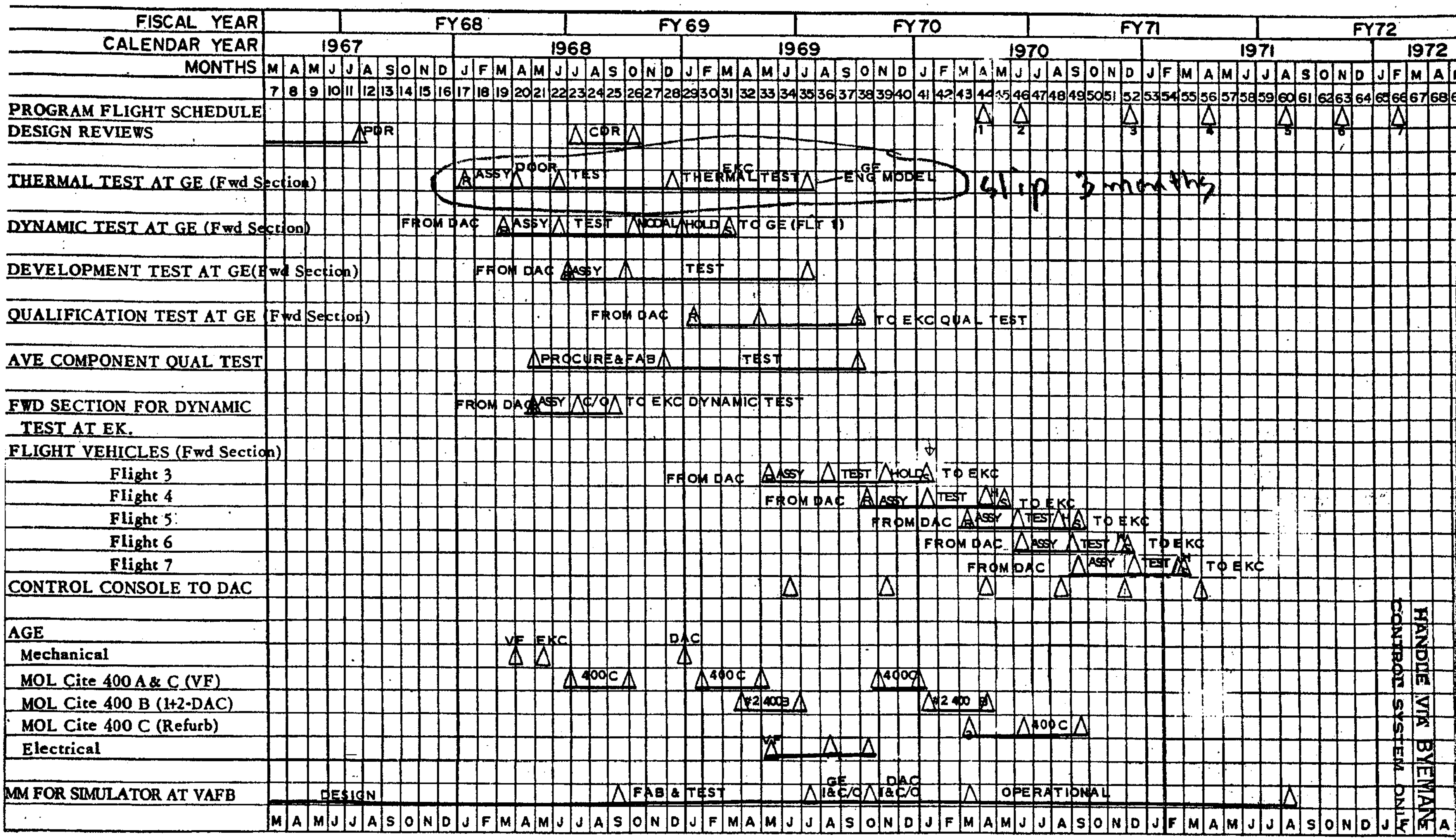

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Figure II - 3

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INTEGRATED TEST PLAN - 12 MONTH COMPACT FLOW

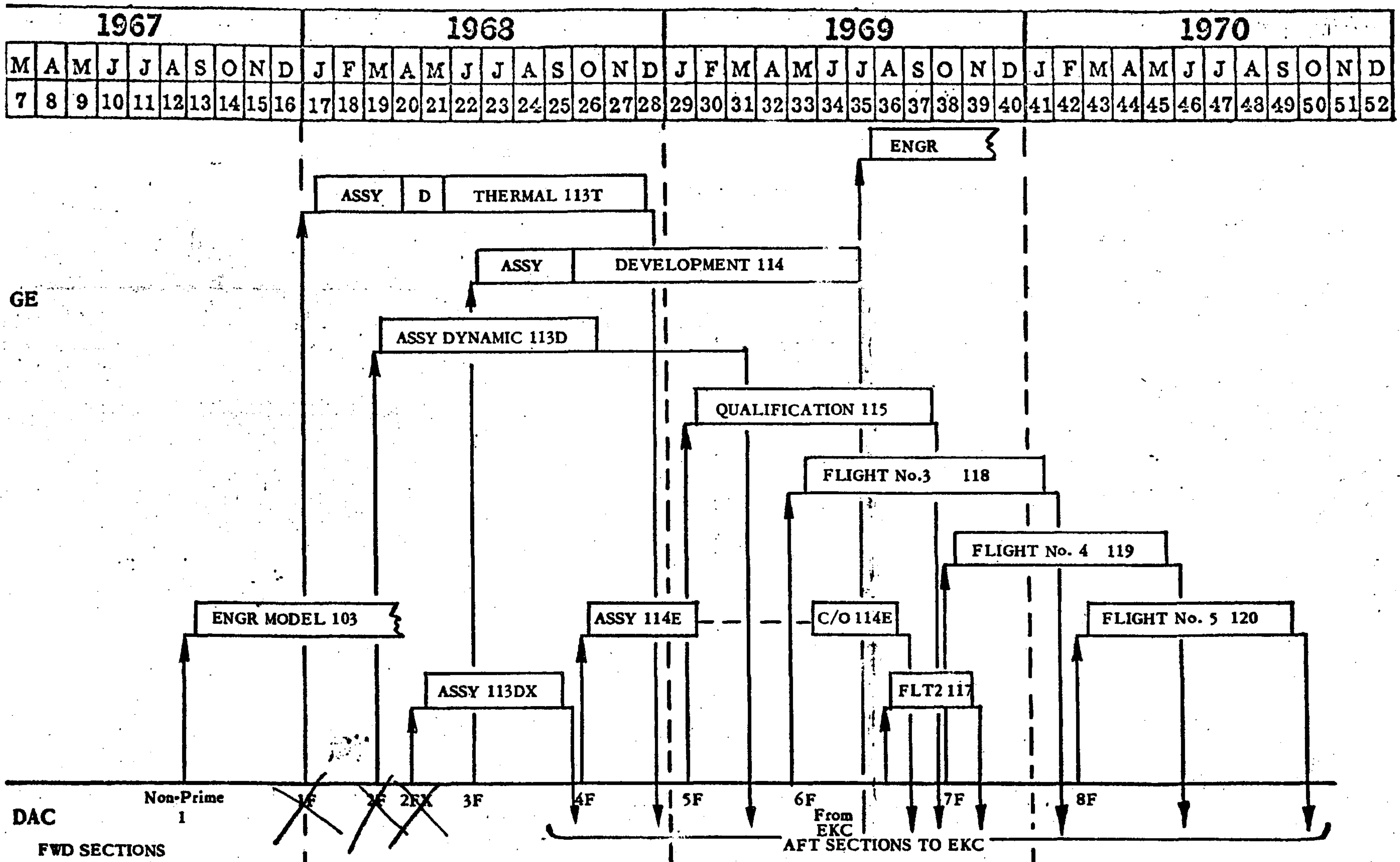


Figure II - 4

Part 4 - Funding Requirements

A. General

Costs are based upon detailed Systems Office estimates and the Phase II contract negotiations, and include an estimate of the schedule adjustment costs and deferred ~~amounts~~ item costs. ~~The~~ Deferrals are described in paragraph B, and identified changes in paragraph C. Funding requirements are shown by major work breakdown structure in Figure II-5. The tasks within the major breakdown structure are as follows:

1. AVE Hardware

~~This provides for~~ Includes the design and development of all airborne mission payload system segment equipment. ~~This~~ HPSS equipment consists of tracking mirror drive and control mechanism, target acquisition and tracking system, navigation and control, data return vehicles, target cueing system and environmental control system for the tracking mirror bay. ~~Included is~~ Flight hardware is included for three manned and two unmanned flights.

2. AGE

~~This~~ Includes design, development, testing and qualification of all AGE to support the Mission Module, including the Mission Module transporter and the environmental control and monitor unit for use with the transporter. Also included is electrical AGE equipment ~~to be used in~~ for testing and checkout of the Mission Module. The AGE ~~will be~~ is installed and operated at General Electric, and at other associate contractor facilities. The set used at General Electric will be refurbished and installed at VAFB. All electrical AGE ~~will be~~ is of similar design and function. However, AGE will be adapted as required ~~for~~ to satisfy peculiar requirements at each specific location. Electrical AGE will be provided to EKC for mission module level testing.

3. Training

~~This~~ Provides for the development, testing and operation of all training equipment associated with the mission payload. It includes the operation of mission payload, simulating and training of astronauts at General Electric Company and at VAFB. Mission Payload simulation equipment is integrated with equipment from other associate contractors to make up the complete MOL simulator ~~which will be~~ installed at VAFB.

4. System Test

~~This task~~ Covers contractor performance of General Electric AVE in-house development and testing at the system level. It includes General Electric Company's participation in system tests at other associate contractor facilities and overall MOL system test at the Laboratory Vehicle contractor's facility and VAFB. This task includes providing the hardware and support required to accomplsih all system testing of General Electric furnished equipment. It also includes General Electric hardware and support required by other associate contractors for their system development and qualification tests.

5. System Engineering and Management

This task includes all engineering analysis and design integration at the mission payload system segment level. System engineering and integration is accomplished on both AVE and AGE hardware and software. Management under this task includes project engineering and planning utilizing PERT and providing a Cost Planning and Control System. Also included is a system effectiveness program to insure that overall system effectiveness requirements are met. Travel, living and training expenses of contractor personnel are included as a direct charge under this task.

6. Documentation

This task includes preparation and publication of all data and reports required of GE.

7. Launch and Flight Operations

Launch operations cover the GE support and services required at VAFB to test launch GE flight hardware and to support other launch activities required at VAFB. Flight operations cover GE software development including computer programs for command and control from the Mission Control Center, on-board computer program for operation of target acquisition, tracking and functioning of all mission payload equipment. This item includes the GE support and services at the Satellite Test Center to provide mission operation support and flight data analysis and reports. The task also includes providing a capability for an off-line data reduction facility at Sunnyvale.

B. Deferral Status

Several tasks were deferred from the Phase II baseline contract pending further definitization. The estimated costs and a brief description, of these items follow:

1. Field Support Program - $43.3M

This effort is in support of GE-AVE/AGE and of Exchange Hardware at DAC-Huntington Beach, VAFB, STC-Sunnyvale, and On-Orbit/ Post-Flight Support.

2. Image Velocity Sensor - $9.0M

The IVS detects relative motion of the primary optical image across the optical format and provides an error signal used to correct the rates of the tracking mirror drive. GE is revising the IVS specification in preparation for participation in an AF and potential subcontractors specification review.

3. Acquisition Tracking System - $27.2M

The ATS is the target selection and acquisition system. The subcontractor, ITEK, has been selected and has been working since January 1967.

4. Data Recovery Vehicle System - $13.8M

The DRVS will provide for the return of the photographic record to the recovery area.

5. Exchange Hardware - $19.1M

This deferred effort covers those items of development/ test exchange hardware which GE will provide to DAC and EK.

6. Logistic Spares - $9.5M

Logistic spare components/hardware will be used to support the field site operations and the support of GE hardware.

7. Support Module - $3.1M

C. Identified Program Changes

Estimated costs and brief descriptions of each program change considered essential to program accomplishment are as follows:

1. Sliding Mask Door (SMD) - $6.4M

The sliding mask door, which replaces the baseline thermal door, will open to expose the tracking mirror viewport, during target acquisition, and remain closed at other times to control the tracking mirror bay thermal environment. The SMD concept is currently under study.

2. Flights 1 and 2 Support - $.9M

In support of Development Flights #1 and #2, GE will define and integrate the GE/EK flight objectives and sensor/data requirements. This will include: equipment substitutes to simulate payload flight conditions, data analysis for GE equipment, and post flight report.

3. Alignment Equipment - $1.4M

Alignment equipment and alignment operation will be in support of GE equipment at the field sites. Alignment will include alignment of low "g" accelerometer, gimbal to COA, deflection compensators, etc.

4. Refurbishment, Qualification Vehicle Consoles - $.3M

The qualification vehicle consoles will be refurbished and retested for FV-5 use.

5. Engineering Model - $2.6M

Refurbishment of Engineering Model 103 for use as an EKC development test vehicle.

6. Mission Module Test Set Installation and Checkout, Qualification Vehicle Test - $.1M

The revised test flow requires that the MM Test Set be installed and checked out with the qualification vehicle prior to its delivery to EK. This is required to assure compatibility of the test equipment with the vehicle prior to delivery since MMTS will be used at EK.

7. Power Interrupt - $1.5M

GE will evaluate and institute the power interrupt capability, which requires that each component and subsystem, as well as system, be provided with protection to withstand a power interrupt and proper initialization sequencing so as to be able to meet all system performance requirements within 30 seconds. This requirement is presently being evaluated for design methods to minimize schedule and cost impact.

8. Command Software - $1.3M

This deferred effort is the design, development and integration of the Executive Routines GE is currently working on the proposal.

GE MISSION PAYLOAD SYSTEM SEGMENT FUNDING REQUIREMENTS

(In Millions)

	FY 67	FY 68	FY 69	FY 70	FY 71	FY 72	TOTAL
AVE	13.9	38.6	50.0	32.9	11.1	4.7	151.2
AGE	7.5	11.5	16.3	6.7	2.0	.4	44.4
Training	.4	1.6	3.1	1.6	1.0	.2	7.9
Systems Test	.8	4.0	14.1	7.3	4.0	1.0	31.2
Systems Engineering	9.9	11.5	13.2	17.8	7.0	4.1	63.5
Documentation	.4	1.6	2.0	9.0	1.0	.2	14.2
Flight Test Operations	.4	1.2	2.3	4.0	3.0	1.3	12.2
	33.3	70.0	101.0	79.3	29.1	11.9	324.6

Figure II-5

SECTION III - PHOTOGRAPHIC SYSTEM

(Eastman Kodak Company)

Part 1 - System Description and Performance Requirements

A. General

The Photographic System contains optical, mechanical, thermal, electrical, and structural components necessary to perform high quality, stereo, photographic reconnaissance. It will provide a static lens-film resolution equal to or greater than 114 lines per millimeter at the film plane at a 2:1 apparent scene contrast and illumination of 890-foot-Lamberts when using film of type 3404 (but with an exposure index of 6.0). The Photographic System will be capable of both north-bound and southbound photography from orbital altitudes of 70 to 230 N.M. It will be capable of both manned/automatic and automatic operation and provides for visual observation through the primary optics at high magnifications in the manned mode.

The baseline Photographic System for the MOL consists of a primary lens system with necessary support structure, provisions for camera recording of optical image or visual observation with variable magnification, control console components, film viewing and processing equipment, necessary electronic and thermal control equipment, and ground support equipment.

B. Technical Description

The primary lens system is a Ross telephoto design with a [redacted] focal length, 70-inch primary [redacted] and a 1.08-degree field of view. A lens barrel provides optical alignment, controls thermal environment, and provides the mounting structure for the 70-inch reflecting aspheric mirror, the Newtonian and Ross (45-degree) folding mirrors, and the Ross corrector lens assembly.

A 70-inch tracking mirror provides for nulling the ground image motion and for directing the optical line-ofsight obliquely up to 40 degrees to either side and approximately 30 degrees fore and aft.

The camera, located in the Laboratory Module, is a frame type. The platen is equipped with across-the-format image motion compensation to decrease resolution degradation at the edge of the frame due to local relative motion during exposure. The image is circular, 9.4 inches in diameter, with attitude, sequence, exposure time, tracking mirror point angle and camera settings recorded within the format of each frame. Variable exposure times are possible with the focal plane shutter at a recycle rate of one frame/second. In the manned/automatic configuration a capacity for 10,250 feet of type 3404 black and white primary film is to be incorporated with additional provisions for 2900 feet of secondary film consisting of color, infrared or other special film types which are employed in a secondary camera. In the automatic configuration 17,400 feet of type 3404 black and white film is provided. The automatic version has necessary film transports (chutes), and cutters to load the re-entry vehicles automatically. In-flight processing equipment is provided by EKC for the Laboratory

Module to allow the crew members to prepare film from the secondary camera platen for photo readout to the ground, when this option is provided. The on-board processor is capable of processing 50 pictures per day at a rate of less than 5 minutes per picture.

The primary optical system can be used by the crew members for high magnification (127X [redacted]) visual viewing. An eyepiece is provided for this capability with an apparent field view of 40 degrees and a full field angle on the ground of 0.4 to 0.04 degrees. Approximately five per cent of the total image illumination is utilized for this purpose.

An environmental control subsystem utilizing passive techniques to the maximum extent is provided for proper temperature control of the Photographic System during ground conditioning, powered flight, and on-orbit.

Special optical and mechanical alignment equipment for the Photographic System will be provided to validate optical and mechanical dimensions of the sensor, to align the navigation and control reference with the optical sensor, and to align automatic film handling equipment as necessary. Handling and transportation equipment will be provided to implement Photographic System vertical and horizontal displacement, erection to a vertical attitude, and in-plant transport in a horizontal attitude.

Part 2 - Operating Concept

The Photographic System incorporates automatic focus control and automatic alignment. The exposure will be controlled by computer command as will the pointing and tracking of the tracking mirror. In the manned/automatic mode these functions can be overridden or refined by the crew.

The automatic mode will provide film loading, cutting and take-up with the film feeding through chutes into the Data Recovery Vehicles. In the manned/automatic mode the crew will perform these functions and load the film into the Data Return Vehicle (DRV) when provided, and into the Data Recovery Capsules (DRC), for return in the Gemini B. In addition, the crew will load the secondary camera platen and process film for system health checks. The crew may determine the quality of the photographic take and recommend or initiate changes in the optical system (focus, exposure, and alignment); the photographs may be read out to the ground when this option is provided.

Part 3 - Schedule Considerations

The fabrication of the large optical surfaces required for the MOL Photographic System is a most exacting and time-consuming process. The procurement/production cycle of the large DORIAN fused silica raw blank is approximately one year. The initial order for MOL, which includes masters, development models and flight models, was placed in October 1965. The first blanks have been delivered and are in the process of being ground and polished. The grinding and polishing of the mirror surfaces is a laborious, artful process requiring repeated machine operations alternated with optical testing using interferometer techniques in an evacuated test chamber. Each iteration of this process refines the surface definition, and the final DORIAN requirements (0.05 wave length for the tracking mirror and 0.1 wave length for the primary mirror), are achieved by selective electroplating techniques. The figure of the primary and tracking mirrors requires repeated comparisons with parabolic, spherical and plano masters during the grinding and polishing operation. Two sets of these masters have been ordered and must be ground and polished prior to flight model primary mirror tests. Frame mounting of the mirrors must eliminate all strains which could cause image distortions, and this process dictates extensive, time consuming testing. The primary and tracking mirrors will distort their surface figure in most attitudes in a one-g field and, therefore, cannot be tested on edge in a horizontal facility.

They must therefore be provided with an air-bag type of support in a vertical facility to hold the on-orbit surface figure.

Production facilities and equipment for development, fabrication and testing of the optical system of EKC were approved in April 1966. Facility construction and equipment procurement and installation will not be complete until approximately December 1967. Present EKC facilities are scheduled for use in early payload equipment design and fabrication but are not adequate to handle the extensive development and flight model fabrication, assembly, and test program required.

Engineering design was started early in the contract definition phase and will progress through mid-CY 1967 to support the development and production of the various test and flight models required. A brief description of the test models and their use follows:

a. Formula Sample - Asphere Ross Corrector elements are ground to the optical mathematical formula and physically tested with the primary mirror to confirm the accuracy of the optical system tolerance calculations and to develop testing and adjustment techniques.

b. Structural Development Model - Duplicates mass, inertia and structural rigidity of the actual flight model. Early tests of this structure uncover resonance problems, structural magnification factors and produce data for component design requirements. This model will be shipped to DAC for structural testing.

c. Structural Model (Static) - Will duplicate the Camera-Optical Assembly (COA) in strength and rigidity and be used to evaluate effects of acceleration loading.

d. Thermal Model (2A) - Duplicate the mass, thermal time constants of the structure, insulation effectiveness and surface radiation characteristics of the flight hardware. The model will be integrated with the GE thermal test model for thermal testing.

Development

e. Engineering Model (3A) - Used to develop flight-type hardware by functional test of components and systems before assembly and test of first flight model. It is also used to test design changes as the program progresses.

f. Qualification Model (4A) - Demonstrates capability of the system to meet performance requirements in a simulated space environment.

The EKC test plan is shown in Figure III-1 and the schedule for the attainment of major design, test, development and production functions is contained in Figure III-2.

INTEGRATED TEST PLAN - 12 MONTH COMPACT FLOW

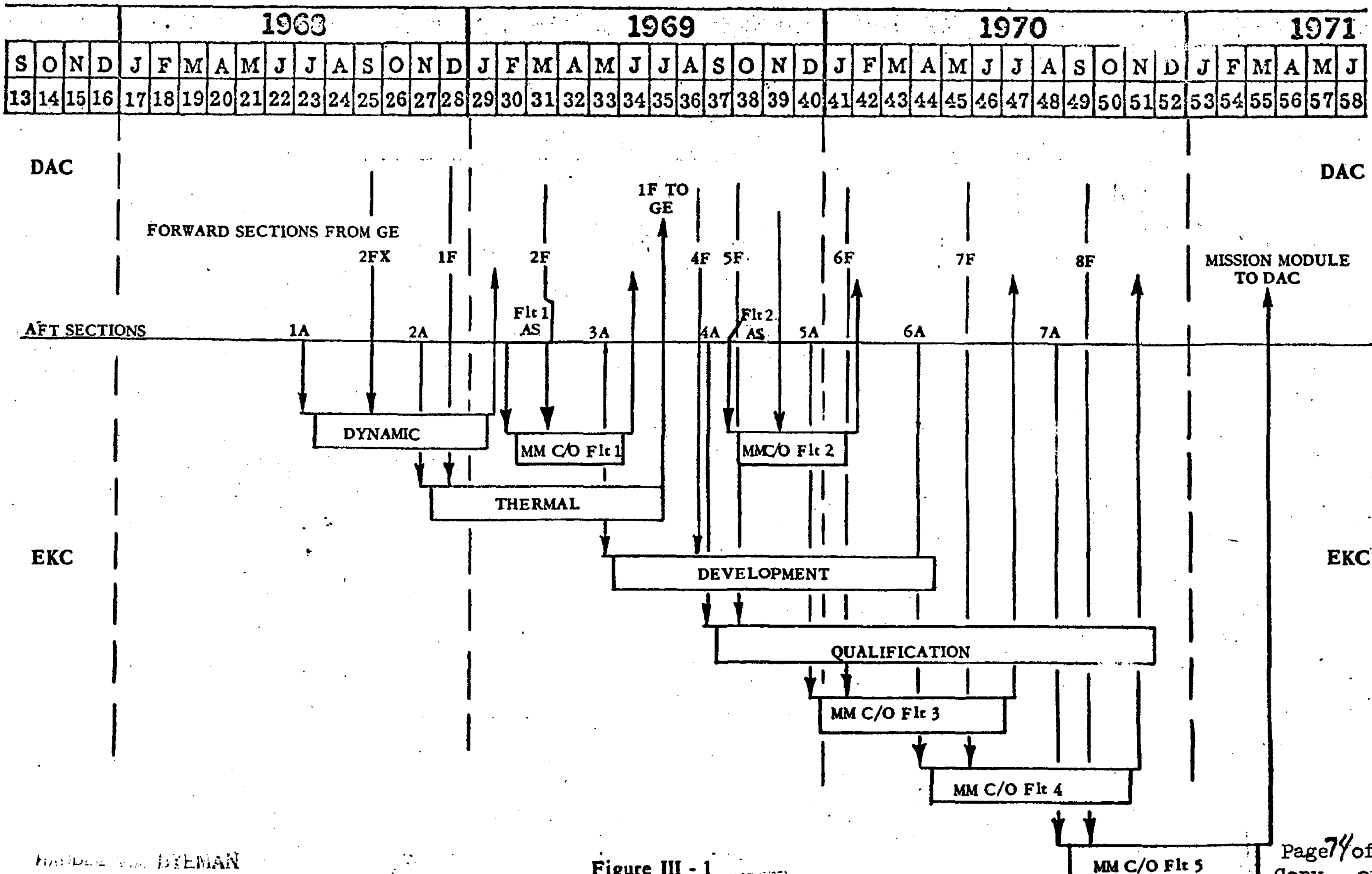
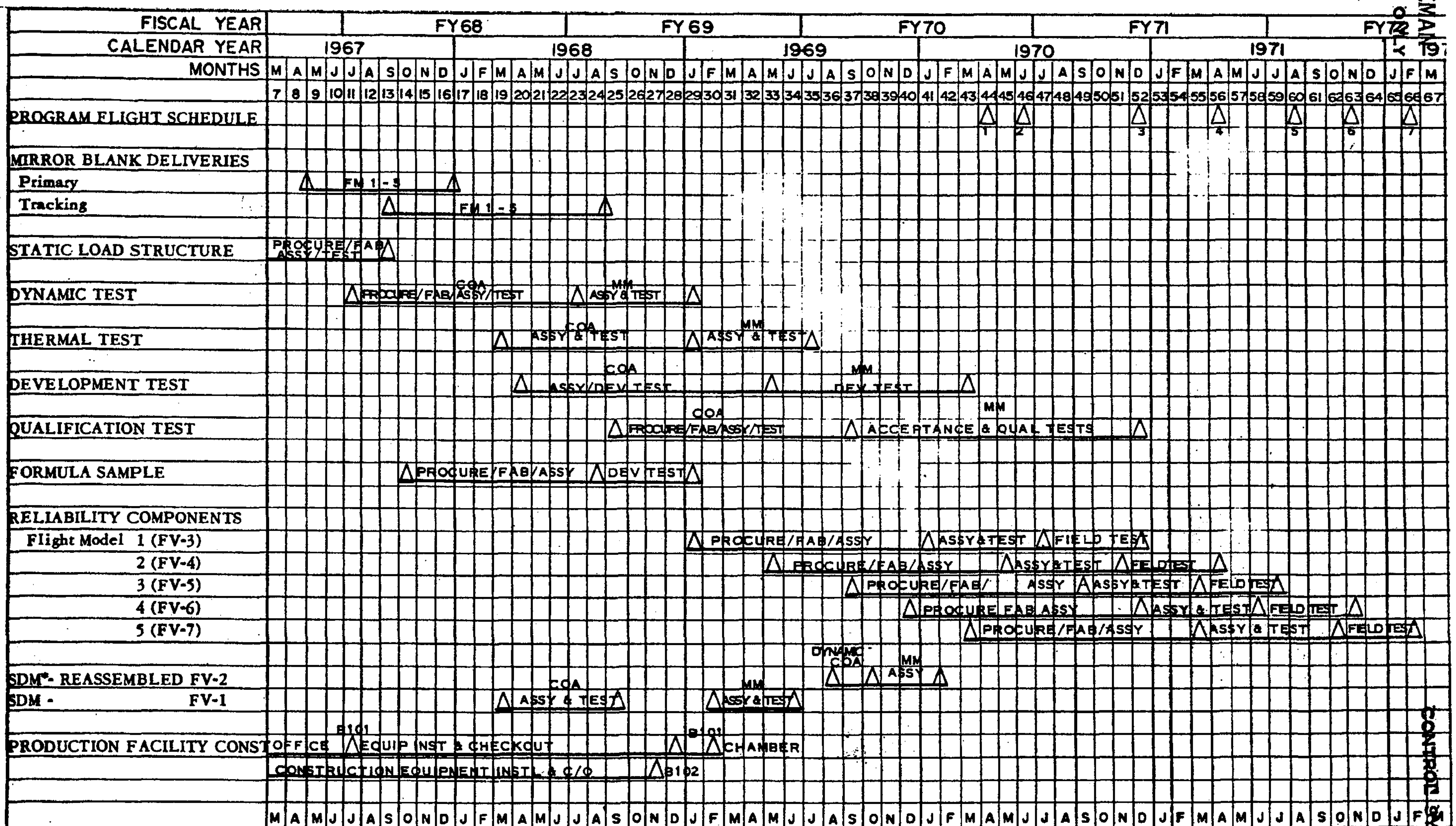


Figure III - 1

SECRET

PHOTOGRAPHIC SYSTEM



* Structural Development Model

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Figure III-2

SECRET

Part 4 - Funding Requirements

A. General

A CPFF contract has been signed with Eastman Kodak for the development and manufacture of five camera payloads for the MOL. The contract includes construction of two buildings, procurement of required industrial, test, and support equipment as well as the hardware for the sensors. A brief description of the effort contracted for follows:

1. Special Industrial Requirements (SIR)

SIR is the designation for non-fee bearing equipment EKC is authorized to procure under terms of the DORIAN contracts. The major facilities in this listing are the Camera-Optical Assembly Test, Primary Mirror Test, Tracking Mirror Test and various Thermal Chambers.

2. Research and Engineering

a. Aerospace Support Equipment

This line item is for ground and test equipment required for development of the sensor. This is not a fixed list of equipment but based on need only. It includes such items as solid test mirror blanks, camera assembly, test equipment, test consoles, unevacuated test towers and chambers, handling equipment, etc.

b. Aerospace Flight Equipment

This line item is the estimated cost for development and manufacture of five camera optical assemblies.

c. Other

Other costs include quality control, reliability, manuals, specifications, reports, etc.

3. Construction

The EKC contract authorizes construction of two buildings for the development, manufacture and test of the DORIAN sensor. The line item also includes installed equipment such as cranes.

4. System Test Operations

EKC has been directed to conduct static and dynamic testing which involves the Mission Module structure, the GE tracking mirror drive and other equipment installed in the Mission Module structure by GE and the Camera-Optical Assembly as a complete unit. Acoustic testing will also be accomplished by EKC. In addition, EKC will support field tests at other installations. These costs are additive to the basic contract.

5. Special DORIAN Efforts

Contractual arrangements are being made to grind and polish the two experimental 72-inch ceramic vitreous (Cer-Vit) mirrors. EKC will not do this work but will be available to consult on the quality of the mirrors and their incorporation into the DORIAN design. Other work includes simulation, image velocity sensor, and special advanced studies and technology.

Some contract changes have been issued. Costs for the payload segment testing, acoustic testing, and support of field test are included in a deferred package yet to be negotiated with EKC. The deferrals are described in paragraph B and new work in paragraph C. Photographic System costs are shown in Figure III-3.

B. Deferral Status

Several tasks were deferred in the original contract negotiations. Deferrals are included in the Photographic System total costs shown in Figure III-3.

1. Acoustic and Mission Payload Segment and Field Testing - $46.8M

Deferred pending completion of test definition studies.

2. Facilities and Equipment - $5.0M

Deferred pending completion of acoustic test study and decision on nitrogen reliquification plant economics.

C. Identified Program Changes

1. Mirror Mounts - $6.0M

Parallel design effort of tracking mirror assemblies for 10-inch thick Cer-Vit and baseline 12-inch thick fused silica mirrors and parallel effort to design, fabricate and test a mount for a 10-inch thick primary Cer-Vit mirror.

2. Data Recovery Capsules (DRC) - $1.0M

Effort to finalize the design of primary and secondary DRC's compatible with the structural and environmental undefined interface constraints of the Gemini vehicle and the untested operational handling requirements.

3. Support Module - $4.3M

Pending definitization of program requirements, a minimum sustaining effort is continuing on film handling hardware for the six Data Return Vehicle configuration for unmanned flights numbers 6 and 7.

4. Thermal Slats - $2.0M

Provide tracking mirror thermal slats for appropriate test models and all flight models which will optimize the thermal and optical effects produced when the sliding mask is operated during the photographic passes.

5. Conformal Coating - $0.5M

Insulate all conducting surfaces not at chassis potential to enhance electrical circuit reliability.

6. Sealed Laboratory Module Systems - $5.2M

Seal Laboratory Module components to the extent practical as a means of controlling contamination, fire, and explosive hazards.

7. Mass Substitute for Flights 1 and 2 - $1.5M

The plan to fly structural development hardware on flights 1 and 2 resulted in a requirement for additional mass substitute components not previously in the program.

8. Overrun - $19.1M

Overruns have been identified in the facility and Itek contracts.

9. Increase in Scope of Deferred Items - $7.6M

Subsequent to the compilation of the deferred list the requirement for increased scope in areas such as security, configuration engineering, interface definition, safety, and subcontract management were determined.

10. Current CCN's - $6.6M

New requirements have been recognized for the following items and are reflected in current CCN's:

a. Acoustic Testing Study

b. Support Module Study

c. DRC Mock-Ups

d. Addition to Building 101

e. Power Switching

f. Mission Development Simulator (MDS), Simulators

g. Increased Cassett Film Capacity

11. Modal Survey - $1.4M

This effort will determine natural modes, shapes, structural damping characteristics and coefficients to verify the dynamic analysis predictions.

12. Environmental Testing - $5.5M

Additional and redefined effort to test Mission Module segments in the Acoustic Test Facility.

13. Other - $2.8M

The following list includes the remainder of the identified deferrals, all of which require further definition prior to being negotiated:

a. Mission Module Simulation Equipment (MMSE) hardware and software inputs for the Mission Module Simulator.

b. MMSE support at GE, Valley Forge.

c. Crew training and modified rehearsal schedule.

d. Mission simulator support at VAFB.

e. Systems Effectiveness.

f. In-house software.

g. Schedule Interface Log (SIL).

h. Training and operations of associate contractor test equipment.

i. Acquire Mission Module Forward Section test capability.

PHOTOGRAPHIC SYSTEM FUNDING REQUIREMENTS

(IN MILLIONS)

	FY 67	FY 68	FY 69	FY 70	FY 71	FY 72	TOTAL
Special Industrial Requirements	6.7	6.2	1.1	-0-			14.0
Research & Engineering	36.0	95.5	98.8	38.9	14.4	.9	284.5
Construction	10.0	2.4	-0-	-0-	-0-	-0-	12.4
Sys Test Operations	-0-	5.9	14.8	20.5	5.6	3.3	50.1
Special DORIAN Efforts	5.8	4.6	5.1	5.2	5.0	5.0	30.7
TOTALS	58.5	114.6	119.8	64.6	25.0	9.2	391.7

Figure III-3

SECTION IV - GEMINI B

(McDonnell Aircraft Company)

Part 1 - Segment Description and Performance Requirements

A. General

The Gemini B is a modified NASA Gemini Vehicle. Its primary function is to transport the flight crew during launch and to return crew and all mission data to a water landing recovery. The MOL requirements that have the largest impact on the Gemini B design are: launch by a Titan IIIM into a polar orbit; dormant storage on orbit for 30 days; autonomous orbit operations (loiter) for 14 hours; re-entry from 80 to 100 degrees inclination orbits; and compatability with the ground tracking and control network.

Certain modifications to the NASA Gemini Vehicle will be made to meet the MOL requirements identified above. These modifications can be grouped into two basic categories:

1. Modifications for ascent/abort crew safety requirements, and

2. Modifications to permit use as a segment of the Orbiting Vehicle rather than as an autonomous spacecraft.

B. Technical Description

1. The Titan IIIM Launch Vehicle imposes a more severe ascent abort environment that the NASA Gemini Launch Vehicle, primarily due to the operation of solid rocket motors at liftoff. However, addition of

guidance and control redundancy and minor changes to the malfunction detection system (MDS) in the Titan IIIM plus two more retrograde rocket motors (required for polar re-entry) permits use of the basic NASA Gemini escape system. Changes in the escape system are primarily in its operational utilization. For escape on-pad, through burn-out of the solid rocket motors, the six retrograde motors will be employed to separate the Gemini and gain altitude. For on-pad and just after liftoff, the ejection seats must be used. The ejection seats will be used for escape from the Gemini only if land landing is imminent, if insufficient altitude will be attained to permit the Gemini parachute recovery system to deploy, or if the parachute recovery system malfunctions. This permits simplication of the NASA Gemini ejection seats by elimination of the sustainer rocket and reduction of the catapult impulse.

For escape beyond solid rocket motor burn-out, use of the separation motors or partial use of the retrograde motors will be made to separate the Gemini, followed by turnaround and re-entry with normal water recovery.

2. The most significant modifications result from the use of Gemini B on orbit as part of the overall Orbiting Vehicle. During the relatively short ascent, loiter and re-entry phases, life support and active temperature control are provided by the Gemini environmental control system (ECS). During the longer period of Gemini dormant storage

on orbit, electrical power and minimum pressure and heat are supplied from the Laboratory Module Subsystem. Batteries in the Gemini are available for necessary electrical power during loiter and re-entry. Thus, the fuel cells, orbit attitude and maneuvering propulsion system (OAMS) and radiator cooling system are eliminated from the NASA Gemini version, resulting in simplification of the Gemini adapter.

3. A means of crew transfer between the Gemini B and the Laboratory Vehicle is provided. The primary mode is through an internal pressurized tunnel. Emergency transfer is by the same tunnel in an unpressurized state or by means of extra-vehicular travel through the Gemini exterior hatches and the DRV hatch in the LM. The tunnel requires a hatch in the Gemini B heat shield and main pressure bulkhead. Initial validation of this design was accomplished with the Heat Shield Test (HST) flight in November 1966. Final validation will be accomplished in the unmanned Gemini B Qualification flight on flight #1.

4. Crew and ground monitoring via the Laboratory Vehicle telemetry of Gemini B status during the on-orbit period requires the addition of an instrumentation interface between the Laboratory Vehicle and Gemini B. There are other selected systems requiring additional sensors.

5. The SP/DR weight for the Gemini B is 6,120 pounds which includes crew member weight and GFE.

6. The Aerospace Ground Equipment (AGE) philosophy and hardware used on the NASA Gemini has been adopted for use with Gemini B. This system is manually operated and will interface with other MOL segment AGE principally by procedural and test conductor contacts. Two sets of AGE are required--one at the contractor's factory and one at the launch site. The AGE previously used for NASA Gemini at the contractor's facility will be utilized to the maximum extent; however, certain revisions must be made and simplifications incorporated as a result of subsystem changes outlined above. The present operational concept requires that the launch site van-mounted AGE items be removed and hard-mounted in the Launch Control Center at Vandenberg AFB.

7. System trainers and a procedures simulator are required to support MOL operations. These items of hardware are to be refurbished units from the NASA Gemini program.

Part 2 - Operating Concept

The Gemini B Vehicle will house the crew during ascent and re-entry. On orbit, it will be stored in a dormant condition ready for return to earth of the crew and data upon completion of the scheduled mission or for immediate occupancy and subsequent return of the crew in the event of an emergency abort of the mission.

The ascent and re-entry phases are being patterned around NASA's flight experience. The crewmembers are carried into orbit aboard the Gemini. After booster shut-down, attitude and translational adjustments will be made from the Gemini through interface control of the Laboratory Module Attitude Control and Translation Subsystem (ACTS). The necessary subsystems in the Laboratory Vehicle will be brought to operational status from the Gemini cockpit, and normal operation verified. The crewmen then transfer into the Laboratory Module through the tunnel and hatch installed in the Gemini heat shield. Laboratory Module and Gemini B atmospheres are stabilized and the Laboratory Module hatch is then closed for the on-orbit mission duration or until there is a need to return to the Gemini.

Provisions are included for backup emergency return to the Gemini by exiting through the Laboratory Module DRV hatch and entering through the Gemini exterior hatches. During dormant storage on orbit the Gemini atmosphere will be maintained at 0.1 psia and Gemini subsystems will remain in a powered down state for the mission duration. The

Laboratory Module oxygen system is sized to provide three repressurizations of the Gemini B while on orbit without reducing mission orbital duration.

Upon completion of the mission, the crewmen return to the Gemini B by way of the transfer tunnel and activate the Gemini B subsystem for re-entry. Two small solid rocket motors are used for separation from the Laboratory Vehicle.. Six retrograde solid rocket motors are fired for de-orbiting.

The Gemini B uses the same re-entry techniques as were used with NASA Gemini including the drogue and descent parachute. Water recovery by surface units as used by NASA in their Gemini flights is also planned.

Part 3 - Schedule Considerations

Principal Gemini B development testing is grouped into four categories: wind tunnel, structural, systems and thermal-vacuum.

Wind tunnel testing extends through early FY 68 to validate analysis of Gemini B aerodynamic, thermodynamic, and structural changes from the NASA Gemini. Testing will be performed in the McDonnell and AEDC facilities for thermodynamic data, and in the Ames transonic and supersonic facility for structural dynamics investigations.

Structural tests required as a result of the new Gemini B adapter design and the crew transfer modifications were initiated in FY 67 with refurbished and newly fabricated test articles. Testing will extend into FY 70 on adapter and re-entry module test articles.

The dynamic conditions induced by the Titan IIIM booster during ascent will require early qualification by vibration testing of the adapter section, and components installed therein must be made in preparation for qualification.

Six solid rocket motors are required for retrofire prior to re-entry. The higher total thrust as compared to that used on NASA Gemini (four motors) is required to satisfy the higher retrograde energy requirement for re-entry from polar orbit. Salvo firing of the six retro-grade motors will also be employed to effect pad and early launch abort in the event of catastropic failure of the boosters. Static loading tests will be conducted to verify structural integrity of mounting provisions for the motors.

Design adequacy, functional parameters, and operational characteristics of various Gemini B subsystems will be determined and evaluated during the period through mid-FY 69, initially as a part of design verification development testing, and later in support of component and system qualification. Electronic systems test and instrumentation mock-up units will be fabricated for this purpose.

The requirement to activate Gemini B subsystems prior to launch and then shut down during the quiescent 30-day period on orbit represents a significant departure from NASA's experience on the Gemini program. On-orbit storage and thermal vacuum tests will be conducted in an environmental chamber to verify adequacy of design under simulated atmospheric and thermal conditions, as part of the Gemini B qualification. These tests will utilize the refurbished NASA Gemini 3A spacecraft with the new adapter design. Test articles must be available by the end of FY 68 to allow completion of the thermal-vacuum test series in time for delivery of the GBQ spacecraft.

The Gemini B development schedule is shown in Figure IV-1. The level of AVE engineering effort required for FY 68 is approximately double that needed in FY 67 and is necessary to provide complete design release for the FY 69 principal engineering effort in support of manufacturing and test. In addition to the early engineering effort required to support AVE and AGE development, substantial engineering will be necessary during FY 68 to develop and/or modify mock-up vehicles, static-test articles, development test assemblies and fixtures, and Laboratory Vehicle interface specimens for Douglas Aircraft Company, all of which are required early in the development cycle.

GEMINI B

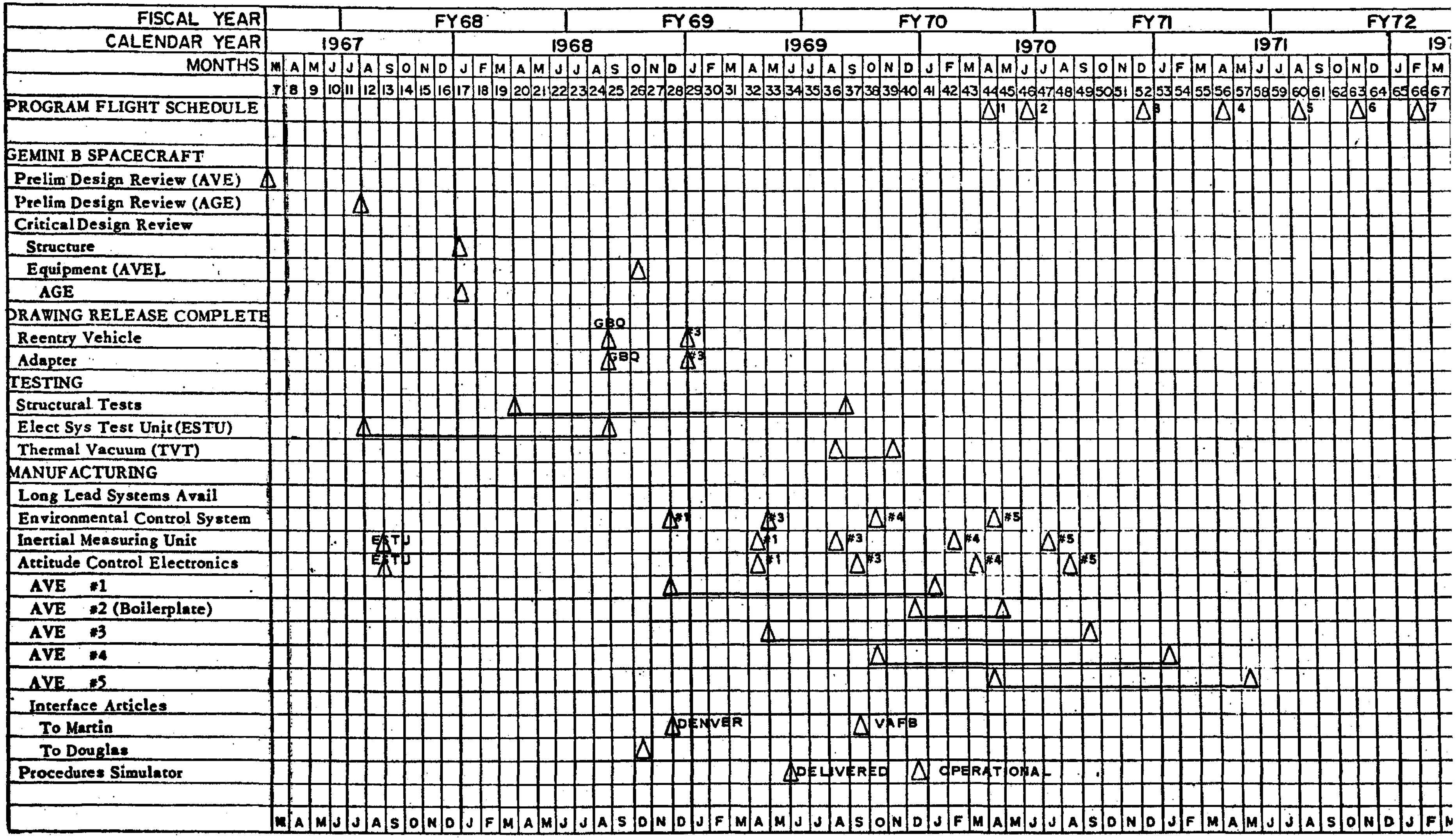

Figure IV-I

Part 4 - Funding Requirements

A. General

Costs are based on Systems Office estimates and the Phase II contract negotiations and include an estimate of the schedule adjustment costs for the Gemini B System Segment. They reflect experience from the NASA Gemini Program modified by estimates of complexity factors, mission peculiar requirements, and number of vehicles. A brief resume of the effort, by work breakdown category follows:

1. AVE Hardware. Includes the engineering and production costs of four Gemini B spacecraft, one aerodynamically similar flight article, and costs for non-recurring spacecraft development and qualification testing.

2. AGE. The hardware and integration of both factory and launch site AGE, and for modifications to existing NASA AGE for use by the MOL Program.

3. Training. Provides for the conversion of the NASA Gemini simulator to the Gemini B procedures simulator, and for crew training and associated part-task trainers, including the modification of NASA egress and centrifuge trainers.

4. Data and Support. Includes the effort in Technical Publication, Documentation, Repair Service, and Facilities Planning. Technical Publications consists of preparation, printing, and distribution of all AGE and AVE operation and service manuals and acceptance test procedures.

Documentation consists of preparation of System Engineering documents, and all graphs and art work. Repair Service consists of repair and maintenance effort for all Government Furnished Property. Facilities Planning is a McDonnell effort in support of the Launch Site Planning Activities.

5. Operations. Support of contractor personnel at the launch site, mission control, and other remote sites. The activities at Vandenberg AFB include support of site activation, spacecraft receiving and inspection, buildup and support of integration, checkout, countdown, and launch. At the Mission Control Center, McDonnell engineers will support the mission director during the flight by monitoring Gemini B status displays and by reviewing data.

6. Management. Includes Configuration Management, Data Management and Schedule Control.

The funding summary is shown by work breakdown structure on Chart IV-4. It includes deferred and identified program changes which are described in paragraphs B and C.

B. Deferral Status

Several tasks were deferred from the contract negotiations. The estimated cost and reason for the deferrals is described below. Deferral costs included in the Gemini B segment total costs are shown in Figure IV-2.

1. Pad Abort Control System (PACS) - $2.500M. As a result of crew safety analysis it was determined that the probability of survival for aborts on or near the launch pad was extremely low. Consequently, the Gemini B baseline was revised to include the incorporation of a thrust vector control system to assure optimum spacecraft orientation during abort. The system consists of solid propellant thruster units and an attitude control electronics package.

2. Spares - $14.000M. This item includes services and equipment which could not be firmly established until NASA Gemini residual spares and equipment inventories and their availability to support MOL were identified.

3. Remote Site - $25.000M. This item includes the post FY 67 remote site operations effort and the associated McDonnell mission planning effort. These efforts required further definition prior to contractual action.

4. Cost/Schedule Planning and Control Specification (C/SPCS)-$2.50 M This item includes the effort to operate and maintain a Cost/Schedule Planning and Control System throughout Phase II and the associated reporting requirements which will satisfy the MOL Systems Office management needs.

C. Identified Program Changes

Revised or new technical requirements and management decisions since December 1966 have resulted in added tasks. The estimated cost and reasons for these change items are described below. The costs are included in the Gemini B segment total costs shown in Chart IV-4.

1. Diode Assembly - $.030M

Interface discussions between McDonnell and Douglas disclosed that the Laboratory supplied electrical power could exceed Gemini B voltage limits. In order to preclude this possibility, McDonnell was directed to install a diode filter assembly on the Gemini B side of the interface since it appeared that this would be less costly than restricting the laboratory power.

2. Non-Availability of 16 AGE Items - $.580M

This includes the effort required to replace 16 NASA AGE items that were previously assumed to be available.

3. Increased Tension Strap Loads - $.900M

The baseline Gemini B re-entry module to adapter attachment straps were identical to those used on the NASA Gemini. During load cycle 2 it was determined that these straps would not withstand the tension loads imposed by Stage 1 shutdown. After a thorough review by the SPO and Aerospace, it was determined that these straps and the associated supporting structure should be increased in strength to avoid later and more costly design.

4. Electrical Substitutes - $.200M

This item includes the delivery of two additional Gemini B to Laboratory Vehicle electrical substitutes to support Douglas testing at Huntington Beach. This requirement resulting from an Interface Control Meeting, requires Douglas to use substitutes for interface testing at Vandenberg AFB and at Huntington Beach.

5. Recovery Documentation - $.100M

Documentation support by McDonnell to aid in defining the Gemini B recovery requirements. Work has started and will continue through FY 70.

6. Facility Design at Vandenberg AFB - $.100M

Due to a change in responsibility after negotiations, McDonnell was required to define Gemini B peculiar support buildings at Vandenberg AFB. Additional effort in this area will be included in Remote Site effort.

7. Adapter Shock Tests - $.100M

The MOL Systems Office requested that the quantity of development test articles being delivered to Douglas by McDonnell be increased in order that Douglas could complete the three required separation shock tests at station Z-49.

8. Blast Shield - $4.000M

After several extensive reviews by the MOL Systems Office and Aerospace, it was determined that the most effective method of providing protection to the laboratory unpressurized section was to change the baseline from local protection to an integral blast shield. McDonnell is presently engaged in design effort to redefine the McDonnell-Douglas interface.

9. Ground Activated Abort Lights - $.100M

This item will modify the baseline Gemini B by adding a separate Mission Control Center activated abort light and a separate guidance switch-over light also activated from the Mission Control Center. This change will also require a modification to the Laboratory Space-Ground Link System (SGLS) to accommodate the necessary uplink and interface to Gemini B.

10. Positive Separation - $.020M

As a result of crew safety studies by McDonnell, Martin and the MOL Systems Office it has been determined that a booster destruct inhibit will improve crew abort survivability. This change is made to assure that the booster will not be destructed until the spacecraft has separated during abort.

11. Fire Hazard - $2.000M

McDonnell is presently conducting a two month study as a result of the recent Apollo fire. The results of this two-month study are expected to lead to some changes in spacecraft equipment and procedures.

12. Heat Exchanger - $.050M

Based on a change of inlet temperature on the Laboratory side of the heat exchanger, McDonnell was requested to submit an Engineering Change Proposal (ECP) to add heaters to the warmant loop of the Gemini B. These heaters will be powered from the laboratory during on-orbit dormant storage and are required to assure the adequate temperature of the Gemini B.

13. Egress Trainer Operation and Maintenance - $.350M

This item will provide flight crew members with experience in egress from the Gemini B during post landing recovery operations. The basic vehicle was used by NASA during the Gemini Program and it is intended to reconfigure the trainer to a MOL Gemini B configuration for training of flight crew members and recovery crews.

14. Abort Trainer Operation and Maintenance - $.450M

This item includes effort by Ling-Temco-Vought Co. (LTV) at Dallas to conduct an engineering simulation for fast reaction pad and ascent mode aborts. This simulation will be similar to others that LTV did for NASA. Gemini B program, Martin, and McDonnell are also required to support this program.

15. Gemini B Procedures Simulator (GBPS) Instructor at Remote Site - $.250M

This item will cover six contractor simulation instructors at the remote site. Flight crew training will start twelve months prior to scheduled launch of Vehicle 3. GBPS will also be used to rehearse Mission Control Center controllers for both the Gemini B Qualification and Vehicle 3 flights.

16. T-IIIM Electrical Substitutes - $.050M

This design effort is needed to support Martin with equipment for use in a functional test of the Gemini B and Booster inertial guidance systems.

17. Data Recovery Capsule (DRC) Flotation - $.100M

This is currently not included on either the DRC or Gemini B contract baselines, but will become a McDonnell responsibility and design effort will start in the fourth quarter FY 67.

18. Survival Kit - $.150M

This item was assumed during negotiations to be contractor furnished equipment. A preliminary list of equipment has been identified and McDonnell should commence effort in FY 68.

19. Support of Air Training Command (ATC) - $.050M

McDonnell support to Air Training Command (ATC) for the development and preparation of training courses for flight controller training.

20. Gemini B Procedures Simulator (GBPS) Computer Complex - $.640M

The Gemini B Procedures Simulator (GBPS) Computer Complex shipped from NASA for MOL does not have the capacity to perform the MOL GBPS functions. The primary reason is the MOL requirement to generate and transmit booster telemetry data in operational data format, the ability to operate closed loop with the Mission Control Center, dynamic simulation of operating conditions, and the requirement to verify Mission Control Center computer software programs.

FUNDING REQUIREMENTS BY WORK BREAKDOWN STRUCTURE

GEMINI B

(IN MILLIONS)

	FY 67	FY 68	FY 69	FY 70	FY 71	FY 72	TOTAL
AVE	30.3	41.6	59.1	29.1	7.4	.7	168.2
AGE (Includes all spares	3.1	5.3	11.3	10.5	3.0	.6	33.8
Training	.5	1.3	1.3	2.3	1.7	.3	7.4
System Support	.4	.7	.9	.7	.5	.2	3.4
Operations	.2	2.5	6.7	9.1	7.7	2.0	28.2
Management	1.8	2.6	3.0	2.5	1.2	.4	11.5
	36.3	54.0	82.3	54.2	21.5	4.2	252.5

Figure IV-2

SECTION V

TITAN IIIM LAUNCH VEHICLE
(Martin Marietta Corporation and Associates)

Part 1. Segment Description and Performance Requirements

The Titan IIIM Launch Vehicle, an adaptation of the Titan IIIC Vehicle, is required to be capable of inserting from Vandenberg AFB launch complex, without yaw steering, a payload of 31,325 pounds, minimum, into a 90 degree inclination orbit with perigee of 80 nautical miles at 55° north latitude, and apogee of 180 nautical miles.

The Titan IIIM Launch Vehicle for MOL consists of three propulsion stages. Stage Zero provides the initial thrust from two 120-inch diameter, seven-segment solid rocket motors. Liquid rocket engines are used in Stages I and II which together comprise the vehicle core. The forward compartment of Stage II contains the inertial guidance system, flight controls, electrical systems, instrumentation systems, and tracking and flight safety equipment. The interface between the Launch Vehicle and the MOL Orbiting Vehicle occurs at the forward end of Stage II, since the Titan III transtage will not be used for MOL.

Performance/design requirements for the Launch Vehicle segment are based upon MOL-peculiar requirements for flight dynamics, payload weight, orbital parameters, crew safety, system effectiveness and launch operations. Other system requirements remain as developed for the Titan IIIC system. Maximum use is being made of Titan IIIC design and components, with changes only where necessary to satisfy MOL-peculiar requirements.

Part 2 - Operating Concept

The system provides for launching a vehicle within a one-hour window on any of three successive days specified two weeks in advance of the scheduled launch date. Provisions are made for a hold capability including programmed holds at appropriate points in the pre-launch countdown sequence.

The Titan IIIM will be capable of launch within the launch window on the next day following a launch abort which occurred during the terminal count and which was caused by conditions external to the launch vehicle/Aerospace Ground Equipment (AGE), except when core propellants or solid rocket motor thrust vector injectant unloading is required.

Part 3 - Development and Schedule Considerations

The overall Titan IIIM system involves four contractors: Martin-Marietta Corporation (MMC); United Technology Center (UTC); Aerojet General Corporation (AGG); and AC Electronics Division of General Motors (AC). Martin has reponsibility for the Titan IIIM airframe and launch vehicle systems integration, checkout and launch. Each of the other contractors is responsible for the on-pad checkout of his portion of the system.

Design changes to the Titan IIIC and development requirements necessary to meet the MOL requirements, discussed by individual contractors, are as follows. The schedule is shown in Figure V-1.

A. Titan IIIM Airframe - Martin

1. Development - Flight Hardware

Modifications and redesigns associated with the airframe involve the structure, flight controls, hydraulic system components, flight sequencer, malfunction detection equipment, explosive bolt ordnance and fuel tank pressurization system.

(a) Stage I Airframe

The method of construction of Stage I remains virtually unchanged from that of Titan IIIC. Principal configuration and structural modifications will be:

(1) Relocation of the solid rocket motor attach fittings.

(2) An increase of 37 and 31 inches, respectively, in the lengths of the Stage I oxidizer and fuel tank barrels.

(3) Redesign of the Stage I heat shield (boattail), primarily the floor, to satisfy the new requirements of the Stage I propulsion system.

(4) Skin gauges, stiffners, raceways, longerons and internal conduits will be modified as dictated by the increased thrust of both the solid rocket motors and Stage I engines plus the increased length of Stage I for added fuel capacity. Various structural beef-ups are also involved for increased crew safety.

(b) Stage II Airframe

A redesigned Stage II forward skirt is needed to house the equipment normally located in the Transtage Control Module. With the exception of the forward oxidizer skirt, the basic configuration and method of construction of Stage II remains virtually unchanged from that of Titan IIIC. Principal configuration and structural modifications will be:

(1) Replacement of the existing forward oxidizer skirt with a redesigned skirt which will be attached to the forward oxidizer tank juncture frame.

(2) Replacement of the existing forward oxidizer tank juncture frame with a redesigned frame which will have attachment provisions to accept the new forward oxidizer skirt.

(3) Replacement of the equipment and instrumentation trusses in the forward oxidizer skirt with trusses of a new design.

(4) Addition of solid rocket motor attach provisions on the new forward oxidizer skirt.

(5) Deletion of retro-rockets including supports and attachment provisions.

(6) Skin gauges, stiffeners, raceways, longerons, and internal conduits will be modified for compatibility with the vehicle loads and propulsion requirements.

Design engineering of these changes was begun in April 1966 to meet the original launch schedule. With the current MOL schedule, this activity will be held to a minimum in FY 67 and 68 commensurate with meeting the critical milestones of a Controls Mock-UP (CMU) in the third and fourth quarter of FY 69 plus the Structural Test in the fourth quarter of FY 69 and first quarter of FY 70.

(c) <u>Flight Controls</u>

A triple redundant analog autopilot with majority voting circuitry is required for adequate crew safety. Existing designs must be modified to meet the guidance requirements during Stage Zero flight and to also accept either the Booster Inertial Guidance or the Gemini Inertial Guidance inputs. The design activity will be conducted at a rate to meet the Controls Mock-Up milestone in the third quarter FY 69.

(d) Hydraulic System Components

In order to mate with the redundant flight control system, a three torque motor majority voting actuator must be designed. In addition, the Stage I hydraulic system requires a redundant hydraulic power supply. This design effort must also meet the Controls Mock-Up milestone.

(e) Flight Sequencer and Malfunction Detection Equipment

Crew Safety and mission success dictates redundancy of the flight sequencer. Due to excessive weight of the Titan IIIC flight sequencer relay matrix, when expanded into a redundant system, a new light-weight sequencer is mandatory.

The Malfunction Detection system requirements for adequate crew safety require the major component redesign for the Titan IIIM. New design logic is needed plus crew displays in the Gemini. The addition of new electrical equipment plus relocation of some existing equipment requires almost complete redesign of the Titan IIIC vehicle wiring.

(f) Explosive Bolt Ordnance and Fuel Tank Pressurization

The heavier payload and increased thrust requires redesign of the Titan IIIC explosive bolts. Increased fuel tank capacity of Stage I necessitates some redesign and resizing of the fuel tank autogenous pressurization system.

2. Production - Flight Hardware

In all the above areas of airframe modification and redesign, the requirement exists to meet the Controls Mock-Up and Structural Test milestones with production articles in late FY 69. Component development will be completed during the third quarter of FY 69. Design insurance and structural tests will be complete during the first quarter FY 70, with First Article final assembly also complete during first quarter FY 70.

3. Development and Production - Aerospace Ground Equipment (AGE)

The numerous changes to the Titan IIIC vehicle plus the conversion from an Integrate Transfer and Launch (ITL) to the MOL Space Launch Complex at Vandenberg AFB necessitate resdesign or resizing of many items such as the Air Conditioning Liquid Nitrogen converters and many electrical components. Delivery of AGE to Vandenberg AFB, initial installation and systems test must begin during the third quarter FY 69. Final installation and checkout for booster AGE should be complete during the third quarter FY 70 in order to permit facility acceptance just prior to the first launch in April 1970.

B. Liquid Rocket Engines - Aerojet

The increased thrust requirements and higher altitude performance levied on the Stage I and II liquid rocket engines due, respectively, to the MOL payload weight and the increased Stage Zero performance demand redesign of combustion chambers, injectors and frames for both stages, plus development of a 15:1 expansion ratio nozzle, an ablative skirt and higher performance turbopump for Stage I.

1. Development -Stage I Engine

(a) The first new combustion chamber was delivered for development testing in the fourth quarter FY 67. Testing has been accomplished to determine thermodynamic, flow and durability characteristics prior to the development of the injector, and the subsequent chamber-injector compatibility tests. A Preliminary Design Review (PDR) has been completed and a Critical Design Review (CDR) is scheduled in the first quarter FY 68.

(b) Dynamically Stable Injector

Fabrication of various baffle configurations, using developed injectors, has been accomplished. Pulse tests have established the baffle configuration and confirmed the dynamic stability.

(c) Ablative Skirt

A conservative thickness basic design skirt was delivered in the fourth quarter FY 66. Component tests have been run on several skirts with the new combustion chambers and baffled injector to acquire data such as char rates and back wall temperatures. Final designs will be formulated from these tests. The Critical Design Review was conducted in March 1967.

(d) Turbopump

Increased Stage I thrust performance demands higher fuel flow rates and therefore higher rotational speeds than the Titan IIIC turbopump can reliably provide. Therefore, redesign of the pump high-speed shaft was required plus analysis of the compatibility of such redesign with other components of the gearbox assembly. The first prototype pump assembly was available for testing in the second quarter FY 67. Critical Design Review will be conducted in the first quarter FY 68.

(e) Engine Frame

Dual hydraulic actuators for MOL crew safety plus increased engine thrust require a new engine frame. The first unit was delivered in the third quarter FY 67 for a static load test followed by engine firing. The Critical Design Review is scheduled for first quarter FY 68.

2. Demonstration - Stage I Engine

Procurement and Assembly of prototype components for overall engine evaluation began in the second quarter of FY 67 and will be followed by a final engine qualification test demonstration on two complete engines during the second and third quarters FY 68.

3. Production - Stage I Engine

The lead time for engine production is 17 months. This requires initiation of production 4 months prior to completion of development/demonstration testing in order to deliver the first engine to the Vertical Test Facility (VTS) at Martin in September 1969. This overlap could be reduced by installing the engines subsequent to the Vertical Test but would not be desirable from an overall system viewpoint. The first engine will be completed in July 1969 with subsequent engines at 2-month intervals.

4. <u>Development - Stage II Engine</u>

Necessary changes to the Stage II engine are not as extensive as for Stage I and therefore result in much less effort and cost.

(a) <u>Combustion Chamber</u>

Increased burn time and a basic chamber-injector incompatibility resulted in redesign of the chamber tubes to more effectively withstand this environment. Design of the new chamber has been completed, and it is available for development/demonstration testing in the second and third quarters FY 68.

(b) <u>Injector</u>

The present Gemini Launch Vehicle baffled injector is being redesigned to provide better film cooling and uniform mixture ratio across the face. The resultant design should produce improved performance needed for the MOL mission.

(c) <u>Engine Frame</u>

Dual hydraulic actuators resulting from the MOL flight control redundancy requirement demand redesign of the engine frame. The first unit is scheduled for testing in the fourth quarter FY 67.

(d) Miscellaneous

Several small items, such as redesigned fittings, plus the gearbox developed for the Gemini Launch Vehicle are scheduled for incorporation. These are low-cost product improvements and have minor effects on development/demonstration schedules.

5. Demonstration - Stage II Engine

Because the changes to the Stage II engine are not as extensive as those to the Stage I, cost and schedule reductions will be effected by eliminating the evaluation tests and conducting only the formal demonstration tests. These tests will be identical to those of Stage I. They will be conducted during the second and third quarters FY 69 to be consistent with FY fund ceiling limitations.

6. Production - Stage II Engine

The production lead time situation will necessitate initiation of production 9 months prior to completion of development/demonstration testing. The delivery schedule will match that of the Stage I engine.

C. Solid Rocket Motors - UTC

1. Development

The MOL payload requirement places maximum design demand on the solid rocket motors. To achieve the required Stage Zero thrust, two segments will be added to the existing 5-segment 120-inch diameter motors, a longer forward closure will be incorporated, the thrust vector control (TVC) fluid tankage and injectant valves will be redesigned and the nozzle and propellant modified.

Verification of the design parameters of the nozzle materials, internal motor ballistics and TVC system, by means of sub-scale testing, was completed in the fourth quarter FY 67.

Design of the forward closure, nozzle and TVC system continued into the last quarter of FY 67 as follow-up to the sub-scale testing.

2. Demonstration

The first development motor test is scheduled for the first quarter FY 69. Three motors will be tested through the third quarter FY 69. Five additional motor tests will constitute the Preliminary Flight Rating (PFRT) demonstration during FY 69 and 70. Fabrication of these motors begins in the first quarter FY 69 to allow sufficient lead time for the critical forgings of the forward closure and the nozzle shell forgings.

3. Production

Due to the long lead time for parts processing and fabrication of the solid motor cases and nozzles, considerable overlap of flight motor production with development and PFRT motor fabrication is necessary. Production is scheduled to begin during the fourth quarter FY 69 to meet a first flight motor acceptance in the first quarter FY 70 followed by delivery in the second quarter FY 70. Additional flight motor pairs will be delivered initially on four-month centers.

D. Inertial Guidance System - AC Electronics

A redundant guidance and control system in the Launch Vehicle is required to meet the MOL crew safety and mission success requirements from launch to orbital injection. Since crew safety is particularly critical during Stage Zero flight, a triple redundant flight control system will be employed in that stage with dual redundancy of guidance system functions in Stage I and Stage II. During the last 120 seconds of Stage II flight, the vehicle will be beyond the range of the ground radar tracking stations used as part of the ground-based slow malfunction detection system. Under this condition, a third redundant configuration will be employed to provide an airborne autonomous slow malfunction detection system.

The basic components of the guidance system for the Titan IIIM consist of an Inertial Measurement Unit (IMU), Missile Guidance Computer (MGC) and a Signal Conditioner (SC). No design effort is required for the Inertial Measurement Unit since it is basically the same as presently used in the Titan IIIC. The Missile Guidance Computer is basically a Univac 1824 computer, but requires redesign for adaptation to the MOL requirements. The Signal Conditioner is a new design which handles the instrumentation requirements, consists of micro-electronic circuits, is within the present state-of-the-art and is available for long lead procurement.

1. Development and Test-Flight Hardware

In order to obtain maximum flight reliability confidence for the MOL mission, the inertial guidance system components are programmed for use on two Titan IIIC flights between the first and second quarter FY 69. Therefore, these flight dates establish the first major milestone for the AC development schedule. The basic design activities for the computer and signal conditioner began in May 1966 and will continue through the development and qualification tests during the first quarter FY 68. These qualification tests, prior to the Titan IIIC flights, consist primarily of the dynamic tests, such as acoustic, shock, acceleration and vibration. Additional flight proof testing will occur in the second quarter FY 69 using early MOL production articles.

2. Production - Flight Hardware

The initial production, started in September 1966, will provide computers for the Titan IIIC flights plus one for the qualification testing and two others to support the systems integration testing at AC and the controls mock-up at Martin. Subsequent to the Titan IIIC flights, computer production for the MOL flight articles will be slowed down to a minimum rate of 1 per quarter. The normal production capacity is 4 per month. Production will, therefore, be completed by the end of FY 69. Production of the signal conditioners, started in September 1966, will provide for the Titan IIIC flights plus a spare and 1 for the qualification tests. No signal conditioners are required to support the systems integration testing at AC or the controls mock-up at Martin. Production of the Titan IIIM flight articles will continue at a minimum rate of one per quarter, to completion by the first quarter of FY 69. Sufficient Inertial Measurement Units are presently available to support the Titan IIIC flights and none is needed for qualification testing. Three IMU's are available from the Titan III resources and will be run through a modification line to incorporate some improved components which will update them to new production quality. This activity will begin in the third quarter FY 68 and result in three IMU units for about one-tenth the cost of each new production unit. New unit production will also begin in the third quarter FY 68 and terminate with the final unit in the second quarter FY 71.

3. Development and Production - Aerospace Ground Equipment

During the last quarter FY 66 basic design effort began on the Telemetry Data Monitoring Set plus modification effort on the Missile Guidance Alignment and Checkout Group and Missile Guidance System Test Set. CEI specification Parts I and II were provided in FY 67 on the Telemetry Data Monitoring Set and Missile Guidance System Test Set, both of which will receive major modifications. Minor modifications to the Missile Guidance Alignment and Checkout Group will be covered by changes to Titan IIIC specifications. Production to meet the installation checkout and launch support of the three Titan IIIC flights and subsequent MOL flights will include three Telemetry Data Monitoring Sets, three sets of computer ground support equipment and modification kits for five Missile Guidance Alignment and Checkout Group and Missile Guidance System Test Set units.

TITAN III M

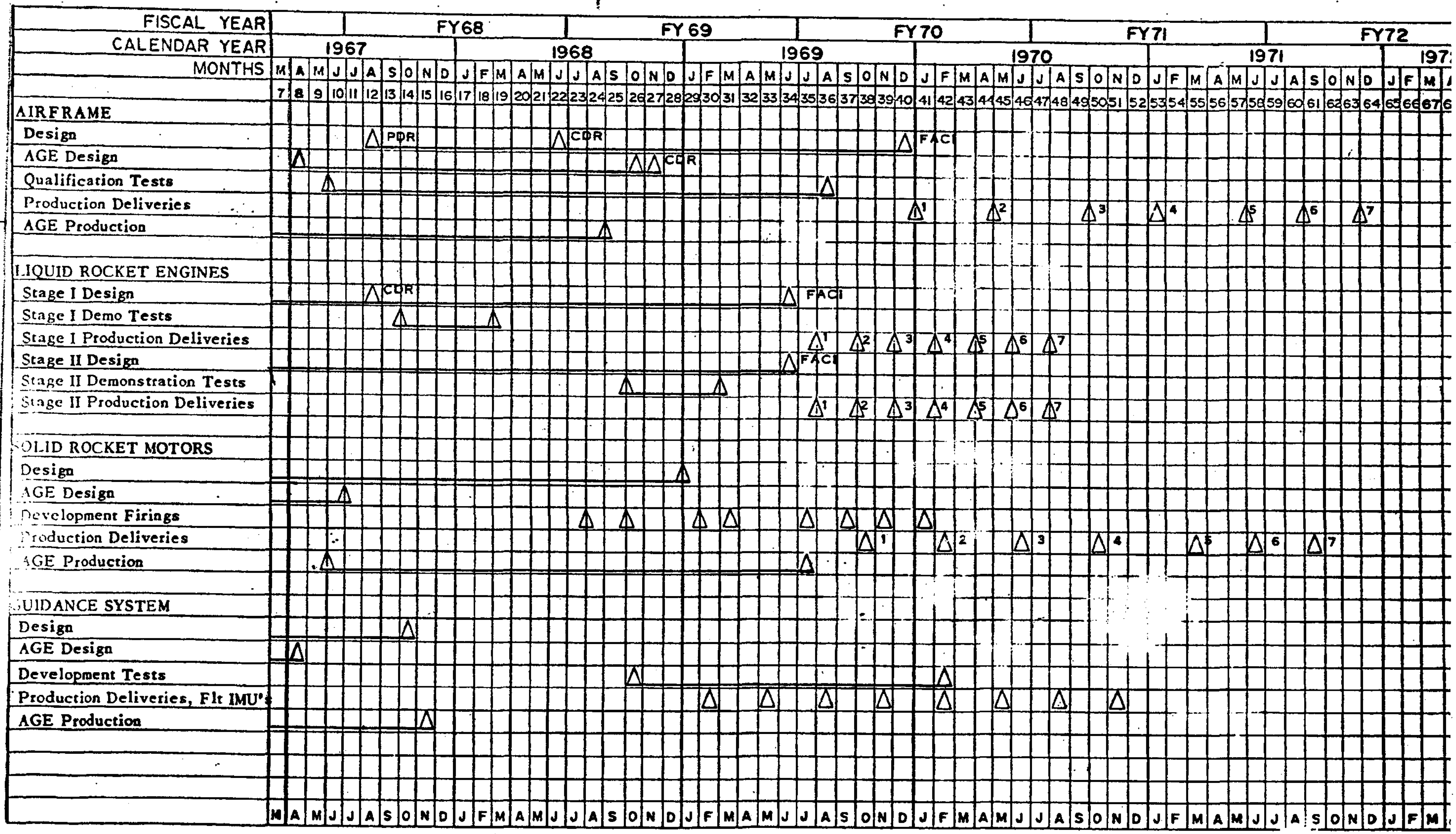

Figure V-1

Part 4 - Funding Requirements

A. General

The costs shown for Titan IIIM reflect the negotiated Phase II contracts, and include an estimate of the schedule adjustment cost. They provide for development and fabrication of seven vehicles. The primary development involves 7-segment solid rocket motors; 15:1 ratio liquid engines and redundancy required for crew safety. The total costs, including deferrals described in paragraph B are shown in Figure V-2. A resume of the tasks included in the cost summary follows:

1. AVE Hardware

Includes airborne design and non-recurring tooling, which involves basic design, preproduction test hardware, airborne equipment evaluation and confirmation testing; airborne hardware production which involves fabrication, delivery and acceptance testing of airborne equipment, recurring engineering and recurring tooling; spares; and production propellants.

2. AGE

Includes the AGE design, production and tooling.

3. System Test and Evaluation

Includes system engineering associated with design requirements, analytical effort, system test planning, control requirements, system effectiveness and system integration.

4. Systems Engineering and Management

Includes program control (costs and schedules management), configuration management and maintenance of Phase II documents.

5. Data

Includes all reports generated for the program.

6. Operations and Services

Includes the receipt, installation, and checkout of AGE; launch planning, vehicle assembly, launch; pre-launch and post-flight evaluation.

7. SE and TD

Aerospace Corporation system engineering and technical direction.

B. Deferral Status

Several tasks were deferred from the contracts negotiated with Martin Company and AC Electronics Division. The estimated costs and reasons for deferring these tasks are listed below. Deferred costs are included in the Titan IIIM Launch Vehicle total costs shown in Figures

1. Martin Company

(a) Several studies are currently underway to determine precise requirements for additional structural beef-up of Stage II, qualification tests, incorporation of POGO hardware, failure analysis/traceability effort, and development of a 1 Amp-hour battery. The estimate for these efforts is $4.2M.

(b) Support to other MOL contractors is not fully defined at this time. The costs estimated for this effort are $2.5M.

(c) The incorporation of GERTS has been directed by the MOL SPO. Estimated costs are $1.5M.

2. <u>AC Electronics Division</u>

Several tasks, such as validation of software for flights past the first MOL flight, rehabilitation of operational computers from qualification units and the controls mock-up (CMU) computer program were deferred during the negotiations. Since the original deferment approximately $0.2 million of FY 67 money has been applied towards the CMU computer program. Estimated cost for the remaining deferred items for FY 68 are $0.4 million.

3. <u>Aerojet General Corporation</u>

Included in the deferrals are items such as POGO hardware, ablative skirt, stage II chamber effort, exit cover test, certain qualification testing, and a contamination task. Estimated cost of this work is $3.7 million.

TIIIM LAUNCH VEHICLE FUND REQUIREMENTS
12 Months Schedule Change
Commitment Funding

EFFORT	FY 67	FY 68	FY 69	FY 70	FY 71	FY 72	TOTAL
AVE	14.4	23.0	43.2	56.8	33.5	4.3	175.2
AGE	7.5	7.4	20.5	4.4	2.2	.9	42.9
Sys Test & Eval	12.9	4.1	14.0	4.7	1.5	.5	37.7
Sys Engr & Mgmt	5.5	6.0	14.2	11.8	7.0	4.0	48.5
Data	-0-	.6	.6	.5	.4	.2	2.3
Oper & Services	-0-	-0-	8.9	12.0	8.3	5.6	34.8
SE & TD	2.7	2.5	3.1	3.4	3.0	2.5	17.2
Facilities	.2	.4	.1				.7
Transportation	-0-	-0-	.1	.5	.5		1.1
TOTAL	43.2	44.0	104.7	94.1	56.4	18.0	360.4

Figure V-2

SECTION VI - FLIGHT CREW EQUIPMENT AND AMD SUPPORT

This section describes the Flight Crew Pressure Suit Assembly, Flight Crew Diet and AMD Developmental and Operational Support. Discussion of each element follows with consolidated funding requirements covering all the elements indicated in tabular form at the end of this section.

Part 1 - Flight Crew Equipment

A. Pressure Suit Assembly

1. General Performance Requirements and Program Approach

The Pressure Suit Assembly (PSA) provides for a breathable atmosphere under sufficient pressure to sustain life, provide thermal protection, micro-meteoroid protection, feeding and drinking, body waste storage, and communications. Mobility provisions will permit the crewman, pressurized if necessary, to accomplish MOL mission requirements. The MOL PSA development will be managed by the MOL Systems Office. Technical guidance, testing and operational support will be provided by a technical team formed by the Aerospace Medical Division of AFSC. The Phase I effort completed in August 1966 resulted in the identification of PSA technical requirements, interface requirements, the solution of specific MOL technical problems, and the publication of a Performance and Requirements Specification. A request for proposal for Phase II suit development was subsequently released. The RFP was unique in that it required the submission of a sample suit to demonstrate the contractor's technical competence and approach. The source selection evaluation of the proposals and the issuance of a contract to the winner, Hamilton-Standard, has since proceeded on a schedule which will permit the timely delivery of suit assemblies for systems engineering and crew training. Pressure suits are required during the 3rd quarter of FY 68 for Air Force developmental testing and for Douglas and McDonnell engineering and design verification tests. The numbers and delivery dates for the suits for Douglas and McDonnell are called out as part of the vehicle contracts. The PSA's required to support the MOL Program will be provided as government furnished equipment and will be delivered in accordance with the schedule shown in Figure VI-2.

2. Operating Concept

The PSA will be designed to permit its use with the environmental systems of the Gemini and Laboratory Vehicle and high pressure gas supplies from the emergency oxygen system or accumulators on the vehicle. In the extra-vehicular modes, it will be able to operate either on its emergency integral supply carried by the crewmen, or through umbilical system from the Orbiting Vehicle. The suit assembly will include an integral communications subsystem that will permit exchange of information between crewmen during suited phases, recording of data on the Orbital Vehicle system, and communications through the vehicle to the ground.

B. Flight Crew Diet (Feeding System Assembly (FSA))

General Performance Requirements and Program Approach

The diet will contain adequate proteins, fats, carbohydrates, minerals, vitamins, and energy to maintain the crewman's health during the 30-day MOL flight and recovery period. The Gemini and Apollo freeze-dehydrated diet has been selected as the most appropriate starting point for diet development to meet MOL requirements. This present diet provides 2650$\pm$250 K Calories, occupies 143 cubic inches of space, and weighs 1.7 pounds, including packages, per man per day.

It is planned to manage the MOL diet development program within the MOL Systems Office. Technical aspects have been assigned to the Aerospace Medical Division of the AF Systems Command. Included within the technical team will be members of the U.S. Army Natick Laboratories, for food preparation and packaging, and the NASA Manned Spacecraft Center, for operational experience with space flight feeding systems. Although the Apollo Block I diet serves as a starting point, it does not meet MOL requirements with respect to preparation time, adaptability to MOL mission timeline variation, or effective nutrition for long periods of time on orbit. The general experience indicates that the Apollo diet:

will require some 1.5 to 2 hrs per man per day for preparation and eating;

does not have a nutritionally adequate liquid component;

bite sized food items do not exploit the current known capability of the food industry.

Therefore, reconfiguration of the Apollo diet will be accomplished:

appropriate nutrient liquid components will be developed and added;

bite-sized food items will be improved;

both will be combined with freeze-dehydrated items for a complete feeding system.

The flexible menu will thus consist of one freeze-dehydrated meal per day requiring about 1/2 hour for preparation combined with supplementary feeding based on bite-sized or bar sized foods requiring no preparation, and the nutrient liquids prepared from a dehydrated powder.

This new MOL menu must have a testing cycle which AMD will undertake in their manned space chambers as part of their MOL simulation studies. The prospective FSA contractor will provide the developmental test rations for these AMD chamber simulation studies. The feeding program is based on a continuing development/production effort aimed at improving palatability, reducing preparation time and increasing the variety of available foods with a view to enhancing crew acceptance. Food production specifications, menu, and quantities for testing, training and flight use will be based on recurring testing requirements so as to maintain a continuous high quality production capability for producing space-qualified food. The U.S. Army Natick Laboratories will assist in developing improved foods and packaging, and will maintain a capability for solving production and quality control problems as they develop. Procurement has been initiated and contract proposals have been received from three prospective contractors. Contract award will be on a schedule which is consistent with the need to assure provision of test diets for the AMD chamber simulations. The milestones schedule for the FSA is shown on Figure VI-4.

MOL FEEDING SYSTEM - CREW DIET

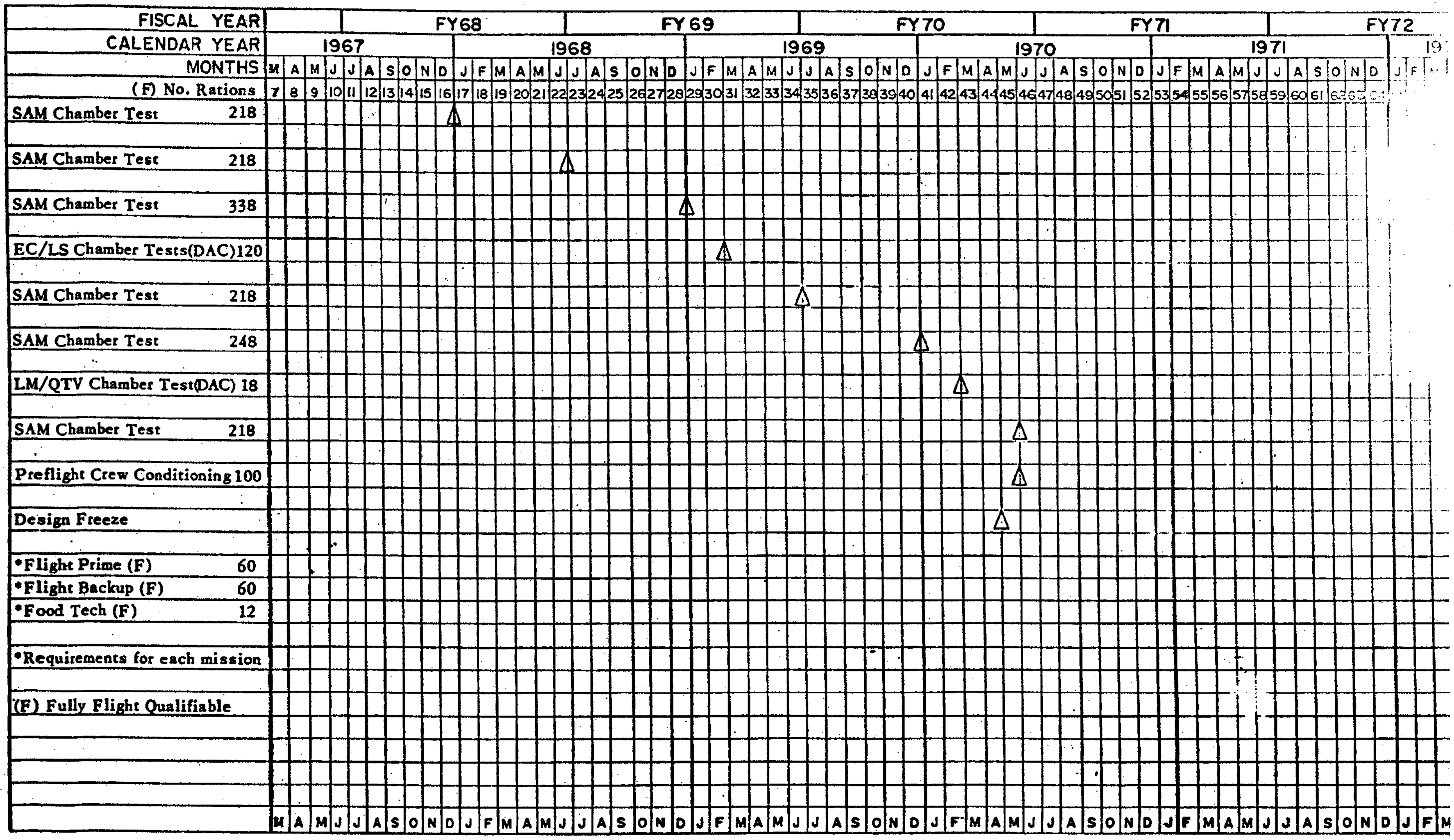

Figure VI-2

MOL PRESSURE SUIT ASSEMBLY

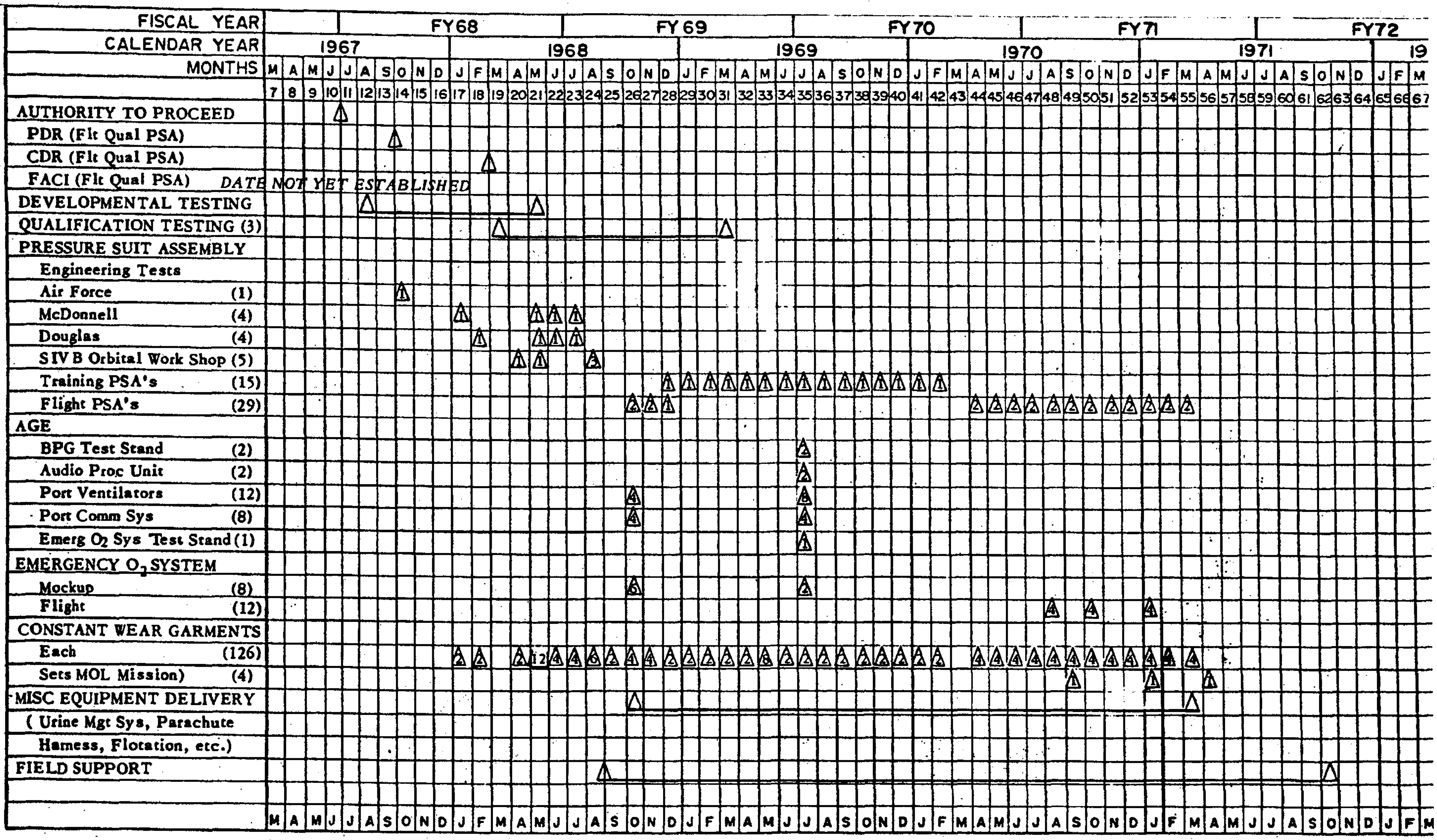

Figure VI-2

Part 2 - Aerospace Medical Division Development and Operational Support

Analysis of the degrees of crew activity required to meet the MOL program objectives and the ideal operation of the vehicle indicates a need to maintain alert and efficient crewmen throughout the 30 day mission. The bioastronautics program has been constructed to meet this requirement.

A review of the manned experience in space flight up through 14 days of flight, has confirmed that predicted physiological and psychological adaptive changes in man as he adjusts to living and working the space environment are occurring. The adaptive changes were predicted through the use of ground based analogue simulation. The simulation events, however, had been limited to predicting accurately the areas of adaptation and the direction the adaptive processes would take. After 14 days weightless experience, the prime areas of concern are the maintenance of cardiovascular, and musculo-skeletal tone and effectiveness. Although these changes have been seen in flight, the 14 day exposure is still of insufficient duration to cause mission limitation. The lack of fidelity of early simulation had prevented prediction of mission significance of the changes as they would relate to the crewman's ability to continue reliable activity through postlanding recovery. As the space flight programs continued, the fidelity of the ground simulations improved and the accuracy in mimicking the actual space events has become much better.

The 30 day MOL mission will provide the additional length of flight duration sufficient to permit the crew adaptation to reach levels that could effect the crewman's efficiency on orbit and, as a result, cause special problems for survival immediately after returning to the earth gravity. The extension of the mission from the present 14 day experience to 30 days also permits some new body systems, which have slower physiological cycles, to reach mission significant levels of adjustment for the crewman. The candidate longer duration cyclic areas of concern include the neurological and endocrine systems, the cellular development process and the psychomotor response pattern.

The MOL bioastronautics program is designed to identify and quantify the adaptive adjustment of the crewmen to 30 days of exposure in the space environment, and in those cases where unchecked adaptive changes are suspected to have an crew operational impact, to develop sufficient control measures to maintain the adaptive processes within acceptable limits for performing the MOL mission. The MOL Program Office has levied the Aerospace Medical Division (AMD) of Air Force Systems Command to undertake an extensive simulation program to accomplish these goals prior to the first manned flight. At the time of flight AMD has been requested to support the operations with medical personnel and inflight data collection to insure that the ground simulation predictions, and the planned control regimens are adequate. AMD is meeting this levy by making the MOL 30 day study and development requirements an important part of their in-house exploratory development program. Resources for these efforts are being individually negotiated to establish the best Air Force approach to meeting the MOL needs. An example of such efforts is the approach to developing special equipments for crew conditioning and the measurement of crew status during flight. In the case of the crew conditioning equipment, the AMD is providing the physiological criteria, developing prototype equipment and demonstrating the adequacy of design. After completion of this effort AMD will provide technical assistance to the Laboratory Vehicle contractor for final design and integration into the vehicle. AMD will develop the operational procedures and the inflight measurement techniques to insure that the devices and procedures do maintain the crew. Another specific example of AMD's unique activity is the development of the inflight mass determination devices. AMD is following a similar invention, development and test of the equipment as noted for crew conditioning. At the time of commitment to MOL use, the same arrangement for technical assistance to the laboratory contractor will be used. Other equipments will be provided by AMD as Government Furnished Equipment (GFE).

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An important part of the AMD support includes the validation of the ground simulation data under flight conditions. In this regard AMD, with the encouragement of MOL, has proposed to develop and flight test models of the crew conditioning exerciser and the mass determination devices on flights of the early NASA Saturn IVB Workshops. This preliminary verification of the data on crew adaptation to the space environment and demonstration of the adequacy of the control measures and procedures should permit a high level of confidence for MOL to undertake a 30 day weightless mission safely before the first MOL manned flight.

The funds noted under this item reflect the matching or unique MOL funds identified as required to carryout the AMD assigned tasks. A summary of present tasks and functions assigned to AMD include the following functions:

1. Blood pressure system (GFE).
2. Body temperature measurement device (GFE).
3. Crew conditioning device development and standardization.
4. Medical kit development.
5. Crew clothing and hygiene equipment evaluation.
6. Mass determination device development and standardization.

AMD will also:

1. Acquire and validate equipment for MOL preflight and post-flight examination and evaluation of the flight crew, (i.e., crew physiological adaptive changes due to weightlessness and operational control procedures).

2. Accomplish MOL specific laboratory testing of human subjects in order to validate the MOL baseline flight environment as reflected in the Laboratory Vehicle and personal equipment design and operating specifications (i.e., testing of the atmosphere, temperature, pressure and gaseous mixture, diet adequacy and other life support provisions).

3. Provide bioastronautics technical assistance to the MOL program in the physiological, medical and human performance areas. The funding schedule in Figure VI-3 will assure timely inputs to system design, integration, and operational concepts.

FLIGHT CREW EQUIPMENT AND AMD FUNDING REQUIREMENTS (IN MILLIONS)

	FY 67	FY 68	FY 69	FY 70	FY 71	FY 72	TOTAL
Pressure Suit Assembly		2.980	2.070	2.070	1.430	.050	8.600
MOL Feeding System		.225	.320	.243	.207		.995
AMD Develop & Operational Support	.270	.300	.150	.080	.060		.860
Clean Room at Natick	.050						.050
TOTAL	.320	3.050	2.540	2.393	1.697	.050	10.505

Figure VI-3